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| RESEARCH ARTICLE

Integrating 3D Multimedia into Nursing and Midwifery Education: A Case Study on Paediatric Massage Instruction

Ralitsa Diana Debrah[1] ✉ Adam Rahman[2], Samuel Antwi[3], Abigail Kusi-Amponsah Digi[4] and Jerry Armah[5]

[12]Department of Communication Design, College of Art and Built Environment, Kwame Nkrumah University of Science and Technology, Kumasi-Ghana

[3]Department of Teacher Education, Faculty of Educational Studies, Kwame Nkrumah University of Science and Technology, Kumasi-Ghana

[4]Department of Nursing, College of Health Sciences, Kwame Nkrumah University of Science and Technology, Kumasi-Ghana; Department of Nursing Sciences, Faculty of Medicine, University of Turku, Finland

[5]Department of Nursing, College of Health Sciences, Kwame Nkrumah University of Science and Technology, Kumasi-Ghana

Corresponding Author: Ralitsa Diana Debrah, **E-mail**: rddebrah.art@knust.edu.gh

| ABSTRACT

Innovative teaching tools are vital for bridging the gap between theory and practice in healthcare education. Three-dimensional (3D) animation offers an interactive and visually engaging way to enhance learning, particularly for demonstrating procedures that require precision and empathy. This study explored the perspectives of undergraduate nursing and midwifery students on the use of 3D animation as an instructional resource for paediatric massage, a non-pharmacological intervention for managing children's pain. A descriptive cross-sectional design was employed with fifty purposively selected students. The animation was developed through structured pre-production, production, and post-production stages, guided by instructional design principles. Using tools such as Autodesk Maya and Adobe Creative Suite, animated characters and scenarios were created, followed by voiceover integration to enrich realism and engagement. After viewing the animation, participants completed a short questionnaire assessing its quality and instructional value. Results revealed strong acceptance of the medium. Most students reported that the animation's colours accurately reflected medical settings (92%) and found the actions easy to interpret (98%). Sound, modelling, and overall quality received top ratings from 70% of participants. Students highlighted the resource's clarity, visual appeal, and potential for improving understanding of paediatric pain management. These findings underscore the value of 3D animation in nursing and midwifery education. Beyond improving engagement, such tools may foster deeper learning and support the integration of non-pharmacological care practices into future clinical work.

| KEYWORDS

3D animation, Multimedia, Education, Nursing, Midwifery, Paediatric pain, Teaching, Learning

| ARTICLE INFORMATION

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1. Introduction

Delivering education effectively plays a critical role in shaping the minds of present and future generations. As such, to truly engage students, classroom resources must go beyond transmitting information, they need to be captivating, interactive, and memorable (Chodkiewicz & Boyle, 2017). Digital presentations, especially when designed with multimedia elements such as videos, images, and interactive quizzes, provide a powerful way to capture attention and make learning enjoyable (Barut Tugtekin & Dursun, 2022). Hands-on activities and experiential learning further strengthen this process, allowing students to actively explore concepts, apply their knowledge, and receive immediate feedback that deepens understanding (Cheng, Hwang, & Chen, 2019; Amerstorfer & Freiin von Münster-Kistner, 2021; Barua, 2023).

Teaching and learning materials generally fall into three categories: visual, audio, and audio-visual (Taghani & Ghafournia, 2018). Each offers unique benefits and limitations. Visual resources such as diagrams, charts, videos, and presentations enhance comprehension and retention, though poorly designed visuals can become distracting (Bărbuceanu, 2020; Brame, 2016). Audio resources, including podcasts and recorded lectures, improve listening skills and imagination but lack visual reinforcement and interactive elements (Lopez, 2020; Hardiah, 2019; Itzchakov & Grau, 2022). Audio-visual tools like animations, multimedia simulations, and videos combine the strengths of both, catering to diverse learning styles, though access may be limited by technological constraints (Abdulrahaman et al., 2020; Hughes, Costley, & Lange, 2019; Dwivedi et al., 2022).

Among these, animation has emerged as an especially valuable tool. Three-dimensional (3D) animation is increasingly recognized as a transformative educational medium, offering immersive, dynamic learning experiences (Praveen & Srinivasan, 2022; Unsworth, 2020). Unlike traditional two-dimensional (2D) methods, 3D animation can bring abstract or complex concepts to life, making them more relatable and easier to grasp (Hung, Chen, & Huang, 2016). In an era where static textbooks no longer fully engage digital-native learners, animation introduces motion, sound, and interactivity that align with modern learning preferences (Samaniego Erazo, Esteve-González, & Vaca, 2015).

