JOMES
journal of mixed methods studies

Issue 13, 2026
Journal of Mixed Methods Studies / JOMES

Enhancing Doctor of Physical Therapy Pain Neuroscience Education Through Telehealth Simulation: A Mixed-Methods Approach

Shannon Logan Emilio J Puentedura Adriaan Louw Melissa Moran Tovin

To cite this article:

Logan, S., Puentedura, E.J., Louw, A., & Moran Tovin, M. (2026). Enhancing doctor of physical therapy pain neuroscience education through telehealth simulation: A mixed-methods approach. *Journal of Mixed Methods Studies*, *Vol (13)*, 1-22. https://doi.org/10.59455/jomes.74

Article Info: *Received*: 23 December 2025 *Revised*: 1 January April 2026 *Accepted*: 14 April 2026

Abstract

Although diverse pedagogical approaches are encouraged in physical therapy education, lectures remain the primary method for teaching modern pain science. The purpose of this study was to examine changes in knowledge, attitudes, beliefs, and clinical recommendations regarding chronic low back pain (CLBP) among entry-level Doctor of Physical Therapy (DPT) students after a pain neuroscience education (PNE) telehealth simulation. A mixed-methods QUAN-qual explanatory sequential design was used. One hundred fifteen students completed quantitative measures, and 32 participated in semi-structured focus groups. Pre- and post-simulation, students completed the Revised Neurophysiology of Pain Questionnaire (RNPQ), Healthcare Providers' Pain and Impairments Relationship Scale (HC-PAIRS), and a clinical vignette. The Simulation Effectiveness Tool-Modified (SET-M) was administered post-simulation. Results demonstrated small but significant improvements in RNPQ, HC-PAIRS, and vignette scores, although effect sizes were modest. Weak positive correlations were found between RNPQ and HC-PAIRS (r = .155) and vignette scores (r = .199). The median SET-M score was 54. Qualitative analysis identified four themes: (1) safe but realistic experience, (2) learning through discomfort, (3) validation of patient pain, and (4) value of metaphors and analogies. Findings support the integration of experiential methods, such as simulation, into pain science education.

Keywords: *Simulation; physical therapy; mixed methods; pain neuroscience*

Introduction

Clinicians use PNE to help patients shift their perspective from a purely biomedical view of pain to a more comprehensive biopsychosocial one. Rather than viewing pain as a sign of "tissue damage," PNE reframes pain as a perceived threat or the body's way of signaling the need for protection (Louw et al., 2016; Moseley & Butler, 2015). Multiple studies show that PNE improves outcomes for individuals with chronic musculoskeletal (MSK) and CLBP (Marris et al., 2021; Puentedura & Flynn, 2016; Tegner et al., 2018). Based on the evidence supporting PNE, this approach should be integrated into professional-level education including physical therapy, which is one of the most commonly prescribed interventions for chronic pain (Yong et al., 2022).

Difficulties are experienced by practicing physical therapists in managing chronic MSK pain and implementing clinical practice guidelines (CPG) for CLBP, which includes PNE (Foster et al., 2018; George et al., 2021). Physical therapists often demonstrate a more biomedical than biopsychosocial attitude and belief system, which can weaken the therapeutic alliance and fails to align with clinical practice guidelines CPG for CLBP, including recommendations for facilitating return to work utilizing PNE (George et al., 2021; Houben et al., 2005). Additionally, physical therapy students struggle to provide recommendations aligned with CPG for activity and return to work relating to CLPB (Leysen et al., 2021). Therefore, attitudes and beliefs play a

critical role in treatment selection aligned with CPGs for CLBP and should be explored when using PNE. Growing evidence supports PNE as an essential intervention for CLBP, as it can positively influence patients' attitudes and beliefs underscoring the importance of incorporating pain science education into entry-level Doctor of Physical Therapy (DPT) curricula (Foster et al., 2018).

Findings from a published study that examined the views of practicing physical therapists indicate strong agreement and recognition for the importance of including PNE in DPT curricula (Louw et al., 2017). Moreover, the International Association for the Study of Pain (IASP) and the Academy of Orthopedic Physical Therapy (AOPT) have updated curricular recommendations for pain education (IASP, 2024; Shepherd et al., 2021). Despite the recommendations for PNE in education and practice, there is significant evidence that modern pain science content continues to be limited in entry-level DPT curricula (Ehrström et al., 2018; Hoeger Bement et al., 2015). Research involving PNE in DPT education often involves lectures ranging from 45 minutes to 26 hours (Adillón et al., 2015; Alodaibi et al., 2018; Colleary et al., 2017; Cox et al., 2017; Mankelow et al., 2020).

Education theory and best practice support the use of active learning over traditional lectures, such as simulation, a form of experiential learning (Collins et al., 2021). A simulation is an educational technique that replicates real-world scenarios or environments to provide learners with hands-on learning opportunities (Pritchard et al., 2016). Simulations aim to mimic the complexity of actual situations, allowing participants to practice skills, make decisions, and solve problems in a controlled, safe, and interactive setting (Pritchard et al., 2016). In simulations, students absorb the presented knowledge and demonstrate improved clinical decision-making (Mori et al., 2015). Recently, educators have effectively implemented simulation activities in physical therapy curricula to augment the learning experience (Mori et al., 2015). Experiential learning through simulations can improve clinical decision-making skills, confidence, and overall potential to thrive in clinical experiences while promoting reflection on practice (Macauley, 2018; Smith & Crocker, 2017).

Kolb's experiential learning theory (ELT) is a frequently used approach in simulation. Knowledge results from the combination of grasping and transforming an experience (Kolb, 1984). Gaining knowledge involves both grasping and transforming an experience. The process includes four phases: concrete experience, reflective observation, abstract conceptualization, and active experimentation (Kolb, 1984; Zigmont et al., 2011). Simulation offers a concrete learning experience, followed by reflective observation during debriefing, where learners and educators analyze both individual and group performance. This reflection supports the development of clinical reasoning and may foster changes in attitudes and beliefs (Poore et al., 2014). Learners then engage in abstract conceptualization and active experimentation, using insights gained to generate new ideas and apply their learning to future clinical encounters (Poore et al., 2014; Smith & Crocker, 2017).

When applied in DPT curricula, ELT allows students to practice in a practical or "real-world" setting (Smith & Crocker, 2017). Basing activities on ELT allows educators in DPT programs to enhance student engagement, knowledge, and application. Through these experiences, students have shown increased confidence, self-efficacy, critical thinking, communication skills, promotion of reflection, and exposure to clinical situations (Lowe et al., 2022; Smith & Crocker, 2017).

A practical example of where ELT can guide simulation is via virtual telehealth experiences. The recent COVID-19 pandemic response resulted in restrictions on access to traditional in-person healthcare and, consequently, allowed for an exponential increase in the adoption of telehealth (Bettger et al., 2020). Synchronous telehealth has shown comparable effectiveness and improvements in pain, physical function, and disability in individuals with osteoarthritis and nonspecific low back pain (Cottrell et al., 2017; Dario et al., 2017). Further, PNE has successfully enhanced pain neurophysiology knowledge and shifted attitudes across various healthcare disciplines within the Department of Veterans Healthcare Administration when delivered via live-streaming (Louw et al., 2019). Thus, PNE can be effectively implemented through technology, rather than solely face-to-face, offering a potential telehealth experience in the classroom. However, telehealth education remains insufficient among healthcare providers (Bettger et al., 2020; Fergus

et al., 2021). To address this gap, curricula should incorporate telehealth to enhance students' skills and provide hands-on experience before they enter clinical practice.

There is a need to identify optimal and practical pedagogical approaches for incorporating pain science education in DPT curricula to align with current pain science competencies, recommendations, and clinical guidelines (Shepherd et al., 2021). Understanding students' personal experiences during this specific pedagogical approach to PNE supports a mixed-methods design.

Mixed Methods Research

Learning is a multifaceted process that occurs across varied contexts and through diverse approaches (National Academies of Sciences, Engineering, 2018). It does not progress in a strictly linear manner based on knowledge acquisition or memory alone, but instead develops through the interaction of multiple processes over time (National Academies of Sciences, Engineering, 2018). Certain learning experiences emphasize deliberate reflection, enabling learners to interpret new knowledge and integrate it into future practice (Kolb, 1984). Given the complexity of this reflective and applied learning process, objective measurement alone is insufficient. Accordingly, a mixed-methods design was deemed most appropriate for the present study.

