

# BMJ Open Use of audience response systems (ARS) in physiotherapists' training: a qualitative study

Gianluca Bertoni , Evelin Marchesini, Francesca Elena Zanchettin, Michele Crestini, Marco Testa , Simone Battista 

**To cite:** Bertoni G, Marchesini E, Zanchettin FE, *et al.* Use of audience response systems (ARS) in physiotherapists' training: a qualitative study. *BMJ Open* 2023;**13**:e073025. doi:10.1136/bmjopen-2023-073025

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (<http://dx.doi.org/10.1136/bmjopen-2023-073025>).

Received 21 February 2023

Accepted 13 July 2023

## ABSTRACT

**Objective** To explore the experience of using audience response systems (ARS) in postgraduate physiotherapy training.

**Design** Qualitative interview study following the 'reflexive thematic analysis' by Braun and Clarke.

**Setting** Higher education university.

**Participants** Ten Italian students (60% men, N=6; 40% women, N=4) agreed to partake in the interviews.

**Results** We generated four themes. Specifically, the ARS were perceived: (1) as a 'Shared Compass' (theme 1) between the student and the lecturers to monitor and modify the ongoing students' learning journey; (2) useful to 'Come Out of Your Shell' (theme 2) as they help students to overcome shyness and build a team with peers; (3) as 'A Square Peg in a Round Hole' (theme 3) as they should not be used in situations that do not suit them; (4) as 'Not Everyone's Cup of Tea' (theme 4) as mixed opinions among ARS' utilities were found under some circumstances (eg, memorisation process and clinical reasoning).

**Conclusion** Physiotherapy lecturers must use ARS critically, respecting when (eg, not at the end of the lesson) and how to propose them, keeping in mind that some skills (eg, practical ones) might not benefit from their use. Moreover, they need to consider that the ARS are not a tool for everyone, so ARS must be integrated into a multimodal teaching paradigm.

## INTRODUCTION

In the last few years, we have witnessed a shift in the strategies adopted in education: from traditional lectures to a more engaging teaching style characterised by the so-called 'active learning'.<sup>1 2</sup> With the term 'active learning', we intend every moment where 'the teacher/facilitator stops talking, and students make progress towards objective learning by actively doing something'.<sup>3</sup> Extensive literature demonstrated the benefits of active learning techniques on outcomes such as knowledge acquisition, information retention, perceived competence, critical thinking and clinical decision-making.<sup>4-6</sup> In this regard, 'audience response systems' (ARS) are becoming a broadly used, active-learning tool many educational institutions

## STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ Semi-structured interviews analysed through the 'reflexive thematic analysis' by Braun and Clarke allow for reaching a deep understanding of the experience of using ARS in physiotherapists' training.
- ⇒ A reflexive and collaborative approach to data analysis.
- ⇒ We only managed to recruit white men/women working in Italy and the private healthcare sector and students in rheumatic and musculoskeletal rehabilitation.

adopt to facilitate student engagement and learning.<sup>7-9</sup> ARS consist of student-controlled input devices, frequently via smartphones, connected to a receiver and a display controlled by the lecturer. Through the ARS, the lecturer can propose multiple-choice questions, true-false answers, word clouds and 'click-on-target' questions. Then, the class' responses are counted and displayed (anonymously or not) on the screen in real time.<sup>10</sup> By doing so, ARS showed to what extent the students understood the content of the lesson, providing a formative assessment of their ongoing learning achievement.<sup>7</sup>

Several works demonstrated the effectiveness of using ARS in teaching.<sup>11-16</sup> ARS can improve students' attendance, attention, participation, engagement and interaction, stimulate peer discussion, increase long-term knowledge retention, and improve students' performance in examinations.<sup>17 18</sup> Therefore, ARS can lead to positive student outcomes once used correctly, face-to-face and remotely.<sup>12 19</sup> A recent systematic review of qualitative studies analysed how students experienced them.<sup>19</sup> ARS were perceived as a valuable tool for improving engagement and interaction. Students reported benefits related to questioning, anonymity, and instant feedback that facilitated their learning.<sup>19</sup> Nevertheless, this systematic review mainly synthesised articles with students from



© Author(s) (or their employer(s)) 2023. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

Department of Neurosciences, Rehabilitation, Ophthalmology, Genetics, Maternal and Child Health, University of Genoa, Genova, Italy

## Correspondence to

Prof. Marco Testa;  
[marco.testa@unige.it](mailto:marco.testa@unige.it)

different disciplines than medicine (marketing, linguistics, engineering), with only three studies involving training nurses.<sup>19</sup> Finally, they mainly considered the positive sides of ARS, reporting only some limits related to the technology rather than personal experience.<sup>19</sup>

So far, no studies have investigated the use of ARS among physiotherapists. Physiotherapists are a peculiar population characterised by the necessity of gaining high clinical knowledge and reasoning skills, compounded by a robust, practical apparatus based on manual and exercise techniques. Due to their mixed learning objectives and expanding evidence-based knowledge, different learning activities are necessary to improve their learning quality.<sup>20 21</sup> Therefore, it is essential to understand which learning activities students perceive as beneficial to inform lecturers and organisations where it is worth investing time and resources. Hence, this paper explored the experience of ARS in physiotherapy through a qualitative study.

## METHODS

### Study design

A qualitative interview study was performed at the University of Genova. We opted for a qualitative study as it allows for exploring people's (in this case, physiotherapy students) experiences and their points of view on a topic (in this case, ARS).<sup>22</sup> It was conducted in respect of the Declaration of Helsinki and reported following the Consolidated Criteria for Reporting Qualitative Research.<sup>23</sup>

### Participants

Participants were identified within the cohort of students attending the Rheumatic and Musculoskeletal Diseases (RMD) rehabilitation postgraduate degree programme at the University of Genova (Genova, Italy) in the academic year 2020/2021. To be able to start this postgraduate degree, students had to complete a bachelor's degree in 'Physiotherapy'.

This programme aims at providing advanced, specialised training in the RMD field following the international standards of the International Federation of Orthopaedic Manipulative Physical Therapists.<sup>24</sup> The physiotherapists who complete this postgraduate degree course acquire a specialised level of competence in the prevention, evaluation and treatment of RMD. The RMD rehabilitation postgraduate degree programme spans 76 days, distributed across 18 months in a blended learning format. Each year, a cohort of 120 students is enrolled in the programme, divided into two groups of 60 students each. Both groups follow an identical syllabus with the same lecturers, ensuring uniformity in curriculum delivery. The comprehensive course entails 1550 hours per student, allocated across various activities. Specifically, it includes 438 hours dedicated to online (synchronous) and face-to-face activities, encompassing lectures and small-group training sessions with case studies and practical skill activities

guided by the lecturers. The lectures focused on anatomy, rheumatology, orthopaedics, clinical reasoning, research methodology, psychology, radiology, etc. Then, specific seminars focus on different anatomical districts (ie, lower limb, upper limb, thoracic-lumbopelvic and cervical). Each seminar is further divided into theoretical and practical components focused on biomechanics, joint-related disorders, manual therapy, exercise, clinical reasoning etc. A clinical placement contributes 150 hours, while thesis preparation requires 250 hours. All these activities are mandatory. Additionally, the individual study comprises approximately 712 hours.