Educational technologies are no longer optional; they are essential for advancing teaching and learning. Multimedia instruction in particular has proven to be both effective and engaging, creating meaningful opportunities for instructional design (Mayer, 2001; Merrill, 2013).

1.1 Merrill's Model of Instructional Design

Among the many instructional design models, Merrill's *First Principles of Instruction* (2002, 2007, 2013) remains one of the most influential for guiding effective teaching. Merrill identified five core principles that shape meaningful learning (See Figure 1):

- **Problem-Centered Learning:** Students learn best when instruction is rooted in real-world problems, giving them practical contexts to apply their skills.
- **Activation:** Building on what learners already know creates a strong foundation for acquiring new skills.
- **Demonstration:** Observing clear demonstrations of a skill makes abstract ideas tangible and easier to understand.
- **Application:** Learners deepen understanding when they actively practice new skills by solving problems.
- **Integration:** Reflecting on and defending newly acquired knowledge encourages transfer to real-life situations (Merrill, 2013, p. 21).

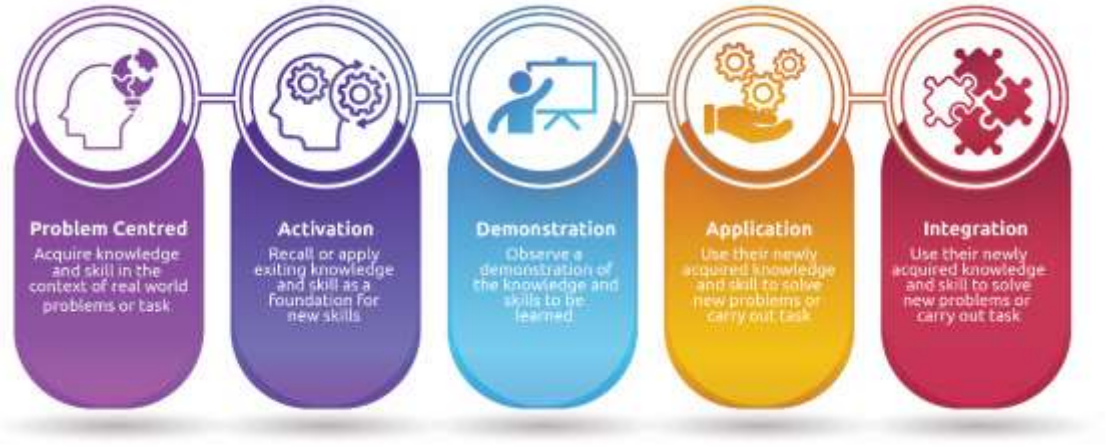

Figure 1: Four-phase cycle of instruction (Merrill's principles of instruction).
Source: Authors' own construct (2024), modelled after Merrill's principles of instruction (Collidu, 2024). Available at: https://www.collidu.com/presentation-merills-principles-of-instruction

As a whole, these principles form a five-phase cycle of instruction (see Figure 1). Merrill emphasized that learning is significantly enhanced when instructional events incorporate multimedia elements, such as 3D animations, to guide attention and sustain engagement.

These principles strongly align with the objectives of this study. In healthcare education, problem-centered learning is evident when students are presented with real-world challenges like paediatric pain management. Through **activation**, students connect prior clinical knowledge with new content, while **demonstrations** in 3D animation provide a vivid and accurate representation of massage techniques. The **application** phase allows learners to mentally rehearse or physically replicate the technique, and **integration** fosters reflection on how these skills apply in clinical practice.

This study also draws on the animation-based learning theory proposed by Byrne, Catrambone, and Stasko (1999), which argues that animations enhance comprehension by engaging both verbal and visual channels of cognition. Compared to static text, animations enable learners to form dual representations that strengthen recall and understanding. In the context of nursing and midwifery education, 3D animation becomes more than a teaching aid, it transforms complex healthcare concepts into immersive, interactive experiences that connect theory to practice (Teplá, Teplý, & Šmejkal, 2022).

As digital and remote learning expand, particularly in the wake of the COVID-19 pandemic, interactive tools such as 3D animation provide timely and relevant opportunities for nursing and midwifery students (Gray et al., 2021; Moule, Ward, & Lockyer, 2010). Beyond engagement, this approach nurtures critical thinking, problem-solving, and the ability to visualise clinical scenarios (Haleem, Javaid, Qadri, & Suman, 2022).