Mixed-methods research incorporates both quantitative and qualitative approaches to data collection and analysis, offering a more comprehensive understanding of a phenomenon than reliance on a single method (Almeida et al., 2017; Carter et al., 2014; Kajamaa et al., 2020). A defining characteristic of mixed-methods research is integration, which may occur at one or more stages of the study and leverages the complementary strengths of both methodological traditions (Almeida et al., 2017). Such integration facilitates triangulation of findings, thereby producing a more robust and holistic perspective.

By exploring the change in knowledge, attitudes, beliefs, and behavior from a quantitative perspective, educators gain further data to support the benefits of simulation as a pedagogical approach to pain science education in the curricula. Qualitative analysis will result in a deeper understanding and holistic perspective of students' educational experience in the simulation and their attitudes and beliefs about PNE as a clinical approach. The purpose of this study is to explore changes in knowledge, attitudes, beliefs, behaviors, and experiences of physical therapy students who participate in a PNE telehealth simulation.

Research Questions

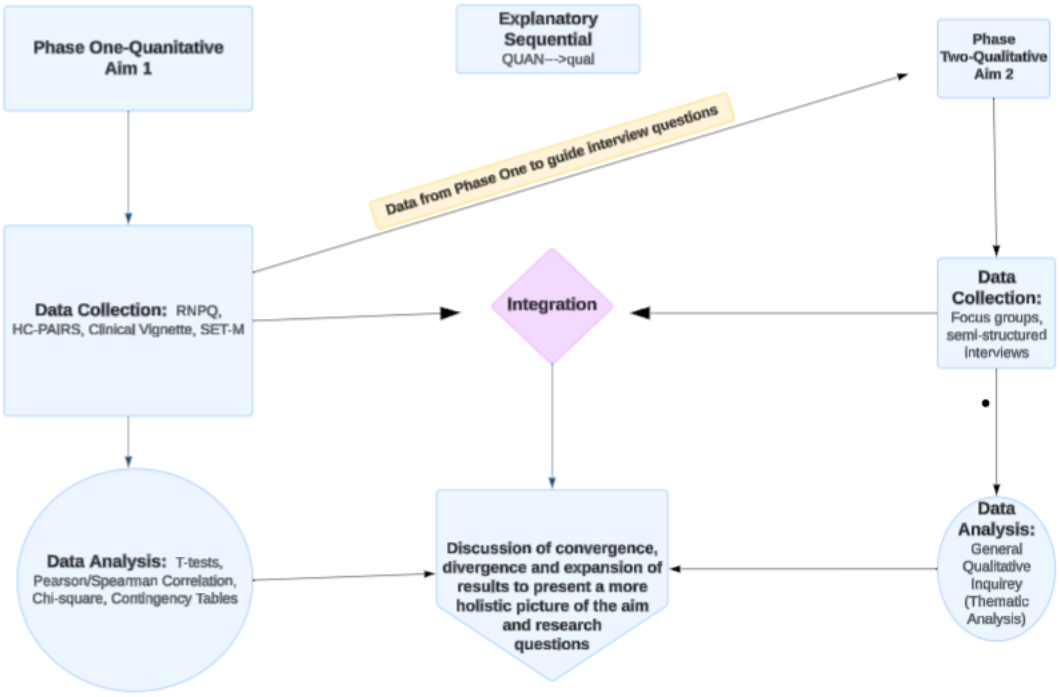
1. Is there a change in knowledge, attitudes and beliefs and clinical recommendations pre- and post-telehealth simulation in PNE for CLBP?
2. What is the perceived effectiveness of the simulation?
3. Is there a correlation between any outcome variables pre- and post-telehealth simulation in PNE for CLBP?
4. What is the experience of students while participating in a PNE-specific telehealth simulation activity for CLBP?

Method

Study Design

This study utilized an explanatory sequential Quantitative→qualitative (QUAN→qual) mixed-methods design. This study followed Mixed Methods Reporting Standards for Health Sciences (MMR-RHS) (Tovin & Wormley, 2023). This design includes two distinct phases: Phase 1 consists of quantitative methods, and Phase 2 consists of qualitative methods. The methods were integrated at two points. First, findings from Phase 1 data collection and analysis informed the semi-structured interview questions (see Figure 1).

Figure 1
Mixed-Methods Design



Phase 2 data collection and analysis enabled integration of findings from both phases, allowing for comparison and interrelation through integration. This mixed-methods approach included a discussion of convergence and expansion (Aarons et al., 2012; Cresswell et al., 2018). Trustworthiness and rigor were established by addressing credibility, dependability, confirmability, and transferability (Lincoln & Guba, 1985) (see Table 1).

Table 1
Specific Actions for Rigor/Trustworthiness

Component	Actions
Credibility	rticipation review/member checking ot testing
Transferability	1. Demographics provided 2. Thick and descriptive findings with interpretation
Dependability	1. Audit Trail/Use of Consolidate Criteria for Reporting Qualitative Research (COREQ)
Confirmability	1. Audit trail 2. Raw data 3. Reflexive journaling and field notes 4. Data integration 5. Data reconstruction/process and synthesis working with committee member

Sampling and Recruitment

Participants were recruited through purposive convenience sampling from the final MSK course of an entry-level DPT program, completed during the last term of didactic work immediately preceding their terminal clinical experiences. The curriculum incorporated PNE concepts, which were scaffolded throughout various courses and primarily delivered through lectures. The curriculum did not include a standalone pain science course or fully align with IASP curricular guidelines, leading to some variation in the delivery of these concepts. The study included three separate campuses of a mid-sized, private, for-profit university in the United States. A total of 161 students were eligible. All participants completed the informed consent before participating in the study to screen for inclusion and exclusion criteria, consent for data release, and willingness to be randomly selected for focus group interviews one week after the simulation. Inclusion criteria included current enrollment in the specified course and completion of the simulation. Participants who provided consent to be contacted for potential follow-up qualitative interviews were also included. In contrast, exclusion criteria consisted of a self-reported history of specific and formal PNE training outside of the curriculum, including continuing education (CE), and any student unwilling to sign the informed consent. Each participant was assigned a unique identifying number to ensure confidentiality.

Phase 1: Quantitative Data Collection

Researchers originally developed the Neurophysiology of Pain Questionnaire (NPQ) to assess a person's understanding of the biological mechanisms behind their pain. The NPQ comprises 19 closed-ended questions answered as true, false, or undecided. Correct responses are awarded one point, and incorrect (or undecided) responses are awarded zero points. Scores can range from 0 to 19, with higher scores indicating greater pain neurophysiology knowledge. The original NPQ is a valid and reliable measurement for health care professionals, patients, and physical therapy students with a Pearson Separation Index of .84 and an acceptable test-retest reliability of 0.97 (G. L. Moseley, 2004; L. Moseley, 2003). Subsequently, the 12-item RNPQ was developed after Rasch Analysis and has been deemed reliable and valid with good test-retest reliability of .989 in patients with chronic spine pain (Catley et al., 2013).

The original HC-PAIRS is an outcome measure used to explore the relationship between healthcare providers' attitudes and beliefs and the relationship between CLBP and impairment. The questionnaire comprises 15 items using a 7-point Likert rating scale ('Completely disagree' = 1 to 'Completely agree' = 7). Scores can range from 7 to 105, with lower scores suggesting positive beliefs and attitudes that pain complaints do not justify impairment or disability. The original HC-PAIRS Cronbach's alpha was 0.78, with good validity relating to work and activity recommendations (Rainville et al., 1995).

The original Simulation Effectiveness Tool (SET) consisted of 19 items using a 3-point Likert scale with 3 = strong agree and 1 = do not agree (Cordi et al., 2012). A modified version, SET-M, was developed to align with current simulation standards. It includes 13 items and additional components that assess pre-briefing, learning, confidence, and debriefing, all using the same 3-point Likert scale. A higher calculated score typically indicates a more positive evaluation of the simulation experience. The intraclass correlation coefficient (ICC) is 0.833 for pre-briefing, 0.852 for learning, 0.913 for confidence, and 0.908 for debriefing indicating good to excellent reliability. Further, the SET-M demonstrates construct validity and a similar factor structure to the original SET after modifications (Leighton et al., 2015).