The ARS were adopted during the shoulder joint seminar. The seminar was divided into two parts: a theoretical one that lasted 30 hours and was conducted remotely and synchronously and a practical one that lasted 20 hours and was done face-to-face, totalling 50 hours. This seminar covered different topics, such as anatomy and biomechanics, upper limb stiffness management, symptom management, clinical reasoning, red flags, upper limb outcome measures and practical skill techniques specific to the shoulder district. The purpose of integrating ARS was to enrich the learning experience by implementing innovative teaching modalities that foster high interactivity in both face-to-face (practical skills) and remote (knowledge) classes. A comprehensive overview of the topics covered with ARS and the purposes that this tool served in managing the specific subject can be found in online supplemental file 1—ARS utilisation overview. All students received an equal degree of exposure to the technology. The ARS software we adopted was Wooclap (Developed by Sébastien Lebbe (CEO) and Jonathan Alzetta (CTO—Brussels, Belgium)). ARS collected anonymous responses to different questions while providing real-time feedback to the students and the lecturers. This academic year was the first one in which ARS were adopted in this programme. At the end of the shoulder seminar, a satisfaction questionnaire about the experience of ARS was sent out to the students to understand whether extending the usage of this system to all the courses offered within the programme would be beneficial. Since the students were overall satisfied, the lecturers of this course will implement ARS use in other seminars.

### Recruitment

Recruitment of study participants was done through purposive sampling to identify those most likely to yield valuable and appropriate information to answer our research question.<sup>25</sup> Therefore, we chose our participants from this postgraduate degree as physiotherapists attending it need to learn high levels of clinical decision-making and expertise in manual skills and exercise. To enrol the students, we emailed the head of the programme, the lecturers, and the placement tutors. We asked them to provide us with a list of students' names that they perceived as most participatory and proactive during lectures and placements. We made this decision due to

the blended teaching approach, which made it difficult to ascertain the extent of tool usage during the distance learning phase. As a result, we chose to target the students perceived to be the most engaged to maximise the probability of effective and actual tool usage. Out of the 20 students eligible under this criterion, we received five acceptances to participate. However, we acknowledged that this method had different limits based on personal perception and might have excluded shyer participants. Therefore, to expand the variability, we extended the study invitation to the entire class group during a second phase, recruiting five additional participants for interviews. The authors and the other people involved in the recruitment process did not contact the students directly. Instead, the didactic secretary's office was approached to reach the abovementioned students. This office sent an email to the identified students explaining the objective of the study, the interview process (ie, proposed locations and dates), and the confidentiality and anonymity of the data. In the email, students were invited to contact GB directly if they were willing to partake in the study so that the organisation did not know which students attended the interviews. This was done to avoid any form of dependability towards the educational organisation. Those students who did not contact the secretary's office to partake in the interviews were not asked to provide any information about their decision. Once GB was reached, he collected the informed consent and arranged the interview. During the conduction of the interview, GB anonymised the participants with 'participant 1', 'participant 2', etc, based on the chronological order of the interviews. This label is the only info shared with the rest of the group. All the students could join the research and withdraw from it at any time.

### Data collection method

An ad hoc semi-structured interview guide (see online supplemental file 2) was created by GB and SB based on the existing literature.<sup>19 26 27</sup> GB is a physiotherapist, PhD student and temporary lecturer. He is not involved in the postgraduate course but is a former student thereof. SB is a PhD student and teaching assistant of the course. He has advanced skills in teaching for health professionals and qualitative studies, and he is an adjunct lecturer in 'Teaching Methodologies for Health Professionals'. They both identify themselves as men.

The purpose of the interview was to shed some light on the experience of using ARS in the postgraduate education of physiotherapists, which they used during one of the programme's seminars. The interview guide consisted of open questions exploring different topics related to the use of ARS in teaching: (1) personal experiences; (2) strengths and weaknesses; (3) expectations; (4) beliefs. Follow-up questions were frequently asked to investigate participants' experiences further. These questions included, 'Can you give me an example?' and 'Can you explain to me what you mean by this sentence?'

The interview script was tested with a pilot interview with a student. The investigative potential of the interview script appeared to be good, and therefore no modifications were made to the interview guide following the pilot interview. Before each interview, the participants filled in the informed consent and a demographic form (ie, age, gender, job, educational path) registered on an electronic sheet by the interviewer. The interviews were performed in February 2022 remotely through teleconferencing software (Microsoft Teams) and lasted approximately 1 hour each. They were recorded and then transcribed verbatim. The interviews were conducted by GB only with the interviewees. No relationship was established before the study between the interviewer and the participants. At the beginning of each interview, the interviewer introduced himself as a fellow physiotherapist, a former master's student and a university lecturer interested in researching how to improve the quality of learning via electronic tools. No follow-up interviews were performed.

### Data analysis

Descriptive sample analysis was conducted to collect information about the gender, age, living/working area, years of professional practice and in which healthcare sectors they were working (private, public, etc). Data analysis of interview transcriptions was performed according to the principles of Braun's and Clark's 'reflexive thematic analysis' (RTA).<sup>28</sup> This choice was made because the research aims to identify patterns of meaning—and consequently generate themes—relating to the experience of using ARS in the postgraduate education of physiotherapists based on their own experiences.

Among the principal thematic analysis approaches,<sup>29</sup> that is, coding reliability TA, codebook approaches to TA, and reflexive approach to TA, we adopted the last one (RTA). RTA is an interpretive approach to qualitative data analysis 'that facilitates the identification and analysis of patterns or themes in a given data set'.<sup>29</sup> RTA is situated in a 'Big Q' qualitative paradigm that involves qualitative data and methods whose qualitative values framework is characterised by adhering to a non-(post)positivist paradigm.<sup>30</sup> Therefore, some practices do not apply to RTA (eg, consensus coding, inter-coder reliability, data saturation, etc) as they are infused 'with assumptions about the nature of reality and meaningful knowledge' that follow a 'small q' (postpositivist) paradigm.<sup>31 32</sup> Moreover, RTA is characterised by researchers' active and creative role in interpreting codes and themes and identifying those more relevant to the research question.<sup>28</sup> Therefore, researchers' view is considered a resource to tap into rather than a bias.<sup>28</sup> Since the analysis involved more than one researcher, the approach was as collaborative and reflexive as possible, intending to achieve richer interpretations.<sup>28</sup> However, it is fundamental to state our theoretical assumptions as researchers since we built our reflexivity on them.