Massage, a long-standing non-pharmacological intervention for pain management, offers an ideal example. It is widely recognised for its ability to relieve pain, reduce muscle tension, promote relaxation, and improve overall well-being (Crawford et al., 2016; Trivedi et al., 2022). Also, by presenting paediatric massage techniques through 3D animation, this study investigates how undergraduate nursing and midwifery students perceive multimedia-based instruction as a modern approach to teaching non-pharmacological pain interventions in children.

2. Methods

2.1 Study Design

This research employed a ***descriptive cross-sectional pilot survey*** combined with a ***design research approach***. The dual strategy allowed the team not only to capture students' perspectives at a specific point in time but also to iteratively design, test, and refine the educational resource. This hybrid approach reflects the growing recognition in design research that empirical user feedback and iterative prototyping are equally important in developing effective instructional tools (Koivisto, Multisilta, Niemi, Katajisto, & Eriksson, 2016). The study was conducted between June and September 2023, making it a time-bounded case study that situates the design of 3D animation within the broader context of health education in Sub-Saharan Africa.

2.2 Setting and Population

The study took place in the Department of Nursing at a public university in Ghana. The department provides both undergraduate and postgraduate programs, combining theoretical instruction with practical exposure in classrooms, virtual platforms, skills laboratories, clinical placements, and community settings. Undergraduate nursing and midwifery students formed the study population. Eligibility criteria required participants to be*: (1) enrolled in an undergraduate nursing or midwifery program* and *(2) available during the study period to attend sessions and share feedback*.

2.3 Sampling and Sample Size

Purposive sampling with a ***maximum variation technique*** was used to recruit 50 participants. This strategy ensured a diversity of perspectives across different years of study, thereby capturing a broad range of experiences and expectations toward multimedia-based instruction.

2.4 Design Process and Animation Production Pipeline

The 3D animation was developed following a ***design research case study model,*** integrating iterative prototyping with user-centered design. The production pipeline consisted of three main stages—***pre-production, production, and post-production,*** **with** each phase involving specific design tasks (see Figure 2).

- **Pre-Production:** Initial research focused on paediatric massage as a non-pharmacological intervention for pain management. Insights from literature and clinical guidelines informed the scriptwriting process. Storyboards and animatics were then created to visualize the sequence of learning events, ensuring alignment with instructional design principles such as Merrill's "First Principles of Instruction."
- **Production:** Using digital tools including Autodesk Maya and Adobe Creative Suite, 3D character models were designed to represent both caregiver and child. Attention was given to anatomical accuracy, movement realism, and cultural relevance. Animators applied rigging and motion design techniques to demonstrate massage sequences clearly.

Backgrounds and props were created to simulate medical settings that resonated with participants' real-life training environments.

- **Post-Production:** Voiceovers were recorded to synchronize narration with animated actions, enhancing dual-channel learning. Lighting, sound effects, and color grading were incorporated to heighten realism and guide learner focus. Iterative feedback loops with faculty and students helped refine timing, clarity, and overall aesthetic quality before the final prototype was presented.

This pipeline highlights how design practice intersects with educational research, transforming abstract knowledge into an engaging visual resource. Through this case study, the animation became not only a teaching aid but also a design experiment demonstrating how creative media can bridge the gap between theory and practice in healthcare education.