A case vignette relating to CLBP was utilized to examine participant behavior or clinical recommendations. The vignette and questions were adapted from previous studies (Bishop et al., 2008; Maguire, N., Chesterton, & Ryan, 2019). The participants answered four multiple-choice questions based on the case information. Participants were instructed to provide recommendations regarding usual daily activities, work, exercise, and bed rest based on the case information. The percentage of recommendations consistent with clinical guidelines was recorded, with higher scores indicating better alignment with best practices.

Phase 2: Qualitative Data Collection

A pilot study of the simulation explored the feasibility of the simulation, reliability of semi-structured interview questions and execution of focus group interviews by SL (Logan, 2024). The reliability of the interview data was supported by audio-recording all focus group sessions using a Sony ICD-PX370 Mono Digital Voice Recorder with built-in USB, followed by verbatim transcription.

Sample Size

An a priori power analysis using G*Power 3.1 was conducted to estimate the required sample size for the quantitative arm. Analysis was calculated using a conventional Cohen's d effect size of 0.5 (moderate), power of 0.80, and alpha of 0.05 for an independent t-test. To account for a 25% exclusion or missing data rate, the final estimated sample size was 50 participants. The qualitative sample size was guided by the principle of data saturation, with estimates suggesting that 90-94% saturation could be achieved within three to six focus groups sufficient to capture the most prevalent themes without the emergence of novel information (Guest et al., 2017; Hennink et al., 2019). Between five to eight participants were included in each focus group.

Procedures

An electronic survey was embedded into the course learning management system, in which the primary investigator was not a lead instructor. The baseline survey was completed in week one, before engaging in the course's didactic content and designed simulation preparatory activities. The survey included demographics, RNPQ, HC-PAIRS, and the clinical vignette. During the required course lab session, participants engaged in a one-hour simulation with a standardized patient, led by the primary author (SL) and lead lab faculty. The simulation was pilot-tested and designed according to best practice standards to achieve the specified learning objectives (Logan, 2024; Watts et al., 2021). The preparation activities before the simulation sessions included a one-hour faculty recorded video reviewing pain science and education concepts including an example of PNE delivery based on the "Why You Hurt: Pain Neuroscience System." (Louw, 2014) The main themes of this educational approach have been used in prior research and included basic PNE concepts that were included in the simulation objectives (Puentedura & Flynn, 2016; Rufa et al., 2019). Participants were required to review the video during the week of the lab activity, as it was not available for review prior to that time. They had the opportunity to revisit it until the simulation was delivered. Immediately before the simulation, the students reviewed a short pre-brief explaining learning objectives, expectations, ground rules, and content. Participants immediately completed the post-survey post simulation, which included the aforementioned, with the addition of the SET-M.

Those who indicated their willingness to participate in focus groups on informed consent were recruited via the Microsoft Excel random number generator to ensure that each participant has equal chance of being selected. The focus group lasted approximately one hour and was conducted by the primary author (SL) via password-protected Zoom 6.0 video conferencing (Zoom Video Conferencing Inc., California). Quantitative results were used to inform the semi-structured interview questions.

Quantitative Data Analysis

Data was analyzed using SPSS 26 (IBM, New York). Descriptive analysis was employed to summarize data, including demographic characteristics. Normality and assumption analysis did not follow a normal distribution, therefore nonparametric statistical tests included the Wilcoxon signed-rank test and Spearman correlation to evaluate changes in outcomes pre and post-simulation as well as correlations. Cohen's d was used to calculate effect size, with standard interpretations: small (0.2), moderate (0.5), and large (0.8). A McNemar test and contingency tables were used to analyze clinical vignette question scores pre and post simulation. Significance levels were set at alpha = 0.05.

Qualitative Data Analysis

Qualitative data was managed through NVivo 12 software (QSR International, Melbourne, Australia). Qualitative content analysis (QCA) was conducted by the primary investigator, SL, based on the methods described by Creswell while utilizing in-vivo coding. In-vivo coding emphasizes the participants' actual spoken words and highlights their voices, giving meaning to the data (Saldana, 2021; Schreier, 2012). A co-author (MT), considered an expert in qualitative research and education, reviewed qualitative data analysis and theme development. In the analysis phase an iterative and constant comparison process, open coding, grouping, categorizing, and generating themes (Saldana, 2021). Saturation was achieved when no new novel information was gathered and illustrative quotes were identified, replacing participants' names with pseudonyms.

Results

Quantitative

Out of 161 eligible participants, 115 (71.42%) were eligible via the informed consent and included in the study, while a subset of 32 participants completed the focus group interviews. Table 2 displays the demographic characteristics for both the quantitative and qualitative data sets.

Table 2
Demographics

Quantitative		
Campus		
Campus 1	36	31.3
Campus 2	33	28.7
Campus 3	46	40.0
Gender		
Female	68	59.1
Male	47	40.9
Type of Program delivery		
Blended	14	12.2
Traditional	101	87.8
Age – Mean (Standard Deviation)	26.9(3.30)	
Licenses or Certification		
CSCS	2	1.7
PTA	2	1.7
Dietician	0	0
EMT	1	.86
Athletic Trainer	2	1.7
Other	16	13.9
Qualitative		
Participants	32	
Age-Mean (Standard Deviation)	27.84(±4.39)	
Licenses or Certification		
CSCS	2	
PTA	2	
Other	2	

Note. CSCS, Certified Strength and Conditioning Specialist; PTA, Physical Therapy Assistant; EMT, Emergency Medical Technician

Participating in a PNE simulation led to statistically significant changes in attitudes and beliefs, as measured by the HC-PAIRS ($z = -4.981$, $p < .001$), though the effect size was small (ES = 0.328). Similarly, the RNPQ showed a significant pre-test to post-test difference ($z = -4.844$, $p < .001$) with a small effect size (ES = 0.319). Clinical vignette scores also varied significantly between the two periods ($z = -2.461$, $p = .014$), but the effect size remained small (ES = 0.162). While these findings indicate meaningful change, the modest effect sizes suggest the overall impact was limited. Scores on the SET-M were considered high, with a median score of 54 +/- 6.477 (see Table 3).

Table 3
Wilcoxon Signed Rank Outcome Analysis

	Pre		Post		Mean ranks			
Outcome	**Median**	**IQR**	**Median**	**IQR**	**Positive**	**Negative**	**Z**	**p**
Attitudes and Beliefs	59	12	53	16	52.95	58.34	-4.981	< .001
Knowledge of Pain Neurophysiology	5	2	6	2	41.25	35.44	-4.844	< .001
Clinical vignette scores	4	3	6	3	40.46	47.46	-2.461	.014

Note. IQR = Inter-Quartile Range

The RNPQ and HC-PAIRS had a weak positive and significant correlation, $r(228) = .155$, $p = .019$. The correlation between the RNPQ and clinical vignette was significant and positive at $r(228) = .199$, $p = .03$. The SET-M had no significant correlation with the other variables. There was a significant difference in overall clinical vignette scores between the two periods ($z = -2.461$, $p = .014$). A contingency table was used to compare the pre- and post-survey periods regarding correct recommendations for individual questions (see Table 4).

Table 4
Correlations

	1	**2**	**3**	**4**
1. HC-PAIRS				
2. RNPQ	.155*			
3. Clinical Vignette	-.099	.199*		
4. SET-M	.100	.151	-.014	

Note. * significant at the .05 level

Most appropriate recommendations improved or remained stable after the simulation. Two recommendations showed minimal decline (<2%): correct answers for 'Limit all activity until the pain disappeared' decreased by 1.7%, and 'Refrain from participation until the pain improves' declined by 0.9% (see Table 5). However, the recommendation to "Perform only pain-free activities" showed a notable improvement from 56.6% pre-simulation to 67.8% post-simulation, which was statistically significant ($p = .035$). Additionally, the recommendation to "Rest in bed until pain improves substantially" increased from 84.3% to 93.0%, with the change also being statistically significant ($p = .041$).