We adopted an experiential qualitative framework because we illustrated the experience of ARS starting



from students' experience to emphasise meaning and meaningfulness as they experienced it.<sup>33</sup> From the perspective of epistemological conception, our study adopted a constructionist approach.<sup>33</sup> We appreciated the meaning and meaningfulness of language as the main criteria in the coding process rather than its recurrence.<sup>33</sup> RTA was conducted with a primarily inductive approach. The codes generated from the analysis of the interviews were produced based on the content of the data. Thus, the data were not coded according to a pre-existing coding framework (ie, the codebook of the deductive approach).<sup>33</sup> The data coding was mostly semantic as it mostly stayed on the explicit or surface meanings of the data.<sup>31</sup> However, we tried to go beyond these descriptive levels of the data when possible. Thus, having clarified the theoretical assumptions and the choice of using RTA, the six steps of the RTA<sup>28</sup> were followed by GB, EM, FEZ, MC and SB for the interviews (see [table 1](#)). FEZ and MC are physiotherapists and teaching assistants in the postgraduate course. EM is a psychologist and a PhD student in neurosciences. SB trained all the authors in conducting qualitative studies. MC identifies as a man; FEZ and EM identify as women.

### Patient and public involvement

Participants and/or the public were not involved in the design, conduct, reporting or dissemination plans of this research.

## RESULTS

Among the cohort of students who were attending the postgraduate degree in RMD rehabilitation at the University of Genova (n=120), 10 (response rate=8.3%) partook in the interviews (age (median and first and third quartile (Q1, Q3): 26 (25, 27); gender (percentage and frequency): 60% men, N=6; 40% women, N=4). Online supplemental file 3 reports the extended demographic and relevant features of each participant (see online supplemental file 3). They were all private self-employed physiotherapists. Moreover, all the interviewees reported that it was their first-time using ARS. Four themes were generated regarding the perceived use of ARS: (1) A Shared Compass, (2) Come Out of Your Shell, (3) A Square Peg in a Round Hole and (4) Not Everyone's Cup of Tea.

### Theme 1: 'A Shared Compass'

The students perceived the ARS as a compass they shared with the lecturers. ARS are a valuable tool for students, providing guidance about their ongoing learning journey (refer to [table 2](#) for the coding process related to this theme), as a compass would do for a traveller. Consequently, the feedback obtained from the ARS allows the lecturer to make adjustments to the course, similar to using a compass to modify the journey's itinerary.

I think ARS are effective for the lecturers to see if what they explained was understood or if there were

some areas of improvement. They allow lecturers to get feedback on the effectiveness of their teaching to see if they need to modify some aspects of it. (Participant 1—Woman)

As per the students, our interviewees discussed ARS as an instrument to understand if they are on the right track in the learning path, as a compass does. Specifically, it allowed them to understand which concepts they had already learnt and which needed further study.

By reading the quiz [on the ARS], I sometimes ask myself, "When did they [the lecturer] talk about this topic?" and by doing so, it [ARS] made me think more and more about the topic than classic oral questions. It stimulated you to go back to the lecture, recall past information, and double-check if you remembered it. It's also useful later when you have already studied and need to test the acquired knowledge. It allowed me to understand what I needed to focus more on what I was studying. (Participant 10—Woman)

Moreover, the students perceive the topic on which ARS is built more relevant than others for the lecturers. Hence, they provide the students with information that guide them on what to prioritise while studying.

The topics used for the ARS were like take-home messages and key points. Those things that the lecturer thought were most important, so I will have to study them better. The class got the message that those were the most important things to keep and relate to in our studying. Things to emphasise better and learn well. (Participant 3—Man)

From the participants' opinions, we reflect on ARS as an effective teaching and learning tool. However, the potential benefits go beyond it, as the students reported that ARS effectively made them step out of their comfort zone, as we are about to describe in the upcoming theme 'Come Out of Your Shell'.

### Theme 2: 'Come Out of Your Shell'

Students perceived the ARS as an incentive to come out of their shells. This theme concerns the emotional, social, and relational aspects of teaching and learning (see [table 3](#) for the coding process of this theme). The students perceived this tool as helpful in overcoming shyness, building the team and enhancing relationships. The ARS seemed to break down and overcome students' emotional barriers that prevented a satisfactory level of participation and enjoyment of the lesson. Some reported examples of these barriers are the fear of speaking in public or the possible judgement that comes with exposing yourself in front of an audience.

ARS allows you to bypass the shyness and fear of having to speak in front of everyone. In that situation, you might feel judged or afraid to say something you consider stupid. In this perspective, ARS are really a great tool!. (Participant 3—Man)

**Table 1** Six steps of the reflexive thematic analysis

Phases	Process	Authors' involvement	Authors' actions
Data familiarisation	All authors read and reread several times the transcriptions of the interviews. This process is fundamental to getting in contact with the data and taking notes of any impressions and insights	All authors engaged in this phase, and they met to reflect on their first insights	<ul style="list-style-type: none"> <li>▶ Document theoretical and reflective thoughts: GB documented field notes ('Memos' and diary) during and after each interview to promote reflexivity</li> <li>▶ Keep records of all data field notes, transcripts and reflexive diary</li> <li>▶ Prolong engagement with data and triangulate different data collection modes to increase the probability that the research findings and interpretations will be found credible: GB, EM, FEZ and MC read and reread the data (transcripts of the interviews, memos and reflexive diary)</li> </ul>
Coding	Four authors systematically coded the data in this phase through an open, evolving and organic process	GB, EM, FEZ and MC systematically coded the data. They adopted semantic data coding	<ul style="list-style-type: none"> <li>▶ Peer debriefing: memos were shared during research meetings for reflexive thoughts</li> <li>▶ Audit trail of code generation: GB, EM, FEZ and MC coded data through the entire data set to identify interesting aspects in the data items that may form the basis of themes across the data set</li> <li>▶ Documentation of all team meetings and peer debriefings to help researchers examine how their thoughts and ideas evolve as they engage more deeply with the data</li> </ul>
Generating initial themes	The researchers generated initial themes from the codes, clustering similar or related codes	GB, EM, FEZ and MC generated initial themes separately, clustering similar codes together	<ul style="list-style-type: none"> <li>▶ Diagramming to make sense of theme connections: GB, EM, FEZ and MC generated initial themes through inductive thematic analysis</li> </ul>
Reviewing and refining themes	The researcher reviewed the initial themes, reworking or discarding some until finding a final set of themes fitting the data	All authors reviewed the coding and initial themes separately and then jointly and generated four themes that fit the data the most. GB, EM, FEZ and MC reviewed the agreed themes against the codes and the entire dataset	<ul style="list-style-type: none"> <li>▶ Themes vetted by team members: the research team frequently met to refine the themes and clearly show how each theme was generated from the data</li> </ul>
Defining and naming themes	The 'story' of each theme is developed by finalising theme names and their definition	All authors finalised the final themes and definitions to set the basis of the written report	<ul style="list-style-type: none"> <li>▶ Peer debriefing and team consensus on themes: the research team met until the final themes were reached</li> <li>▶ Documentation of theme naming</li> </ul>
Producing the report	The authors produced the final report and refined them if necessary	GB, EM, FEZ and MC selected the illustrative quotations from the interviews, and all authors reviewed and agreed. SB and VC led the writing of the paper, and all authors participated in this phase	<ul style="list-style-type: none"> <li>▶ Producing the report using direct quotes from participants</li> <li>▶ Report on reasons for theoretical, methodological and analytical choices throughout the entire study</li> </ul>

Furthermore, as per students' perspectives, implementing ARS effectively reduced the perceived distance between themselves and the lecturer, enhancing the sense of connectedness and

relatedness. By actively engaging with ARS, students felt a stronger connection to the instructor, leading to an increased sense of being part of the learning community.