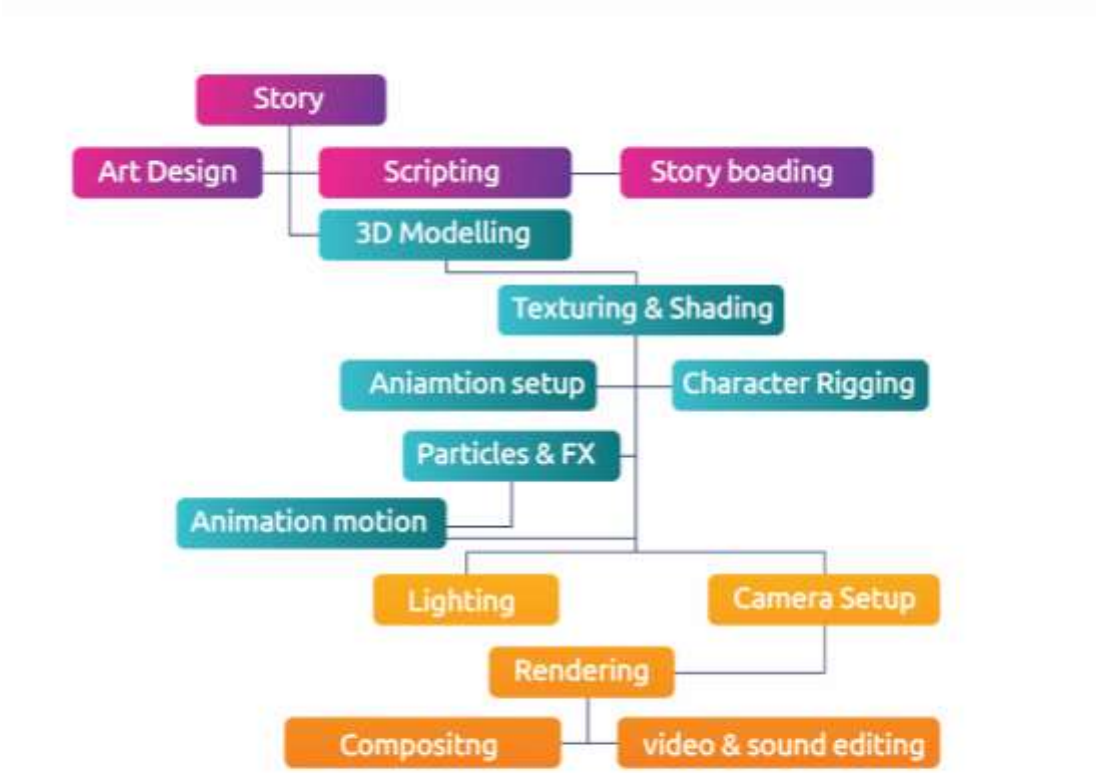

Figure 2: Animation production pipeline.
Source: Authors' own construct, modelled after standard animation design workflows.

2.5 Pre-Production Stage

The pre-production stage is a crucial part of the creative process, laying the foundation for both the technical and pedagogical success of the animation. This stage began with in-depth research into paediatric pain management and the role of non-pharmacological interventions such as massage. Insights from this research informed the design brief and emphasized the need for instructional media that could bridge the gap between theoretical knowledge and practical application in healthcare education.

A detailed script was then developed, translating medical content into a structured narrative suitable for visual storytelling. This script guided the design of ***storyboards,*** which provided the first visual interpretation of the material. The storyboards included captions and annotations specifying camera placement, shot sizes, scene timing, sound effects, and background tracks (see Figures 3 and 4). Beyond technical guidance, the storyboards served as a design tool to align the educational objectives with narrative flow, ensuring clarity and engagement.

Collaborative brainstorming sessions followed, allowing the design team to explore alternative visual metaphors and ensure cultural and contextual sensitivity in the representation of both caregiver and child. These sessions underscored the iterative nature of design, where creative exploration informed the refinement of the storyline. Once ideas were consolidated, ***animatics*** were developed to simulate motion, pacing, and scene transitions. Acting as an animated storyboard, the animatic not only helped the team refine timing and sequencing but also provided a valuable reference for production.

This pre-production process reflects established design practices where problem analysis, ideation, and prototyping occur before full-scale development. It demonstrates how research-informed storytelling, combined with iterative visual design, can transform abstract healthcare concepts into accessible, engaging, and instructionally sound media (see Figure 3 for excerpts of the storyboard).