Table 5
Clinical Vignette Contingency Table

Question	Pre(%)	Post(%)	p
Return to normal work	42(36.5)	42 (36.5)	1.00
Return to part-time or light duties	112 (97.4)	112 (79.0)	1.000
Be off work until pain has improved	88(76.5)	91(79)	.720
Be off work until pain has completely disappeared	113 (98.3)	114 (99.1)	1.000
Be off work for a further 2 weeks	96 (83.5)	97 (84.3)	1.000
Refrain from participating for a further 2 weeks	108 (93.9)	107 (93.0)	1.000
Refrain from participating until pain has improved	83 (72.2)	82 (71.3)	1.000
Refrain from participating in exercises until pain has completely disappeared	111 (96.5)	112 (97.4)	1.000
Return to normal exercises routine	18 (15.7)	22 (19.1)	.523
Return to light class participation	92 (80.0)	97 (84.3)	.458
Perform Usual Activities	22 (19.1)	27 (23.5)	.458
Perform activities within patient's tolerance	104(90.4)	105(91.3)	1.000
Perform only pain free activities	65(56.5)	78 (67.8)	.035*
Limit all physical activities until pain disappears	114(99.1)	112 (97.4)	.625
Avoid resting in bed entirely	19(16.5)	25 (21.1)	.327
Avoid resting in bed as much as possible	55(47.8)	67 (88.3)	.065
Rest in bed only when pain is severe	38(33.0)	42 (36.5)	.627
Rest in bed until pain improves substantially	97(84.3)	107 (93.0)	.041*
Rest in bed until pain disappears	109(94.8)	112 (97.4)	.508

Note. * significant at the .05 level

Qualitative

Four themes emerged from the data: (a) real-world but safe experience, (b) discomfort while embracing learning, (c) validation of the patient's pain experience, and (c) the value of metaphors and analogies.

Main Theme 1: Real World, But Safe
This theme highlights students' experiences with telehealth physical therapy and simulated learning related to PNE and CLBP. Many students believed the simulation offered a safe space for real-world practice. They emphasized how the simulation helped them develop communication skills and deepen their understanding of critical concepts. Participants strongly appreciated the simulation, describing the patient scenario as highly valuable. Participants reported that completing the simulation made the concepts of pain neurophysiology clearer as they gained knowledge. They also emphasized how this experience would help them in future real-world interactions with patients.

> *"...it is a safe environment." (Sally-FG 2)*
> *"So I think that's like just getting ready for that in practice, like navigating those conversations is the big thing." (Michael-FG 2)*
> *"I think just to kind of get some of those kinks out of how you want to word" (Dan-FG 2)*

"And through this experience, I feel like I actually understand pain science now." (Tim-FG 1)
"I think it was really good practice for, you know, the real world." (Michael-FG 2)

This simulation introduced many students to telehealth for the first time in the context of physical therapy and patient interactions. Students also recognized the importance of telehealth in physical therapy practice.

"...telehealth is getting more prominent" (Tim-FG 1)
"...educating them, telehealth is very valuable." (Sandra-FG 3)

Despite the benefits expressed, participants extensively discussed the challenges of telehealth. They highlighted its limitations, including communication difficulties and the impersonal nature of the interaction. Participants expressed strong emotional reactions to using telehealth, with most describing a sense of awkwardness when interacting through a screen rather than face-to-face.

"So the physical limitation of telehealth are definitely the biggest thing for me." (James-FG 3)
"It's always really hard to speak to someone and interact with them virtually versus being in person." (Kerry, FG 3)
"I didn't really like it so much because like it didn't feel very personable." (Jade-FG 2)
"Maybe at first it was initially kind of awkward just trying to talk through a screen and getting comfortable with that." (Erica-FG 3)

Main Theme 2: Discomfort While Embracing Learning
The simulation experience generally evoked strong emotions in participants. Most initially expressed negative feelings during the simulation.

"...always a little bit nervous." (Beth-FG 2)
"...nerve wracking, but it is a safe environment." (Sally-FG 2)

Yet, after their initial emotions settled, participants actively reflected on the experience and acknowledged their learning gains. Many expressed newfound confidence in educating actual patients about PNE, along with improved ability to communicate its concepts.

"...help(s) make you a lot more confident in moving forward." (Kyle-FG 3)
"I guess you don't really know until you have to do it." (Stephanie-FG 4)
"But I think in general it definitely increased my confidence and abilities to educate on chronic pain science." (Jill-FG 2)
"I think in addition to patient education, which seems like a lot of the basis on, I like being able to explain it, but there's that whole process of learning of like, OK, you can read it, you can like, say it out loud, but then being able to teach it to someone like we had learned all the information. (Tara-FG 1)

Main Theme 3: Validation of the Patient's Pain Experience
The simulation prompted a shift in participants' attitudes and beliefs. They expressed how their views on CLBP changed, emphasizing the importance of focusing on a patient's abilities rather than disabilities. Participants highlighted the need to validate a patient's pain experience and recognize the complexity of chronic pain. After interacting with the patient, this experience led them to adopt a more biopsychosocial and ability-centered perspective.

"But in terms of like, accepting it and kind of understanding it in terms of like a patient perspective, it just depends on them. But I think that what everybody else has said is, well, like their chronic pain patients have a very scientific and valid reason for their pain, and that's something that we should consider." (Jennifer-FG 1)

Main Theme 4: The Value of Metaphors and Analogies

While discussing PNE with an actual patient, participants found metaphors and analogies extremely helpful. Most emphasized their value, noting that they now have more "tools" for future patient interactions. They also highlighted the versatility of these tools and reflected on how they could have been helpful in past clinical experiences.

> *"I think the analogies are probably the most helpful because in real-life, we are explaining that to patients." (Dan-FG 2)*
> *"...it gave more tools to kind of explain it to the patients a little better." (Jill-FG 2)*
> *"I notice, like I didn't have those tools or those metaphors to tell my patients in the clinic what they were feeling." (Jennifer-FG 1)*
> *"So I kind of took the alarm system and then put it into a different analogy that related more to him and his like activities and stuff." (Tim-FG 1)*

Integration

Quantitative results revealed improved knowledge of pain neurophysiology, appropriate clinical recommendations, and a shift to a more biopsychosocial and positive attitude and belief system toward CLBP. Qualitative results indicated a greater understanding of pain science concepts among students, whereas their attitudes and beliefs shifted towards ability versus impairment and disability. Participants said the patient's pain was subjective, valid, and multifactorial, consistent with a biopsychosocial versus a biomedical perspective. Post-simulation, clinical recommendations for work, physical activity, exercise, and bed rest showed improvement. Qualitative data highlighted a shift in focus from patients' disability to their capabilities with CLBP, affirming the simulation' potential influence. High SET-M scores indicated confidence in knowledge transfer, while qualitative feedback confirmed the simulation as beneficial despite some discomfort during learning. Additionally, SET-M scores reflected self-confidence in applying knowledge to real-world contexts, and qualitative insights showed increased confidence in delivering PNE in future practice.

Integrating both sets of data expanded our understanding and provided deeper insights. Quantitative outcomes showed improvements in participants' knowledge of pain neurophysiology, along with shifts in attitudes, beliefs, and clinical recommendations. Qualitatively, this integration highlighted the significance of foundational knowledge, metaphors, and analogies.

> *"...definitely a better grasp and understanding of the concept." (Tim-FG 1)*
> *"I always found it really hard to do, but I think that just like going through this experience helps me kind of better understand, like just the new analogies that I can use and hopefully make more sense to patients." (Beth-FG 2)*
> *"....an organized place to start" (Jill-FG 2)*
> *"...those metaphors made it really easy. And just like a good place to reference back to." (Stephanie-FG 4)*
> *"...how much external factors really come into play with pain, their lifestyle or the stresses outside of that heavily influenced that it is very multifactorial." (Gretchen-FG 4)*

Tim from FG 1 further expanded on the simulation and why knowledge alone may not suffice, saying:

> *"I feel like we learned a lot about pain science in school, but I don't think I necessarily recognized their relevance of the different components of science when we were learning them."*

Quantitatively, attitudes and beliefs shifted towards a biopsychosocial perspective focused on ability, leading to more appropriate clinical recommendations. Qualitatively, Dan from FG 2 offered insight into this shift, emphasizing the focus on progress:

"...focusing more on what are you able to do more now than you were able to do yesterday?"

Qualitative data further elaborated on participants' high quantitative SET-M scores. Consistent with these scores, they reported a perceived increase in self-confidence. This boost in self-confidence extended to their communication skills and their ability to educate others about pain science concepts.