**Table 2** Illustrative data extracts for theme 1: 'A Shared Compass'

<b>Theme 1: 'A Shared Compass'</b>	
Codes defined by researchers	Example of quotes extracted from the interviews
Learning feedback	I think ARS represent the key parts of the lecturer. By answering multiple choice questions, you can see if you learnt those key parts. (Participant 2—Woman)
Useful for self-assessment for the final exam	The ARS were more useful during the study and review phases than during class. Also, in view of the exam to see if I could answer a multiple-choice question. With this purpose, in my opinion, it is a very useful tool. (Participant 3—Man)
Feeding the lecturer back on the effectiveness of teaching (understanding)	[I would use ARS] to understand if some concepts I explained were misunderstood, and if so, I would either explain them in a different way or provide a second explanation. (Participant 3—Man)
Feeding the lecturer back on teaching effectiveness (attention and participation)	The ARS allow you to evaluate engagement because I don't know how many people are actually listening to me, so it's also a way to see who's really connected ... not just because they're online ... but really connected with their mind. (Participant 2—Woman)
Fixation and focus of concepts	For me, the ARS were maybe helpful as a fixation of the concepts we talked about during class. They gave me a chance to review to focus better on what we had just been told. Let's just say they were very relevant summaries of what they had explained to us. (Participant 1—Woman)
Encouraging doubts and questions	The ARS helped raise questions about topics that no one was asking about. The lecturers with the ARS suggested topics that they knew were important or that they wanted to emphasise more!. (Participant 9—Man)
Hierarchical segmentation of activities	The ARS allowed us to figure out how to break down the steps of the learning activities (...) They showed you how to take something big in pieces. (Participant 3—Man)

With the ARS, I felt maybe the lecturer wanted to have more contact with us somehow. I appreciated this tool sincerely. I also felt a little bit more important as a student. (Participant 4—Woman)

Finally, not only did this shared tool facilitate individual learning, it also fostered a sense of being part of a group among the students, encouraging peer discussion and interaction. By using ARS, students were able to compare their answers with those of their peers, which they found profoundly beneficial. The opportunity to gain insights from different perspectives was particularly advantageous,

especially in the context of online classes with face-to-face interactions being limited. Being able to consider alternative viewpoints expanded their understanding and enhanced their overall learning experience. The ARS effectively created an inclusive environment where diverse opinions were valued and encouraged, enriching the educational journey for all participants.

This tool was useful from our point of view, it was really useful as a group. Because also, remotely, someone might ask, "Guys, do you know how to answer?" This would happen with a message in a group chat. When

**Table 3** Illustrative data extracts for theme 2: 'Come Out of Your Shell'

<b>Theme 2: 'Come Out of Your Shell'</b>	
Codes defined by researchers	Example of quotes extracted from the interviews
Overcoming emotional barriers	[Thanks to the ARS], we were truly encouraged to ask questions rather than remaining in the shadow ... so it was really helpful. (Participant 4—Woman)
Increasing relatedness	In my opinion, it was beneficial to increase the interaction and therefore enhance the closeness, especially considering that we were at distance. I would say it brought the student closer to the lecturer. This was the most significant aspect. Furthermore, it was useful precisely because we were closer ... it increased the importance of the relationship. (Participant 3—Man)
Making students feel part of a group	Let's start from the assumption that I was very, very sad about having to have online classes because I'm someone who usually interacts a lot, and I realised I couldn't. I mean, I didn't like it, I couldn't interact the way I wanted to. With Wooclap, it made things, for me, more interesting, more interactive because I could interact with the lecturer and stay somewhat more connected with the group. (Participant 5—Man)

I was unsure, I would write in the group “Which one could be the right one?” and a friend would try to answer, “For me, it’s x or y ...” so it definitely creates comparison and bonding. For me it’s very important to see what other people think and try to get to a solution together. (Participant 3—Man)

While participants have highlighted the significant benefits and strengths of using ARS, it is essential to approach their implementation cautiously. Without careful consideration, their usage may lead to the intended results. Based on the analysis of respondents’ opinions, we found they described a mismatch between how ARS should be implemented and their actual implementation, analogous to fitting a ‘Square Peg in a Round Hole’.

### Theme 3: ‘A Square Peg in a Round Hole’

Interviewees reported that ARS are functional under some circumstances, as stated above. However, they also highlighted that ARS have some flaws and should not be used for all learning purposes. If they are not adopted wisely, they lose their effectiveness. Therefore, we created the theme ‘A Square Peg in a Round Hole’ as ARS should not be used in situations that do not suit them (see [table 4](#) for the coding process). Our interviewees did not see any advantages in using ARS to learn and improve clinical skills and manual techniques.

I think ARS can be a tool that helps in the acquisition of knowledge, but I don’t think they are a turning point for students for clinical skills [...] let alone

**Table 4** Illustrative data extracts for theme 3: ‘A Square Peg in a Round Hole’

Theme 3: ‘A Square Peg in a Round Hole’	
Codes defined by researchers	Example of quotes extracted from the interviews
Low room for audience response systems (ARS) in learning manual techniques	As far as manual learning techniques is concerned, I really think that these tools are not helpful. I’m trying to think of any aspect of learning a manual technique that would benefit from this tool, but I can’t picture any. (Participant 8—Man)
Low room for ARS in learning clinical skills	So, for the clinical part, I’m not sure how much it can help. In my opinion, it should remain a tool to be used when presenting theory. (Participant 7—Man)
Low ARS utility if not followed by discussion and explanation	These Wooclap questions were posed, but they weren’t then elaborated on, you see. Despite being very important, they weren’t explored in depth. So, let’s say the usefulness for effective memorisation ... but if they weren’t explained afterward, they lost their utility. (Participant 3—Man)
Low ARS utility as a teaching tool at the end of a lesson	If ARS are used right after the lesson, at time zero, they are not very effective immediately. (Participant 2—Woman)
Student’s difficulty in answering questions too early	As far as I’m concerned, during the lesson, I struggled a bit because I didn’t have the concepts firmly ingrained in my mind to answer more complex questions. (Participant 1—Woman)
Difficulties generated by the reduced response time	Perhaps one of the biggest limitations in using the ARS was the little time we had to give the answers (...) lecturers need to understand that, obviously, when you take the quiz, you haven’t studied yet and that you have to try and give an answer by remembering something you only heard a few minutes before. The time for this work must be enough. Otherwise, it’s tough. (Participant 3—Man)
Student’s difficulty in being deprived of breaks	During some lessons, lecturers replaced breaks with ARS moments. We hadn’t even time for a break to get a coffee or go to the bathroom. If ARS was followed by a 5-minute break to relax, this problem would not occur. (Participant 8—Man)
Different efficacy of ARS in relation to different types of questions	I wouldn’t use ARS for asking overly complicated questions. For instance, if you have to read text in a question, it becomes difficult ... I would prefer more immediate multiple-choice questions ... maybe making connections ... perhaps linking two statements together. (Participant 1—Woman)
Low ARS utility if not optimised on the topic	Deciding how to set the questions must be functional to learning. If you have a limited amount of time and a limited number of questions, you must think about which questions are more functional. I would then choose the questions on the most crucial points of the lecture. I would make fewer ARS moments, but more relevant. (Participant 8—Man)
Low suitability of ARS for long, complex and specific questions	I think ARS don’t work with complicated questions or where you have to read a lot of text. They are more suitable for multiple-choice questions that are more immediate. Then to give learning feedback may be better to avoid too specific questions. More for the type of question than anything else. For that purpose, better generic questions where you can get there by reasoning, but not extremely specific. (Participant 10—Woman)



manual techniques. To learn those skills, I think it would be wild to adopt these tools. (Participant 6—Man)