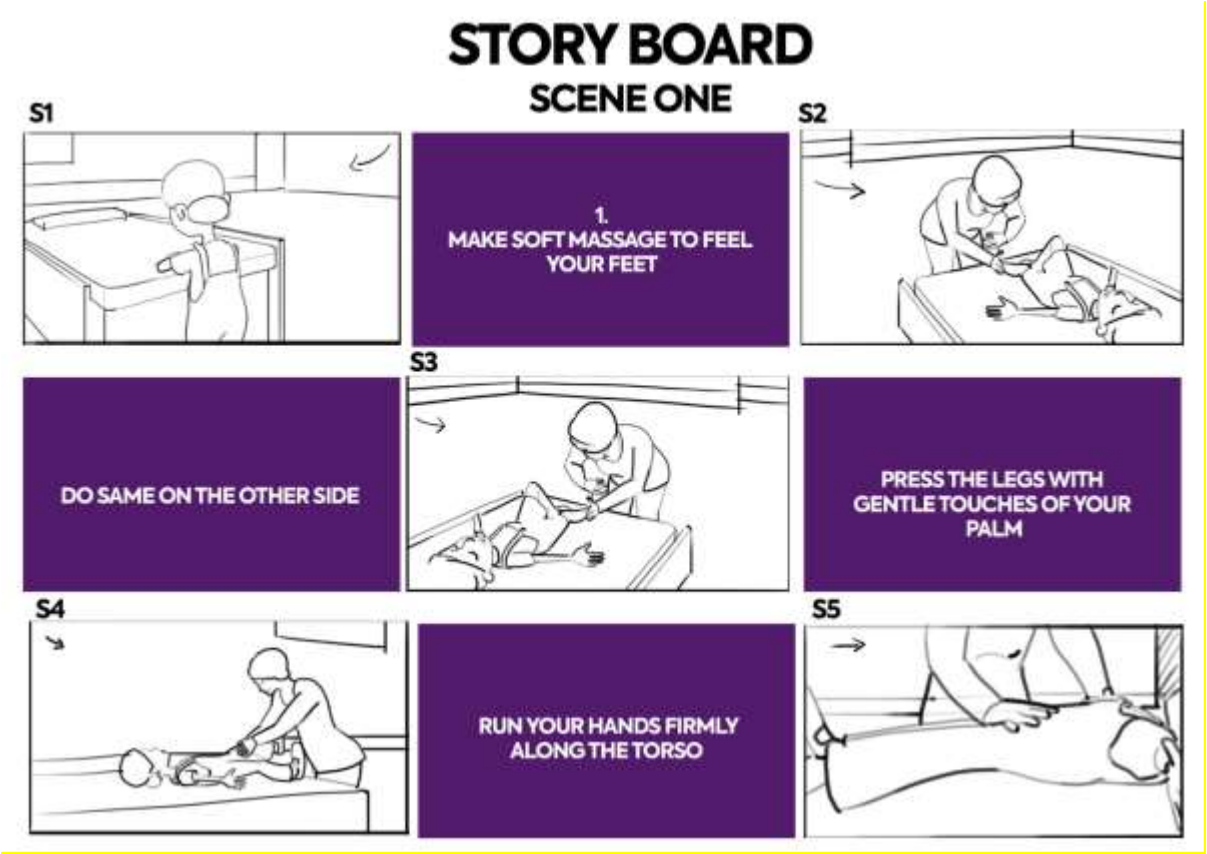

Figure 3: Pre-production stage – storyboard of the second major session in the therapeutic massage process. Source: Authors' own construct.

2.6 Production Stage

The production stage marked the transition from conceptual planning to actual creation, where the animation began to take form as a three-dimensional learning resource. At this stage, animators and designers moved from sketches and animatics into building digital assets that reflected both educational accuracy and visual engagement. Characters were carefully modelled to represent the caregiver and child, ensuring anatomical correctness, cultural relevance, and an approachable design aesthetic that would resonate with learners.

Alongside character development, props, environments, and background elements were created to simulate realistic healthcare settings. Color palettes were deliberately chosen not only for visual appeal but also to reinforce medical authenticity and focus learners' attention on key instructional details. Motion references were captured through video recordings of massage techniques, which were then digitally translated into precise animations.

The technical workflow began with creating ***polygon-based 3D primitives***, which formed the foundation for characters and environments. These were refined through *texturing*, adding lifelike detail, followed by ***rigging***, where skeletal systems were

embedded to enable fluid movement. This rigging process allowed characters to perform the massage actions accurately, maintaining a balance between realism and instructional clarity. Spatial depth and environmental interaction were then layered into the scenes, ensuring a sense of immersion that aligned with the storyboard and animatics.

Lighting design and camera setups were introduced to enhance mood, highlight critical actions, and direct learner focus. Frame-by-frame rendering transformed the animated sequences into picture files, which were organized into a structured sequence to establish smooth transitions and coherent storytelling. Finally, atmospheric details, such as stylistic coloring, ambient effects, and genre-specific visual treatments were applied, preparing the animation for refinement in *post-production* (see Figure 4).

This stage underscores the integration of ***design practice, technical execution, and instructional strategy***. The animation pipeline in this phase demonstrates how design research principles such as *iteration, contextual sensitivity, and visual storytelling* can be embedded into healthcare education tools, transforming abstract concepts into immersive and accessible learning experiences.