"...gave me even the confidence to be able to talk to someone so that I can be able to like verbalize better" (Kyle-FG 3)

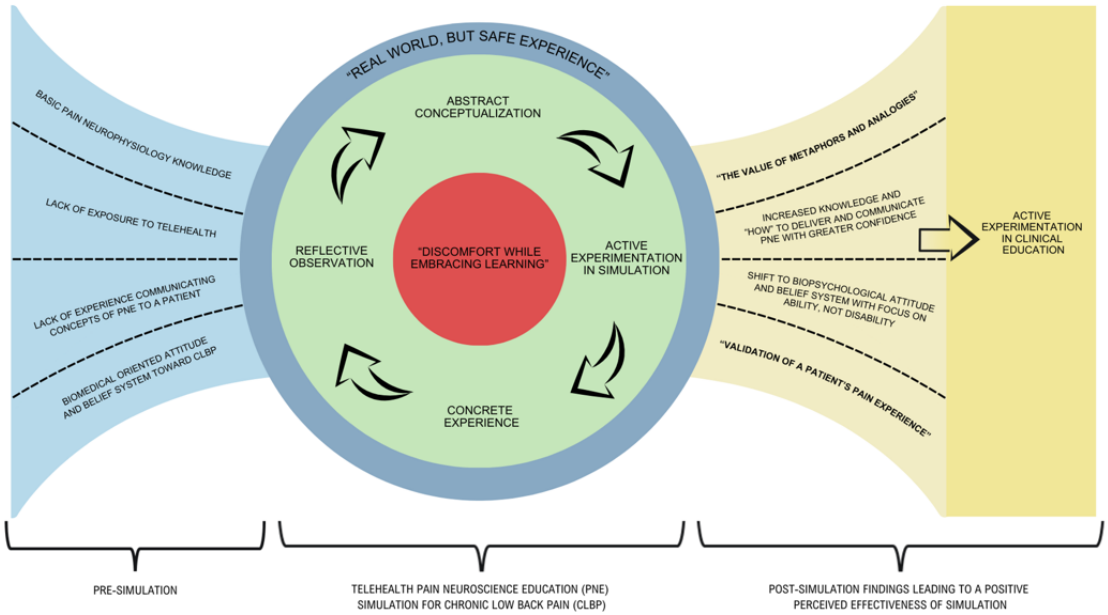
Finally, SET-M measures participants' self-reflection on learning and ability to transfer knowledge to real-world situations. The simulation experience encouraged them to consider how they would apply PNE with actual patients in the future. Additionally, participants recognized the need to practice if they intended to incorporate PNE into their future practice.

"...an eye opener for me to like practice."
"...it was cool to like, see the whole scene unfold and just kind of the education be provided in a different way." (Tim, FG 1)

Meta Inference

A meta-inference is where overall conclusions are drawn by integrating insights from both quantitative and qualitative inferences (see Figure 2). Before the simulation, the participants received basic pain neurophysiology knowledge through the curriculum. Participants displayed an enhanced focus of a more biomedical perspective on CLBP based on the current curriculum design while also reporting a need for more experience with telehealth and communication of PNE concepts. They reported possessing the knowledge but needed to feel more confident communicating these concepts to an actual patient. Consistent with experiential learning, the telehealth PNE simulation for a patient with CLBP was a concrete experience for the participants, which they reported as a safe but realistic environment for learning. Despite this safety, participants reported discomfort through the process of the experience, reflective observation, and abstract conceptualization, which are all components consistent with Kolb's ELT (Kolb, 1984).

Figure 2
Meta Inference



Overall, participants reported that the simulation was effective and resulted in a high self-perception of learning and self-confidence, which then can be transferred to the context of the real-world via active experimentation. Post-simulation outcomes include both quantitative and qualitative aspects. For example, students gained knowledge in pain neurophysiology and how to confidently communicate these concepts to patients, noting that metaphors and analogies were beneficial tools. Participants conceptualized the importance of validating a patient's pain experience and the complexity of CLBP. A shift to a more biopsychosocial attitude and belief perspective can be a beneficial approach to focusing on the ability of an individual rather than disability and perhaps can impact the choice of interventions in future clinical practice.

Discussion, Conclusion and Recommendations

Discussion

The overall mean of RNPQ scores, both pre-test (41%) and post-test (50%), were lower than those reported in physical therapy curricula outside the United States, yet similar to a study by Cox and Puentedura (2017) conducted within the United States (Adillón et al., 2015; Alodaibi et al., 2018; Marques et al., 2016). Overall, accreditation guidelines and varying approaches to integrating modern pain science into entry-level DPT curricula limit direct comparisons among programs. Gains on the RNPQ were statistically significant, but modest in effect size, suggesting minimal impact by the simulation itself. Due to prior curricular exposure, participants may have already been introduced to PNE concepts through previous coursework, limiting the degree of additional learning a single simulation exposure could provide. In other words, a ceiling effect may have influenced the results if students entered the simulation with relatively high baseline knowledge due to prior curricular exposure or preparatory activities, leaving limited room for measurable improvement and contributing to the small observed effect size. Finally, it is important to note that exclusion criteria related to prior exposure to PNE concepts outside the curriculum was based on self-report. While this approach was practical, it may have influenced the overall results.

More importantly, the primary objective of this simulation was to communicate and implement PNE, which may explain the modest gains on the RNPQ compared to previous studies. Although instructors ask students to recall and understand pain science concepts on exams, they only sometimes require them to actively communicate these topics with patients. Debriefing in a simulation is critical to improving reflective practice, in which knowledge is derived from grasping and transforming the experience (Kolb, 1984; Smith & Crocker, 2017). For example, Ohtake, Lazarus, Schillo, and Rosen (2013) compared knowledge gains after simulation, in-class debriefing, in-class discussions with a research essay, and in-class discussions only in the critical care environment. Simulation with debriefing resulted in the most effective mode for knowledge retention. Additionally, students reported increased confidence and communication ability after participating in experiential learning (Smith & Crocker, 2017). During debriefing, participants emphasized the significance of metaphors and analogies in delivering PNE to patients in an accessible manner. These metaphors can facilitate new avenues of understanding (Guilherme & Souza de Freitas, 2018). Therefore, these outcomes highlight the value of integrating qualitative data to provide deeper insight into the student learning experience.

As measured by the HC-PAIRS, attitudes and beliefs regarding CLBP significantly shifted toward a more biopsychosocial perspective, albeit modest in effect size. Participants' perspectives on CLBP may have been shaped by the broader curriculum, with the simulation providing an opportunity to apply and communicate pain neuroscience concepts. As with knowledge gains, changes in attitudes and beliefs may reflect cumulative educational exposure, rather than the simulation alone. However, qualitatively, participants expanded on attitudes and beliefs, stating the importance of validating a patient's pain and the complex and multidimensional nature of pain. The importance of this expansive conceptualization is that it reiterates what current literature has found about physical therapists struggling to address chronic MSK pain and following CPGs (Foster et al., 2018; Louw et al., 2017). Practicing physical therapists have reported feeling ill-prepared to provide the biopsychosocial aspects of PNE due to a lack of knowledge, confidence, and time constraints

(Holopainen et al., 2020). However, these same clinicians reported increased confidence and improved communication skills after training (Holopainen et al., 2020). In DPT curricula, Helms, Mayhew, and Zimney (2021) explored active learning activities in a pain science curriculum. The researchers investigated its impact on practical outcomes, attitudes, beliefs, and confidence. The outcomes were measured pre- and post an 8-week curriculum. Similar to this study, improved morale and communication of concepts was found. Qualitative findings further highlighted how the simulation enhanced knowledge, application, and communication.

A weak positive correlation between the RNPQ and HC-PAIRS was found, indicating that greater knowledge of pain neurophysiology was linked to attitudes and beliefs about CLBP and disability, consistent with findings in first-year physiotherapy students (Springer et al., 2018). This simulation occurred before students completed two 12-week clinical experiences. Clinical practice, not just theoretical knowledge, is crucial for student learning, as real-world interactions expose them to diverse patient experiences. Clinical experiences also shape students' attitudes toward specific pathologies. For example, a two-week experience significantly improved the attitudes of medical interns specializing in psychiatry (Hemanthjumar et al., 2017). Similarly, Houben et al. (2005) found that physical therapy students improved biopsychosocial scores after clinical experiences. Therefore, the weak correlation may reflect the limitations of a single simulation experience, which might not fully capture participants' attitudes and beliefs following clinical experiences or over the long term.