Interviewees also reported that ARS lost their effectiveness once the lecturers did not plan a moment of discussion revolving around the students' answers. A moment of a debate was considered helpful for the students to have a deeper understanding of the topic and the reasons why they made such a mistake. In this way, ARS are perceived as valid in memorisation and comprehension.

Just seeing the correct answer allowed you to understand that you made a mistake, but not why you made that mistake. Therefore, these tools are functional only if followed by moments of discussion and interaction. (Participant 2—Woman)

To stress what was mentioned above, the interviewees reported that ARS are useless at the end of the lesson as there is no time to discuss ARS' results. Therefore, for this reason, choosing the end part of the lecture to examine the effects of ARS proves ineffective as it hampers the opportunity to address and clarify doubts due to time constraints adequately.

Right there, at the end of the class, it is difficult to digest everything and give the answers. If you could use a tool like this after the classes and after studying the material, it would be even more helpful for memorising and learning the content. (Participant 7—Man)

Similarly, ARS are not valid if offered too early to students while they are still processing information and taking notes. The students highlighted the importance of pondering the concepts learnt during the classes. Thus, answering questions posed by ARS during classes was difficult because the information was new and unprocessed. To maximise the utility of the ARS, it would be helpful to use them later in the learning process once the students have had time to familiarise themselves with the concepts explained.

When I attend class, I am wholly focused on taking notes. So I struggle with already having the knowledge and answering questions right away. I need to process the information and make it my own, so maybe I struggled with answering questions at that time. (Participant 1—Woman)

In addition, the students reported that ARS should not replace student breaks. ARS are an integral part of the lesson and moments of active learning. ARS are valuable tools that can significantly assist students in their learning process, and it is generally regarded as applicable by students. However, it is crucial to use ARS at the appropriate time. Students do not find ARS helpful if used too early or too late in the learning session. It is essential to strike a balance and ensure that ARS do not disrupt the necessary breaks, as breaks are crucial for active learning and integral to the overall learning process.

Deciding how to set the questions must be functional to learning. If you have limited time and a limited number of questions, you must consider which questions are more functional. I would then choose the questions on the most crucial points of the lecture. I would make fewer ARS moments, but more relevant. (Participant 8—Man)

In addition to their feedback, students highlighted that the effectiveness of ARS was contingent on the specific types of questions being utilised. The students emphasised the importance of instructors employing a discerning approach when preparing questions, focusing on essential topics while taking into account the limited time available for instruction. By carefully selecting key points, lecturers can optimise the ARS experience by homing in on the most crucial information, ensuring that the questions posed are concise, direct, and free from unnecessary complexities or irrelevant details. This mindful approach to question design enables students to benefit from the ARS by facilitating comprehension and engagement with the material at hand, while avoiding potential confusion or information overload caused by lengthy or convoluted questions. By prioritising simplicity and clarity in their question formulation, educators can leverage the ARS as a valuable tool for active learning, fostering effective student participation and enabling prompt and accurate responses.

Questions must be functional for learning. Having a certain time and number of questions. Lecturers should reason upon which questions are functional for learning. Otherwise, ARS work poorly. (Participant 8—Man)

From the insights provided by the respondents, we acknowledged that ARS can be effective tools for teaching and learning, enabling individuals to overcome obstacles and broaden their comfort zones. However, it is essential to recognise that personal preferences and inclinations may lead some individuals not to prefer their use, even when implemented correctly and for appropriate purposes. These reflections gave rise to the following theme: 'Not Everyone's Cup of Tea'.

#### Theme 4: 'Not Everyone's Cup of Tea'

Interviewees reported different and opposite opinions in some specific areas of ARS' use. Regarding the memorisation process and clinical reasoning skills, some students perceived the benefits of using ARS, while others did not. In addition, students' different technological skills and anxiety management abilities raised some concerns about the benefits of using ARS with all the students. Therefore, we reflected that ARS are tools that can be or be not valuable based on students' preferences and attitudes, generating the theme 'Not Everyone's Cup of Tea' (see [table 5](#) for the coding process). Regarding the memorisation process, some interviewees argued that ARS express their most significant potential in facilitating memorisation of



**Table 5** Illustrative data extracts for theme 4: Not Everyone's Cup of Tea

Theme 4: Not Everyone's Cup of Tea	
Codes defined by researchers	Example of quotes extracted from the interviews
Uncertain usefulness in promoting notion acquisition and memorisation	I believe that ARS has been helpful for me to better memorise certain concepts, so I would say especially for that ... for enhancing my memorisation. (Participant 3—Man) I wouldn't use it for factual information ... anything related to memorisation and mere studying. If it's a simple notion that just needs to be memorised without deep understanding, [ARS] serve little purpose. (Participant 6—Man)
Uncertain usefulness in promoting clinical reasoning	Regarding clinical reasoning, [ARS] have certainly been a valuable tool because they provided input for reasoning and were stimulating. (Participant 6—Man) Perhaps for structured clinical reasoning, I wouldn't use [ARS] because it didn't help me much. For that, I would prefer more direct vocal interaction, especially in the initial moments. (Participant 4—Woman)
Performance anxiety generated by audience response systems (ARS)	I feared the lecturer could see my name and figure out how many mistakes I made. (Participant 2—Woman)
Difficulties of low-tech expertise students	So basically, if you're quite proficient in digital stuff, you can manage pretty well in the lessons. But if you're not great at it, you'll struggle. (Participant 10—Woman)

conceptual knowledge that can only be remembered by heart.

Certainly, the ARS helped me a lot with the notion and memorisation part, for instance, anatomy and biomechanics. These concepts are often the ones that are a little bit harder to remember because you need to remember them by heart. So I would say that they are more useful in memorising theoretical knowledge than carrying this knowledge into clinical contexts. (Participant 5—Man)

Conversely, a group of respondents expressed their belief that ARS did not contribute significantly to memorising information that relies solely on rote memorisation. These interviewees asserted that ARS did not offer any distinct advantages when it came to mnemonic learning of specific facts or concepts that necessitate memorisation through repetition and recall. From their perspective, ARS proved to be more functional and effective in facilitating critical thinking and reflection on complex topics. These students acknowledged that the interactive nature of ARS encouraged active engagement and stimulated deeper understanding of intricate subjects. However, when it came to purely memorisation-based tasks, they contended that the usage of ARS did not provide substantial benefits and advocated for alternative strategies that focus more explicitly on mnemonic study methods.