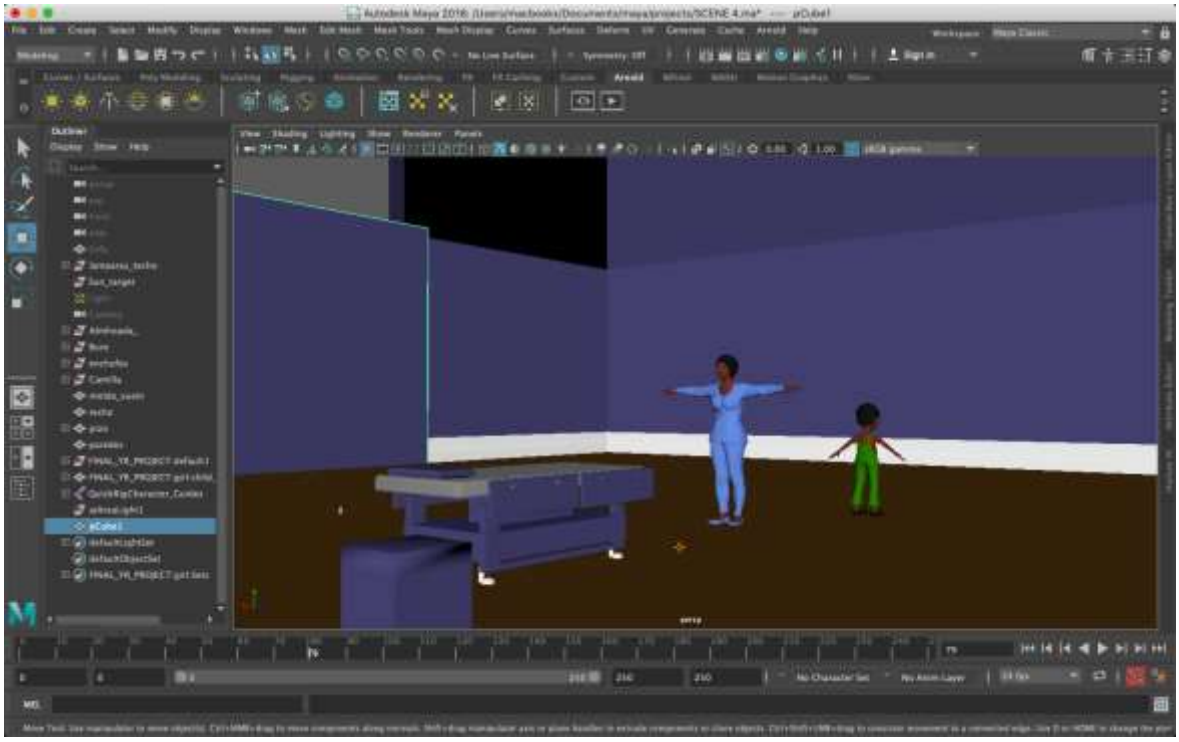

Figure 4: Production stage – modelling process in the 3D animation workflow.
Source: Authors' own construct, based on standard modelling and rigging practices in 3D design.

2.7 Post-Production Stage

The post-production stage represents the final refinement of the animation, where technical precision and creative vision merge to prepare the resource for its intended audience. At this point, the raw sequences generated during production are polished, edited, and enhanced to achieve both narrative coherence and instructional clarity. Guided by the original script, storyboard, and animatics, the design team ensured that every element that is visual, auditory, and interactive, contributed to a seamless learning experience.

The process began with detailed editing of character performances. Animators and editors carefully adjusted movements, gestures, and facial expressions to ensure characters conveyed appropriate emotions and maintained believability. Close attention was paid to ***micro-details*** such as *body language, eye gaze, and lip synchronization*, as these subtle cues heighten realism and strengthen learners' emotional connection with the material.

Lighting and shading were then refined to balance aesthetics with narrative intent. Each scene was evaluated for highlights, shadows, and reflections, ensuring that visual depth supported both the mood and the clarity of the massage demonstration. Subtle ***visual effects*** were incorporated such as dust particles, environmental textures, or ambient details to enhance

atmosphere without overwhelming the instructional focus. Color grading and correction further established tone and mood, drawing on principles of ***color theory*** to align visual aesthetics with the learning objectives (See Figure 5).