Consistent with other quantitative findings, overall clinical vignette scores and most individual question outcomes improved post-simulation, though with modest effect sizes. Notably, two question outcomes declined. Improvements were primarily seen in recommending activities within the patient's tolerance. The modest effect sizes in clinical vignette improvements may reflect prior curricular exposure, limiting the simulation's additional impact. The decline in two question outcomes could stem from variability in student interpretation, cognitive overload during the simulation, or a shift in clinical reasoning that was not fully aligned with assessment criteria. Additionally, the simulation may have emphasized broader patient-centered communication, influencing certain recommendations more than others.

However, quantitative findings are consistent with Theme 4, which focused on ability rather than disability. This shift to "ability" is positive and consistent with CPGs for CLBP, including PNE as an intervention (George et al., 2021). Additionally, Leysen et al. (2021) reported that students recommended more guideline-adherent interventions in physical therapy as their beliefs shifted to a more biopsychosocial perspective. Further, the correlation between the RNPQ and overall clinical vignette scores was significant and positive, meaning as knowledge improved, the choice of appropriate recommendation improved. This finding is unsurprising, as PNE emphasizes the benefits of movement and exercise, which align with the clinical vignette and appropriate recommendations for CLBP (George et al., 2021; Moseley & Butler, 2015). Finally, questions in the clinical vignette are not solely knowledge-based but directed more toward application, which active learning, such as simulation, promotes. Simulation promotes content application and retention, which may have contributed to this finding (Pritchard et al., 2016).

In line with emerging work on simulation, participants had a high perception of effectiveness and improved self-confidence post-PNE simulation (Smith & Crocker, 2017). Both the replication of real-world processes and psychological fidelity contribute to overall satisfaction with the simulation, including the use of a standardized patient. However, simulations and the use of standardized patients have been shown to induce anxiety and stress, as reflected in Theme 1 (Pritchard et al., 2016). Yet, these emotions are common in experiential learning and lead to reflective observation and active experimentation (Kolb, 1984). Participants reflected on the need to practice communication with an actual patient, consistent with experiential learning and interacting with standardized patients. In a systematic review, Pritchard et al. (2016) stated students considered standardized simulation patients valuable for improving confidence and clinical skills. Participants in this study noted how beneficial it was to practice PNE and telehealth with a "real person" or in a "real world" scenario, which again expands upon the high SET-M scores. This outcome is consistent with research that suggests students desire more active or practice-based learning (Helms et al., 2021). Helms, Mayhew,

and Zimney (2021) reported the value of introducing active learning in a pain education curriculum from a qualitative perspective, stating, "It was good to practice speaking about topics without having to worry about messing it up in front of a real patient."

Finally, healthcare students report a shift in their perspectives on telehealth after participating in a simulation. They noted increased knowledge, improved attitudes, and recognized its value, particularly for patient check-ins. Exposure to this model generally boosts confidence and prepares students for patient communication and interactions (Randall et al., 2016; Serwe et al., 2020). Overall, active or experiential learning methods, such as simulation, effectively engage students and enhance their knowledge of pain neurophysiology, attitudes, beliefs, confidence, and communication skills.

Limitations

The sample size exceeded initial estimates, increasing the likelihood of detecting statistically significant results. While a larger sample from three campuses within the same institution enhances representation and generalizability, concerns of an overpowered study remain. Despite the small effect size, even modest improvements in complex educational settings can have meaningful cumulative impacts on learning. These findings support the feasibility of integrating this approach into DPT curricula and provide a foundation for future research.

Variability in faculty expertise, clinical experience, and curriculum delivery may have influenced participants' foundational knowledge of modern pain science concepts. Additionally, controlling exposure to general content, such as podcasts or discussions on PNE during DPT enrollment, is challenging and may have impacted outcomes. For most students, this simulation was their first telehealth experience with a standardized patient, potentially influencing results. Clinical vignettes served as a proxy for clinical behavior rather than the gold standard of direct observation in randomized controlled trials (RCTs). While RCTs typically include a control group, they are not always ideal for educational research as they fail to reflect real-world conditions, where the context and outcomes often involve complex, multifaceted variables that are difficult to standardize or control (Sullivan, 2011).

Outcome measures were collected in the short term after a single pedagogical intervention and at the curriculum's conclusion, potentially contributing to a ceiling effect on clinical vignette scores. Since data collection occurred during the final term of their didactic coursework and simulation preparatory activities, this timing may have further influenced the results. Longitudinal studies could offer deeper insights into sustained learning outcomes. Finally, while qualitative research is inherently interpretive, several steps were taken to enhance trustworthiness and rigor. However, the data were analyzed collaboratively rather than independently by two authors.

Conclusion and Recommendations

This study demonstrates that a single telehealth simulation focusing on PNE for CLBP has a possible and potential immediate but possible only a small influence on some areas of knowledge, attitudes, and beliefs, and supports appropriate clinical recommendations, though its longer-term usage, target participants, and impact needs further research. It serves as a viable and complementary pedagogical strategy within a DPT curriculum, fostering the communication skills essential for clinical practice and patient-centered care. However, although statistically significant improvements were observed, effect sizes were small, indicating that while the simulation contributed to changes in knowledge, attitudes, beliefs, and recommendations, the overall impact was modest. These findings highlight the greater value of qualitative insights, which offer a deeper understanding of how students engage with and process the learning experience and warrant further research.

Incorporating qualitative and integrative components in this study provided a richer perspective on the impact of simulation from the learner's viewpoint. Mixed-methods research offers a nuanced understanding of the

"how" and "why" behind simulation outcomes, revealing aspects of participant experiences that quantitative data alone cannot capture. These insights can shape and enhance educational practices for excellence in physical therapy education. Advancing learning sciences and educational research remains crucial for the profession, contributing to ongoing exploration in this critical area. This study also establishes a foundation for replicating the pedagogical approach while adhering to best practices for simulation.

Future research should explore implementation across diverse delivery models and curricula in DPT education to improve generalizability. Including a control group in future studies could further strengthen study design and provide a clearer understanding of the intervention's effectiveness. Additionally, comparing PNE delivered via telehealth versus in-person could offer valuable insights into the relative impact of different simulation formats. Examining longitudinal and long-term outcomes would help assess content retention, while developing a more specific clinical vignette for PNE research and simulations could enhance applicability and impact.

Declarations Acknowledgments Funding:

The authors received no financial support for the research, authorship, and/or publication of this article.

Ethics Statement:

This study was approved by institutional review board (IRB) and all participants completed an informed consent for data release and participation in focus group interviews.

Conflict of Interest:

The authors declare that there is no conflict of interest regarding the publication of this article.

References

Aarons, G. A., Fettes, D. L., Sommerfeld, D. H., & Palinkas, L. A. (2012). Methods for implementation research: Application to evidence-based practice and staff turnover in community-based organizations providing child welfare services. *Child Maltreatment, 17*(1). https://doi.org/10.1177/1077559511426908

Adillón, C., Lozano, E., & Salvat, I. (2015). Comparison of pain neurophysiology knowledge among health sciences students: A cross-sectional study. *BMC Research Notes, 8*(1), 1–9. https://doi.org/10.1186/s13104-015-1585-y

Almeida, F., Gaya, P., Queirós, A., & Faria, D. (2017). Strengths and limitations of qualitative and quantitative research methods. *European Journal of Education Studies, 3*(9), 369–387. https://doi.org/10.5281/zenodo.887089

Alodaibi, F., Alhowimel, A., & Alsobayel, H. (2018). Pain neurophysiology knowledge among physical therapy students in Saudi Arabia: A cross-sectional study. *BMC Medical Education, 18*(1), 1–5. https://doi.org/10.1186/s12909-018-1329-5

Bettger, J. P., Thoumi, A., Marquevich, V., De Groote, W., Battistella, L. R., Imamura, M., Ramos, V. D., Wang, N., Dreinhoefer, K. E., Mangar, A., Ghandi, D. B. C. C., Ng, Y. S., Lee, K. H., Tan, J., Ming, W., Pua, Y. H., Inzitari, M., Mmbaga, B. T., Shayo, M. J., & Stein, J. (2020). COVID-19: Maintaining essential rehabilitation services across the care continuum. *BMJ Global Health, 5*(5), 1–7. https://doi.org/10.1136/bmjgh-2020-002670