I wouldn't use this tool to gain knowledge for anything that needs to be remembered only by the heart. I think it would make it redundant. These tools don't seem very useful to me if it's a notion that simply needs to be studied or memorised and not understood. (Participant 9—Man)

Furthermore, some participants found ARS helpful in implementing knowledge in clinics, stimulating some clinical reasoning skills. With ARS, the lecturer can pose clinical questions that students can reflect on. By doing

so, ARS allowed students to start travelling from theory to practice smoothly.

This tool allows you to identify and address critical issues in the transition between the notional aspect and clinical reality [...] yes, it really helps you in your clinical reasoning skills. (Participant 8—Man)

On the other hand, it was observed that a subset of students expressed scepticism regarding the efficacy of ARS in fostering the development of clinical reasoning skills. These students argued that the nature of multiple-choice questions, which are commonly used in ARS, falls short in capturing the intricate complexities encountered in real-world clinical scenarios. According to their perspective, clinical reasoning skills require a deeper level of analysis, synthesis, and critical thinking that goes beyond the scope of traditional multiple-choice questions. These students believed that the nuances and intricacies of clinical practice, such as uncertainty, ambiguity, and the need for context-dependent decision-making, are challenging to simulate through the restricted format of ARS questions. Consequently, they questioned the practical value of using ARS as a tool for enhancing clinical reasoning skills and advocated for alternative methods that provide a more comprehensive and realistic assessment of these abilities.

Clinical reasoning is not always the same and changes from case to case. It is difficult to resolve the complexity of clinical reasoning with a multiple-choice question. (Participant 5—Man)

Then, students reported instances where ARS could become unpleasant, particularly when they pose challenges for individuals who are less familiar with technology or consider themselves non-tech-savvy. While ARS can offer numerous benefits, such as increased interactivity and engagement, it is essential to acknowledge that not all students may feel comfortable or confident

navigating the technical aspects of using ARS. For ‘non-tech-savvy users’, which refers to individuals who have limited knowledge or proficiency in using technology or digital devices, the learning experience may be hindered by the additional effort and frustration in understanding and operating the ARS platform. These individuals may struggle to keep pace with the class or feel left behind due to their limited technological proficiency.

I’m not a huge tech person, so it was a bit tricky for me at first. I would get it wrong many times because of the tool. For example, I would answer late or click the wrong one. Also, I often could not understand the results and how to read and interpret them. It was a bit complicated for me, but I admit that maybe I’m a bit different from my classmates because I’m not familiar with the technology’. (Participant 4—Woman)

Finally, it is essential to note that using ARS can evoke negative emotions in individuals who experience higher levels of performance anxiety, even when they are assured of the anonymity of their responses. Despite the anonymity, actively participating and engaging with ARS can trigger feelings of self-consciousness, apprehension, or fear of evaluation among those with heightened performance anxiety. This emotional response may stem from the perceived pressure to provide correct or impressive answers in a public or semi-public setting, even if their identities are concealed. These individuals may feel heightened scrutiny or judgement, leading to increased stress and potentially compromising their learning experience.

However, you might get a little anxious when you use these devices because you never know if your answer can be seen by others and lecturers. ARS are nice, but there is also some anxiety with using them. (Participant 9—Man)

## DISCUSSIONS

This is the first study that explored the experience of ARS in a cohort of training physiotherapists. From what was retrieved from the interviews, ARS succeeded in generating improvements in attendance, attention, participation, engagement, and interaction, stimulating discussion with very positive repercussions in both the student learning process and the lecturer’s teaching activities. By ensuring higher-order thinking, engagement, and collaboration, ARS can be considered a valuable instrument to promote an active-learning approach to teaching.<sup>4 34</sup> Active learning strategies facilitate learning as students build their knowledge with the lecturer rather than passively absorb it.<sup>3</sup> This approach is positively associated with students’ outcomes.<sup>3</sup>

Moreover, our interviewees reported that ARS created a ‘learning community’ as they felt part of a group. These strengths of this tool are already recognised by the literature.<sup>17 18</sup> Another fundamental element highlighted in

this study concerns the human and emotional aspects that this tool can improve by creating connections between students, the lecturer and the peers themselves. This potential is yet to be fully explored by the literature. From the interviewees’ perspective, ARS appears to increase the so-called ‘relatedness’, that is, the intrinsic need for students to feel close to significant people in their lives, including lecturers.<sup>35</sup> Relatedness can improve students’ educational experience and, subsequently, their performances. Finally, ARS allow the most reluctant and reserved students to engage with the class, creating a more inclusive learning atmosphere.

While the possible advantages of this tool are thoroughly studied, there are only a few analyses and considerations of its limitations, weaknesses and potential flaws. On top of that, these limitations are more focused on the lecturer rather than the students.<sup>36</sup> A possible pitfall reported by the interviewees was that the very usefulness of the tool is hindered when not accompanied by a subsequent reflection on the experience. The ARS can provide stimuli and feedback on the learning process to students. Nevertheless, if these stimuli and feedback are not internalised and discussed, they remain useless and unproductive. A moment of insight and explanation following the experience is deemed to be necessary by our interviewees. This process is called ‘reflection-on-action’,<sup>37</sup> which focusses on what emerged as significant during learners’ experience from their point of view. This moment allows for taking a step back and returning to the experience with a reflective and critical attitude, leading to awareness and thorough knowledge.<sup>38 39</sup>

Not only should a lecturer consider the plurality of advantages and disadvantages of this instrument, they should also consider all the possible threats that may come with introducing a new tool. From what we retrieved, the lecturers need to reflect on the time they have while lecturing. Overuse of this tool may result in overstretching class time, making the lesson dull and weighing down the learning experience. Considering the time lecturers have, they need to consider that ARS are active learning moments and a whole part of the lesson. The lecturer should not consider these moments as break time, even if they are fun and engaging. Some literature emphasises the importance of taking class breaks to relax and recharge.<sup>40</sup> Breaks are essential to achieving productivity,<sup>40</sup> above all for students who spend hours huddled in front of a computer in distance learning. Not taking regular breaks can significantly reduce academic performance and, in some cases, serious health problems such as anxiety, insomnia and depression.<sup>41</sup> Another dynamic that can undermine ARS users’ experience is the choice of topics and how and when these tools are implemented. They are reported as pointless if they are constructed with long, complex and specific questions or without carefully choosing the topics.