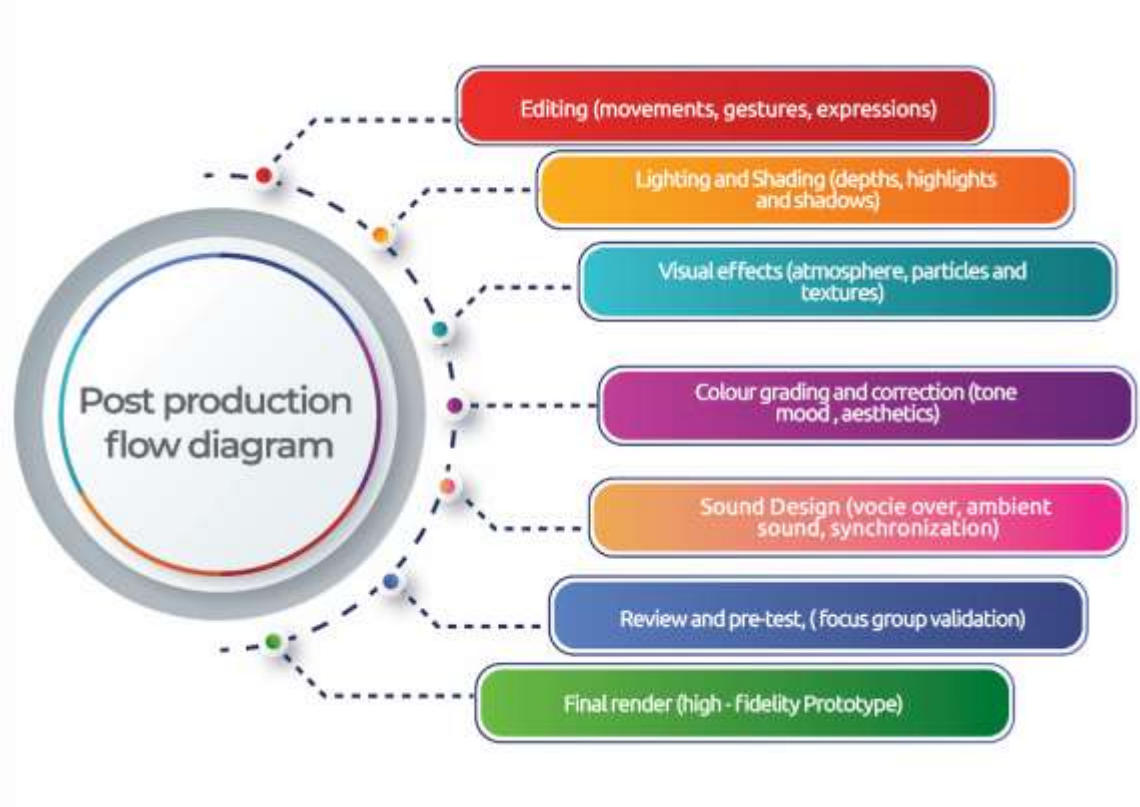

Figure 5: Post-production flow diagram.
Source: Authors' own construct, adapted from animation post-production pipeline frameworks.

Sound design was a critical parallel process. Voiceovers were recorded using the script as a guide, allowing characters' dialogue to align with on-screen actions. This audio layer was enriched with ambient sounds and synchronized precisely with movements to create a cohesive sensory experience. The combination of narration, sound effects, and music elevated the animation beyond visual engagement, making it multisensory and immersive.

Before final rendering, the animation underwent iterative reviews involving both the technical team and a small focus group of nursing students. This pre-test not only identified technical adjustments but also offered valuable user feedback that informed refinements to pacing, clarity, and emphasis. Such integration of ***case study evaluation within the design pipeline*** reflects best practices in design research, ensuring that creative outputs are validated in authentic learning contexts.

Ultimately, post-production transformed the animation into a high-fidelity instructional prototype. The final resource balanced ***technical precision, narrative flow, and pedagogical intent,*** creating an engaging educational tool that communicates complex healthcare procedures in a visually accessible and emotionally resonant way (see Figure 6).

Figure 6: High-fidelity prototype of 3D animation characters with excerpts from multimedia learning materials on pain management (video). Source: Authors' own construct.

3. Data Collection and Analysis

To explore participants' perspectives on the instructional value of the 3D animation, data were gathered using a structured questionnaire designed in alignment with the study's objectives. The instrument was first ***pretested with twenty nursing and midwifery students,*** which served as a formative design evaluation. Feedback from this pretest informed several refinements: simplifying ambiguous wording to ensure clarity, and incorporating ***Likert-scale items*** that captured attitudes, levels of agreement, and perceived effectiveness of the animation. This iterative refinement of the instrument reflects a design research mindset, where testing and adjustment are embedded into the development process.

The final questionnaire consisted of four sections. **Section A** captured demographic information such as age, academic year, and preferred modes of classroom communication, establishing context for interpreting responses. **Section B** focused on visual elements, particularly the colour choices and psychological impact of the animation, linking directly to theories of design aesthetics and learner attention. **Section C** evaluated sound and voiceover quality using a 5-point scale (1 = very poor, 5 = very good), ensuring alignment between auditory design and instructional clarity. **Section D** provided a holistic evaluation of the animation's overall quality, again using a 5-point Likert scale to allow comparative analysis across design dimensions.