Bishop, A., Foster, N. E., Thomas, E., & Hay, E. M. (2008). How does the self-reported clinical management of patients with low back pain relate to the attitudes and beliefs of health care practitioners? A survey of UK general practitioners and physiotherapists. *Pain, 135*(1–2), 187–195. https://doi.org/10.1016/j.pain.2007.11.010

Carter, N., Bryant-Lukosius, D., DiCenso, A., Blythe, J., & Neville, A. J. (2014). The use of triangulation in qualitative research. *Oncology Nursing Forum, 41*(5), 545–547. https://doi.org/10.1188/14.ONF.545-547

Catley, M. J., O'Connell, N. E., & Moseley, G. L. (2013). How good is the neurophysiology of pain questionnaire? A Rasch analysis of psychometric properties. *Journal of Pain, 14*(8), 818–827. https://doi.org/10.1016/j.jpain.2013.02.008

Colleary, G., O'Sullivan, K., Griffin, D., Ryan, C. G., & Martin, D. J. (2017). Effect of pain neurophysiology education on physiotherapy students' understanding of chronic pain, clinical recommendations and attitudes towards people with chronic pain: A randomised controlled trial. *Physiotherapy, 103*(4), 423–429. https://doi.org/10.1016/j.physio.2017.01.006

Collins, K., Layne, K. C., Andrea, C., & Perry, L. A. (2021). The impact of interprofessional simulation experiences in occupational and physical therapy education: A qualitative study. *Brazilian Journal of Occupational Therapy, 29*, 1–19. https://doi.org/10.1590/2526-8910.CTOAO2256

Cordi, V. L. E., Leighton, K., Ryan-Wenger, N., Doyle, T. J., & Ravert, P. (2012). History and development of the simulation effectiveness tool (SET). *Clinical Simulation in Nursing, 8*(6), e199–e210. https://doi.org/10.1016/j.ecns.2011.12.001

Cottrell, M. A., Galea, O. A., O'Leary, S. P., Hill, A. J., & Russell, T. G. (2017). Real-time telerehabilitation for the treatment of musculoskeletal conditions is effective and comparable to standard practice: A systematic review and meta-analysis. *Clinical Rehabilitation, 31*(5), 625–638.

Cox, T., Louw, A., & Puentedura, E. J. (2017). An abbreviated therapeutic neuroscience education session improves pain knowledge in first-year physical therapy students but does not change attitudes or beliefs. *Journal of Manual and Manipulative Therapy, 25*(1), 11–21. https://doi.org/10.1080/10669817.2015.1122308

Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). Sage.

Dario, A. B., Cabral, A. M., Almeida, L., Ferreira, M. L., Refshauge, K., Simic, M., Pappas, E., & Ferreira, P. H. (2017). Effectiveness of telehealth-based interventions in the management of non-specific low back pain: A systematic review with meta-analysis. *The Spine Journal, 17*(9), 1342–1351. https://doi.org/10.1016/j.spinee.2017.04.008

Ehrström, J., Kettunen, J., & Salo, P. (2018). Physiotherapy pain curricula in Finland: A faculty survey. *Scandinavian Journal of Pain, 18*(4), 593–601. https://doi.org/10.1515/sjpain-2018-0091

Fergus, A., Hartsook, K., Smith, J., Hale, M., Kellar, D., & Fergus, A. (2021). A novel physical therapy learning experience in pediatrics via telehealth: A qualitative case analysis. *Journal of Physical Therapy Education, 35*(2), 159–167. https://doi.org/10.1097/JTE.0000000000000184

Foster, N. E., Anema, J. R., Cherkin, D., Chou, R., Cohen, S. P., Gross, D. P., Ferreira, P. H., Fritz, J. M., Koes, B. W., & Peul, W. (2018). Prevention and treatment of low back pain: Evidence, challenges, and promising directions. *The Lancet, 391*(10137), 2368–2383. https://doi.org/10.1016/S0140-6736(18)30489-6

George, S. Z., Fritz, J. M., Silfies, S. P., Schneider, M. J., Beneciuk, J. M., Lentz, T. A., Gilliam, J. R., Hendren, S., & Norman, K. S. (2021). Interventions for the management of acute and chronic low back pain: Revision 2021. *Journal of Orthopaedic & Sports Physical Therapy, 51*(11), CPG1–CPG60. https://doi.org/10.2519/jospt.2021.0304

Guest, G., Namey, E., & McKenna, K. (2017). How many focus groups are enough? Building an evidence base for nonprobability sample sizes. *Field Methods, 29*(1), 3–22. https://doi.org/10.1177/1525822X16639015

Guilherme, A., & Souza de Freitas, A. L. (2018). Discussing education by means of metaphors. *Educational Philosophy and Theory, 50*(10), 947–956. https://doi.org/10.1080/00131857.2016.1198250

Helms, J. T., Mayhew, T. P., & Zimney, K. J. (2021). The effectiveness of active learning approaches in a pain education curriculum within a physical therapy program. *Journal of Physical Therapy Education, 35*(3), 218–226. https://doi.org/10.1097/JTE.0000000000000191

Hemanthjumar, G., Keetish, N., Sathyanarayan, M., & Hyder, S. (2017). Attitude of interns towards psychiatry before and after 2 weeks of clinical rotation. *Indian Journal of Social Psychiatry, 33*(4). https://doi.org/10.4103/0971-9962.218598

Hennink, M. M., Kaiser, B. N., & Weber, M. B. (2019). What influences saturation? Estimating sample sizes in focus group research. *Qualitative Health Research, 29*(10), 1483–1496. https://doi.org/10.1177/1049732318821692

Hoeger Bement, M. K., & Sluka, K. A. (2015). The current state of physical therapy pain curricula in the United States: A faculty survey. *Journal of Pain, 16*(2), 144–152. https://doi.org/10.1016/j.jpain.2014.11.001

Holopainen, R., Simpson, P., Piirainen, A., Karppinen, J., Schütze, R., Smith, A., O'Sullivan, P., & Kent, P. (2020). Physiotherapists' perceptions of learning and implementing a biopsychosocial intervention to treat musculoskeletal pain conditions: A systematic review and metasynthesis of qualitative studies. *Pain, 161*(6), 1150–1168. https://doi.org/10.1097/j.pain.0000000000001809

Houben, R. M. A., Gijsen, A., Peterson, J., De Jong, P. J., & Vlaeyen, J. W. S. (2005). Do health care providers' attitudes towards back pain predict their treatment recommendations? Differential predictive validity of implicit and explicit attitude measures. *Pain, 114*(3), 491–498. https://doi.org/10.1016/j.pain.2005.01.017

IASP. (2024). *IASP pain curriculum outline for PT*. https://www.iasp-pain.org/education/curricula/iasp-curriculum-outline-on-pain-for-physical-therapy/

Kajamaa, A., Mattick, K., & de la Croix, A. (2020). How to do mixed-methods research. *Clinical Teacher, 17*(3), 267–271. https://doi.org/10.1111/tct.13145

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Prentice Hall.

Leighton, K., Ravert, P., Mudra, V., & Macintosh, C. (2015). Updating the simulation effectiveness tool: Item modifications and reevaluation of psychometric properties. *Nursing Education Perspectives, 36*(5), 317–323. https://doi.org/10.5480/15-1671

Leysen, M., Nijs, J., Van Wilgen, P., Demoulin, C., Dankaerts, W., Danneels, L., Voogt, L., Köke, A., Pitance, L., & Roussel, N. (2021). Attitudes and beliefs on low back pain in physical therapy education: A cross-sectional study. *Brazilian Journal of Physical Therapy, 25*(3), 319–328. https://doi.org/10.1016/j.bjpt.2020.08.002

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Sage.