This work also revealed that there are still some grey areas in the experience of using ARS about the didactic purposes of the instrument. These areas arose from the

plurality and difference of respondents' opinions, attitudes, preferences and learning styles. For instance, some students may have issues with this tool if they struggle with technology.<sup>42–43</sup> Students may feel frustrated if they are not familiar with this system. Some of our interviewees also reported this risk. In line with that, we might suggest investigating the class' general attitude towards technology at the beginning of the course to understand whether they would be open and enthusiastic about it. It is also possible to create some simple preliminary ARS about using this tool itself, to help students get familiar with this system.

Moreover, this study reported conflicting results on whether this tool could promote the acquisition and memorisation of notions or with higher educational objectives such as promoting clinical reasoning or supporting problem-solving. This uncertainty lies in the fact that teaching is a complex practice and each student has unique preferences and characteristics.<sup>44</sup> Therefore, while some consider this valuable tool for the simple memorisation of concepts without considering it advantageous to support higher reasoning, other students preferred it to guide clinical reasoning and not for memorising ideas. Therefore, lecturers should frequently vary the parameters and purposes of using this tool to meet and satisfy the preferences of each part of the class, meeting the plurality of students' characteristics.<sup>44</sup> Underlying this caution is the theory of 'Personalisation' of learning content for individual students. Students have and adopt different methods of learning.<sup>44</sup> Diversifying teaching methods, varying meaning-making activities and possible approaches will facilitate our students' learning process.

This study has different limitations and strengths that need to be acknowledged. As per the limitations, this study focused on postgraduate physiotherapy students in RMD rehabilitation, reducing the transferability of our results. However, it is worth noting that the characteristics of ARS reported by the interviewees may have applicability beyond the specific field of study. Another limitation is the homogeneous demographic composition of the participants, consisting solely of white men and women working in the private healthcare sector in Italy. This is significant because cultural elements such as gender, ethnicity, living area, and work background can influence educational perceptions and experiences.<sup>45–47</sup> Therefore, caution must be exercised once extending the results to other populations. Future studies should employ alternative research designs, such as quantitative surveys or mixed-method approaches, to generalise the findings more effectively. In addition, during the initial phase, we primarily included students who were perceived to be highly engaged in the learning process, aiming at increasing the chances of instrument usage. Subsequently, we broadened the invitation to the entire class group. Nevertheless, it remains uncertain whether we successfully included or inadvertently excluded the more reserved students. However, we observed that

the interviewed students reported that the tool can be helpful in increasing interaction among reserved or reluctant students. Therefore, it should be investigated whether these specific students agree with this observed perspective.

On the other hand, this study has different strengths. First, it thoroughly analysed the user experience of ARS tools in physiotherapy training, providing valuable insights into the practical application of ARS in the context of physiotherapy. Moreover, the study specifically explored the use of ARS in RMD training, an area of significant importance within the Italian and Mediterranean contexts.<sup>48</sup> Given the higher educational needs of healthcare professionals working with RMD in Mediterranean countries compared with those in Northern Europe, it becomes necessary to develop new strategies to enhance the learning quality in these regions. Another strength lies in the study's focus on addressing the experience of ARS in both knowledge acquisition and practical skill learning. This comprehensive approach contributes to a more holistic understanding of the potential benefits and challenges associated with implementing ARS in physiotherapy education. Additionally, while the existing literature predominantly emphasises the positive aspects of ARS implementation, this study sheds some light on the limitations and negative aspects of this tool, offering a more balanced perspective on its efficacy and usability.

In conclusion, the analysis of the experience with ARS suggests that they can serve as effective strategies to enhance student concentration, improve focus, and provide valuable feedback to lecturers on their teaching effectiveness and student learning. However, it is essential to recognise that ARS may not be as suitable for teaching clinical and practical skills essential for professionals in rehabilitation. ARS have their strengths and weaknesses. Therefore, lecturers should strive to integrate ARS into a multimodal teaching paradigm that encompasses various learning experiences, catering to the diverse needs of a wide range of students.

**Twitter** Gianluca Bertoni @GianlucaBerto88 and Simone Battista @SimoneBattista\_

**Acknowledgements** This work was developed within the DINOGMI Department of Excellence framework of MIUR 2018–2022 (Legge 232 del 2016).

**Contributors** GB made substantial contributions to the conception or design of the work, the acquisition, analysis and interpretation of data. GB drafted the work or revised it critically for important intellectual content. GB approved the version to be published. GB agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. EM made substantial contributions to the conception or design of the work, the acquisition, analysis and interpretation of data. EM drafted the work or revised it critically for important intellectual content. EM approved the version to be published. EM agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. FEZ made substantial contributions to the conception or design of the work, the acquisition, analysis and interpretation of data. FEZ drafted the work or revised it critically for important intellectual content. FEZ approved the version to be published. FEZ agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. MC made substantial contributions to the conception or design of the work, the acquisition, analysis and interpretation of data. MC drafted



the work or revised it critically for important intellectual content. MC approved the version to be published. MC agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. MT made substantial contributions to the conception or design of the work, the acquisition, analysis and interpretation of data. MT drafted the work or revised it critically for important intellectual content. MT approved the version to be published. MT agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. MT is the guarantor. SB made substantial contributions to the conception or design of the work, the acquisition, analysis and interpretation of data. SB drafted the work or revised it critically for important intellectual content. SB approved the version to be published. SB agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

**Funding** The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

**Competing interests** None declared.

**Patient and public involvement** Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

**Patient consent for publication** Not applicable.

**Ethics approval** This study involves human participants and ethical approval was obtained from the Ethics Committee for University Research (CERA: Comitato Etico per la Ricerca di Ateneo), University of Genova (approval date: 18 January 2022; CERA2022.06). Participants gave informed consent to participate in the study before taking part.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** All data relevant to the study are included in the article or uploaded as supplementary information. Not Applicable.