Logan, S. (2024). Designing and implementing a telehealth simulation for pain neuroscience education in a Doctor of Physical Therapy curriculum: A pilot study. *International Journal of Higher Education Pedagogies, 5*(2), 71–82. https://doi.org/10.33422/ijhep.v5i2.648

Louw, A., Puentedura, E. J., Zimney, K., Cox, T., & Rico, D. (2017). The clinical implementation of pain neuroscience education: A survey study. *Physiotherapy Theory and Practice, 33*(11), 869–879. https://doi.org/10.1080/09593985.2017.1359870

Louw, A., Vogsland, R., Marth, L., Marshall, P., Cox, T., & Landers, M. (2019). Interdisciplinary pain neuroscience continuing education in the Veterans Affairs: Live training and live-stream with 1-year follow-up. *Clinical Journal of Pain, 35*(11), 901–907. https://doi.org/10.1097/AJP.0000000000000756

Louw, A., Zimney, K., Puentedura, E. J., & Diener, I. (2016). The efficacy of pain neuroscience education on musculoskeletal pain: A systematic review of the literature. *Physiotherapy Theory and Practice, 32*(5), 332–355. https://doi.org/10.1080/09593985.2016.1194646

Lowe, L., Flowers, M., Fletcher, J., & Yates, C. (2022). The effects of experiential learning on perceived clinical reasoning and self-efficacy of Doctor of Physical Therapy students. *Journal of Physical Therapy Education, 36*(2), 122–127. https://doi.org/10.1097/JTE.0000000000000225

Macauley, K. (2018). Evaluating changes in clinical decision-making in physical therapy students after participating in simulation. *Health Professions Education, 4*(4), 278–286. https://doi.org/10.1016/j.hpe.2018.06.001

Maguire, N., Chesterton, P., & Ryan, C. G. (2019). The effect of pain neurophysiology education on sports therapy and rehabilitation students' knowledge, attitudes and clinical recommendations towards athletes with chronic pain. *Journal of Sports Rehabilitation, 28*(5), 438–443.

Mankelow, J., Ryan, C., Taylor, P., & Martin, D. (2020). The effect of pain neurophysiology education on healthcare students' knowledge, attitudes and behaviours towards pain: A mixed-methods randomised controlled trial. *Musculoskeletal Science and Practice, 50*, Article 102249. https://doi.org/10.1016/j.msksp.2020.102249

Marques, E. S., Xarles, T., Antunes, T. M., Silva, K. K. D., Reis, F. J. J., Oliveira, L. A. S., & Nogueira, L. A. C. (2016). Evaluation of physiologic pain knowledge by physiotherapy students. *Revista Dor, 17*(1), 29–33. https://doi.org/10.5935/1806-0013.20160008

Marris, D., Theophanous, K., Cabezon, P., Dunlap, Z., & Donaldson, M. (2021). The impact of combining pain education strategies with physical therapy interventions for patients with chronic pain: A systematic review and meta-analysis of randomized controlled trials. *Physiotherapy Theory and Practice, 37*(4), 461–472. https://doi.org/10.1080/09593985.2019.1633714

Mori, B., Carnahan, H., & Herold, J. (2015). Use of simulation learning experiences in physical therapy entry-to-practice curricula: A systematic review. *Physiotherapy Canada, 67*(2), 194–202. https://doi.org/10.3138/ptc.2014-40E

Moseley, G. L. (2004). Evidence for a direct relationship between cognitive and physical change during an education intervention in people with chronic low back pain. *European Journal of Pain, 8*(1), 39–45. https://doi.org/10.1016/S1090-3801(03)00063-6

Moseley, G. L., & Butler, D. S. (2015). Fifteen years of explaining pain: The past, present, and future. *Journal of Pain, 16*(9), 807–813. https://doi.org/10.1016/j.jpain.2015.05.005

Moseley, G. L. (2003). Unraveling the barriers to reconceptualization of the problem in chronic pain: The actual and perceived ability of patients and health professionals to understand the neurophysiology. *Journal of Pain, 4*(4), 184–189. https://doi.org/10.1016/S1526-5900(03)00488-7

National Academies of Sciences, Engineering, and Medicine. (2018). *How people learn II: Learners, contexts, and cultures*. National Academies Press. https://doi.org/10.17226/24783

Ohtake, P. J., Lazarus, M., Schillo, R., & Rosen, M. (2013). Simulation experience enhances physical therapist student confidence in managing a patient in the critical care environment. *Physical Therapy, 93*(2), 216–228. https://doi.org/10.2522/ptj.20110463

Poore, J. A., Cullen, D. L., & Schaar, G. L. (2014). Simulation-based interprofessional education guided by Kolb's experiential learning theory. *Clinical Simulation in Nursing, 10*(5), e241–e247. https://doi.org/10.1016/j.ecns.2014.01.004

Pritchard, S. A., Blackstock, F. C., Nestel, D., & Keating, J. L. (2016). Simulated patients in physical therapy education: Systematic review and meta-analysis. *Physical Therapy, 96*(9), 1342–1353. https://doi.org/10.2522/ptj.20150500

Puentedura, E. J., & Flynn, T. (2016). Combining manual therapy with pain neuroscience education in the treatment of chronic low back pain: A narrative review of the literature. *Physiotherapy Theory and Practice, 32*(5), 408–414. https://doi.org/10.1080/09593985.2016.1194663

Rainville, J., Bagnall, D., & Phalen, L. (1995). Health care providers' attitudes and beliefs about functional impairments and chronic back pain. *Clinical Journal of Pain, 11*(4), 287–295.

Randall, K., Steinheider, B., Isaacson, M., Shortridge, A., Byrd, S., Ciro, C., Ross, H., & Loving, G. (2016). Measuring knowledge, acceptance, and perceptions of telehealth in an interprofessional curriculum for student nurse practitioners, occupational therapists, and physical therapists. *Journal of Interactive Learning Research, 27*(4), 339–353.

Rufa, A., Beissner, K., & Dolphin, M. (2019). The use of pain neuroscience education in older adults with chronic back and/or lower extremity pain. *Physiotherapy Theory and Practice, 35*(7), 603–613. https://doi.org/10.1080/09593985.2018.1456586

Saldaña, J. (2021). *The coding manual for qualitative researchers* (4th ed.). Sage.

Schreier, M. (2012). *Qualitative content analysis in practice*. Sage.

Serwe, K. M., Heindel, M., Keultjes, I., Silvers, H., & Stovich, S. (2020). Telehealth student experiences and learning: A scoping review. *Journal of Occupational Therapy Education, 4*(2). https://doi.org/10.26681/jote.2020.040206

Shepherd, M., Wassinger, C., Rubine, B., Sluka, K., Bement, M., Zimney, K., Harrington, S., Tran, R., Sions, M., & Clarno, K. (2021). *Pain education manual*. AOPT. https://www.orthopt.org/uploads/content_files/files/Pain_Manual_Draft_FINAL_6.25.2021%281%29.pdf

Smith, S. N., & Crocker, A. F. (2017). Experiential learning in physical therapy education. *Advances in Medical Education and Practice, 8*, 427–433. https://doi.org/10.2147/AMEP.S140373

Springer, S., Gleicher, H., & Hababou, H. (2018). Attitudes and beliefs about musculoskeletal pain and its association with pain neuroscience knowledge among physiotherapy students in Israel. *Israel Journal of Health Policy Research, 7*(1), 1–9. https://doi.org/10.1186/s13584-018-0266-4

Sullivan, G. M. (2011). Getting off the "gold standard": Randomized controlled trials and education research. *Journal of Graduate Medical Education, 3*(3), 285–289. https://pubmed.ncbi.nlm.nih.gov/22942950/

Tegner, H., Frederiksen, P., Esbensen, B. A., & Juhl, C. (2018). Neurophysiological pain education for patients with chronic low back pain. *Clinical Journal of Pain, 34*(8), 778–786. https://doi.org/10.1097/AJP.0000000000000594

Tovin, M. M., & Wormley, M. E. (2023). Systematic development of standards for mixed methods reporting in rehabilitation health sciences research. *Physical Therapy, 103*(11), pzad084. https://doi.org/10.1093/ptj/pzad084

Watts, P. I., Rossler, K., Bowler, F., Miller, C., Charnetski, M., Decker, S., Molloy, M. A., Persico, L., McMahon, E., McDermott, D., & Hallmark, B. (2021). Onward and upward: Introducing the healthcare simulation standards of best practice. *Clinical Simulation in Nursing, 58*, 1–4. https://doi.org/10.1016/j.ecns.2021.08.006

Yong, R. J., Mullins, P. M., & Bhattacharyya, N. (2022). Prevalence of chronic pain among adults in the United States. *Pain, 163*(2). https://doi.org/10.1097/j.pain.0000000000002291

Zigmont, J. J., Kappus, L. J., & Sudikoff, S. N. (2011). Theoretical foundations of learning through simulation. *Seminars in Perinatology, 35*(2), 47–51. https://doi.org/10.1053/j.semperi.2011.01.002