**Supplemental material** This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

**Open access** This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>.

## ORCID iDs

Gianluca Bertoni <http://orcid.org/0000-0002-1223-5048>

Marco Testa <http://orcid.org/0000-0001-8643-7200>

Simone Battista <http://orcid.org/0000-0002-7471-1951>

## REFERENCES

- Derek B. Teaching with classroom response systems: creating active learning environments [Jossey-Bass]. 2009. Available: [https://books.google.com/books/about/Teaching\\_with\\_Classroom\\_Response\\_Systems.html?hl=it&id=1vXz3P-oF88C](https://books.google.com/books/about/Teaching_with_Classroom_Response_Systems.html?hl=it&id=1vXz3P-oF88C) [Accessed 29 Jan 2022].
- MacArthur JR, Jones LL. A review of literature reports of Clickers applicable to college chemistry classrooms. *CHEM EDUC RES PRACT* 2008;9:187–95.
- Dolan EL, Collins JP. We must teach more effectively: here are four ways to get started. *Mol Biol Cell* 2015;26:2151–5.
- Freeman S, Eddy SL, McDonough M, et al. Active learning increases student performance in science, engineering, and mathematics. *Proc Natl Acad Sci U S A* 2014;111:8410–5.
- Dversdal RK, Gold JA, Richards MH, et al. A 5-day intensive curriculum for interns utilizing simulation and active-learning techniques: addressing domains important across internal medicine practice. *BMC Res Notes* 2018;11:916.
- Melo Prado H, Hannonis Falbo G, Rodrigues Falbo A, et al. Active learning on the ward: outcomes from a comparative trial with traditional methods. *Med Educ* 2011;45:273–9.
- Kay RH, LeSage A. Examining the benefits and challenges of using audience response systems: A review of the literature. *Computers & Education* 2009;53:819–27.
- Abrahamson L. A brief history of Networked classrooms: effects, cases, Pedagogy, and implications. *Audience Response Systems in Higher Education: Applications and Cases* 2006.
- Kocak O. A systematic literature review of web-based student response systems: advantages and challenges. *Educ Inf Technol* 2022;27:2771–805.
- Latessa R, Mouw D. Use of an audience response system to augment interactive learning. *Fam Med* 2005;37:12–4.
- Caldwell JE. Clickers in the large classroom: Current research and best-practice tips. *CBE Life Sci Educ* 2007;6:9–20.
- Kennedy GE, Cutts QL. The association between students' use of an electronic voting system and their learning outcomes. *J Comput Assist Learn* 2005;21:260–8.
- Beckert T, Fauth E, Olsen K. Clicker satisfaction for students in human development: differences for class type, prior exposure, and student Talkativity. *N Am J Psychol* 2009;11:599–612.
- Schackow TE, Chavez M, Loya L, et al. Audience response system: effect on learning in family medicine residents. *Fam Med* 2004;36:496–504.
- Stowell JR, Nelson JM. Benefits of electronic audience response systems on student participation, learning, and emotion. *Teaching of Psychology* 2007;34:253–8.
- Abdulla MH. The use of an online student response system to support learning of physiology during lectures to medical students. *Educ Inf Technol* 2018;23:2931–46.
- Benson JD, Szucs KA, Deluliis ED, et al. Impact of student response systems on initial learning and retention of course content in health sciences students. *J Allied Health* 2017;46:158–63.
- Preszler RW, Dawe A, Shuster CB, et al. Assessment of the effects of student response systems on student learning and attitudes over a broad range of biology courses. *CBE Life Sci Educ* 2007;6:29–41.
- Wood R, Shirazi S. A systematic review of audience response systems for teaching and learning in higher education: the student experience. *Computers & Education* 2020;153:103896.
- Leahy E, Chipchase L, Blackstock F. Which learning activities enhance Physiotherapy practice? A systematic review protocol of quantitative and qualitative studies. *Syst Rev* 2017;6:83.
- Kamper SJ, Moseley AM, Herbert RD, et al. 15 years of tracking Physiotherapy evidence on Pedro, where are we now *Br J Sports Med* 2015;49:907–9.
- Moser A, Korstjens I. Series: practical guidance to qualitative research. part 1: introduction. *Eur J Gen Pract* 2017;23:271–3.
- 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;19:349–57.
- IFOMPT. The global leader in OMPT excellence. Available: <https://www.ifompt.org> [Accessed 28 Nov 2022].
- Campbell S, Greenwood M, Prior S, et al. Purposive sampling: complex or simple? research case examples. *J Res Nurs* 2020;25:652–61.
- Atlantis E, Cheema BS. Effect of audience response system technology on learning outcomes in health students and professionals: an updated systematic review. *Pathology* 2015;13:3–8.
- Nelson C, Hartling L, Campbell S, et al. The effects of audience response systems on learning outcomes in health professions education. *Medical Teacher* 2012;34:e386–405.
- Braun V, Clarke V. Thematic analysis: A practical guide. *SAGE Open Med* 2021. Available: <https://uk.sagepub.com/en-gb/eur/thematic-analysis/book248481>
- Braun V, Clarke V. Should I not use TA? comparing Reflexive thematic analysis and other pattern-based qualitative analytic approaches. *Couns Psychother Res* 2021;21:37–47.
- Braun V, Clarke V. Is thematic analysis used well in health psychology? A critical review of published research, with recommendations for quality practice and reporting. *Health Psychol Rev* 2023;1–24.
- Braun V, Clarke V. Thematic analysis: A practical guide. SAGE Publications; 2021. Available: <https://books.google.se/books?id=mToqEAAQBAJ>
- Braun V, Clarke V. To saturate or not to saturate? questioning data saturation as a useful concept for thematic analysis and sample-size Rationales. *Qual Res Sport Exerc Health* 2019;13:201–16.
- Byrne D. A worked example of Braun and Clarke's approach to Reflexive thematic analysis. *Qual Quant* 2022;56:1391–412.



- 34 McCoy L, Pettit RK, Lewis JH, *et al.* Evaluating medical student engagement during virtual patient simulations: a sequential, mixed methods study. *BMC Med Educ* 2016;16:20.
- 35 Guay F, Stupnisky R, Boivin M, *et al.* Teachers' relatedness with students as a Predictor of students' intrinsic motivation, self-concept, and reading achievement. *Early Childhood Research Quarterly* 2019;48:215–25.
- 36 Teri S, Acai A, Griffith D, *et al.* Student use and pedagogical impact of a mobile learning application. *Biochem Mol Biol Educ* 2014;42:121–35.
- 37 Schon D. *Educating the reflective practitioner: towards a new design for teaching and learning in the profession*. San Francisco: Jossey-Vass, 1987.
- 38 Munby H. Reflection-in-action and reflection-on-action. *Eac* 1989;9:31–42.
- 39 Botelho M, Bhuyan SY. Reflection before and after clinical practice-enhancing and broadening experience through Self-, Peer- and teacher-guided learning. *Eur J Dent Educ* 2021;25:480–7.
- 40 Bunce DM, Flens EA, Neiles KY. How long can students pay attention in class? A study of student attention decline using Clickers. *J Chem Educ* 2010;87:1438–43.
- 41 Medic G, Wille M, Hemels ME. Short- and long-term health consequences of sleep disruption. *Nat Sci Sleep* 2017;9:151–61.
- 42 Draper SW, Brown MI. Increasing Interactivity in lectures using an electronic voting system. *J Comput Assist Learn* 2004;20:81–94.
- 43 Stuart SAJ, Brown MI, Draper SW. Using an electronic voting system in logic lectures: one practitioner's application. *J Comput Assist Learn* 2004;20:95–102.
- 44 Priniski SJ, Hecht CA, Harackiewicz JM. Making learning personally meaningful: A new framework for relevance research. *J Exp Educ* 2018;86:11–29.
- 45 Battista S, Furri L, Pellegrini V, *et al.* Which lecturers' characteristics facilitate the learning process? A qualitative study on students' perceptions in the rehabilitation sciences. *BMC Med Educ* 2023;23:431:431..
- 46 Seeleman C, Suurmond J, Stronks K. Cultural competence: a conceptual framework for teaching and learning. *Med Educ* 2009;43:229–37.
- 47 Bailey LE, Graves K. Gender and education. *Review of Research in Education* 2016;40:682–722.
- 48 Vliet Vlieland TPM, van den Ende CHM, Alliot-Launois F, *et al.* Educational needs of health professionals working in rheumatology in Europe. *RMD Open* 2016;2:e000337.