Participants were recruited based on eligibility and provided informed consent before the viewing sessions. To foster a more interactive case study environment, fifty students were divided into ***five groups of ten,*** each experiencing the animation projected on screen with audio delivered through Bluetooth speakers. This group-based approach not only simulated a classroom setting but also allowed shared reflection and natural peer-to-peer discussion during and after the viewing.

Completed questionnaires were collected immediately after the session. Responses were entered into Microsoft Excel for cleaning and subsequently exported into **SPSS version 28** for analysis. Descriptive statistics, frequencies, ranges, and percentages were used to summarize the data. This analytical approach aligned with the pilot nature of the study, focusing on patterns of perception rather than inferential testing.

Positioning data collection and analysis within a ***design research framework*** underscores how empirical feedback closes the loop in the animation production pipeline. The structured evaluation of visual, auditory, and overall qualities directly informs future iterations, ensuring that the animation is not only technically polished but also pedagogically effective and contextually relevant.

3.1 Data collection procedures and design principles

The data collection procedures and questionnaire items were carefully structured to align with the study's objectives and design principles. Each section of the instrument was mapped against *Merrill's First Principles of Instruction* and multimedia learning theory to ensure that the evaluation captured not only participants' perceptions but also the instructional effectiveness of the 3D animation. This alignment provided a structured way to connect learner feedback with the underlying design choices that informed the animation's development.

Table 1 presents this mapping in detail, illustrating how the questionnaire guided data collection while simultaneously reflecting key design principles and instructional theory. The table thus provides clarity on how empirical feedback was embedded within the *design research framework*, ensuring that the evaluation of visual, auditory, and overall qualities was both systematic and theoretically grounded (refer to Table 1 on the next page).

Table 1: Alignment of Questionnaire Sections with Design and Instructional Principles

Questionnaire Section	Focus Area	Design/Instructional Principle Alignment	Rationale in Study Context
Section A: Demographics	Age, academic year, preferred mode of communication	**Learner-Centered Design** (Know your audience; Merrill's *Activation*)	Understanding learners' backgrounds and communication preferences ensures that the animation design is tailored to their context and learning styles.
Section B: Visual and Colour Psychology	Evaluation of visuals, colours, and aesthetics	**Multimedia Learning Theory** (Mayer, 2001); **Colour Psychology in Design**	Colours and visuals influence attention, retention, and emotional engagement. Evaluating these ensures the animation supports comprehension and medical realism.
Section C: Audio and Sound Effects	Voiceover clarity, sound quality, synchronization	**Dual-Coding Theory** (Paivio); **Merrill's Demonstration Principle**	Sound and narration enhance verbal representation and support visual content. Clear voiceover ensures accurate transmission of complex medical concepts.
Section D: Overall Animation Quality	Holistic evaluation of animation as an instructional tool	**Merrill's Integration Principle**; **Constructive Alignment in Design**	Learners assess the overall effectiveness, reflecting whether the animation successfully integrates visual, auditory, and narrative elements into a coherent instructional experience.

3.2 Ethical Considerations

Ethical approval for the study was granted by the Committee on Human Research, Publication and Ethics (CHRPE) of the School of Medicine at KNUST. In addition, administrative clearance was obtained from the Head of the Department of Nursing to ensure institutional accountability. Prior to recruitment, all participants were provided with clear written information about the study and gave informed consent. This process emphasized transparency, ensuring that participants understood the purpose of the research, the procedures involved, and their freedom to decline or withdraw at any stage without penalty or coercion.

Protecting participants' autonomy was central to the research design. Students were assured that participation was entirely voluntary and that their responses would remain anonymous, with data reported in aggregate form to safeguard privacy. Such practices align with ethical standards in both health and design research, where the focus extends beyond compliance to building *trust, respect, and equity* in participant engagement.

Within the context of *design-based educational research,* ethics is not only about formal approval but also about cultivating a participatory environment where learners feel empowered to share authentic feedback. In this study, the use of informed consent and confidentiality protocols ensured that students' perspectives on the 3D animation were treated as valuable contributions to the iterative design process. This approach underscores the *human-centered orientation of design practice,* where participants are not passive subjects but active collaborators in shaping multimedia learning tools (See Table 2).

Table 2: Ethical Practices Aligned with Human-Centered Design Principles

Ethical Practice	Description in Study	Aligned Human-Centered Design Principle	Contribution to Design Quality
Ethical Approval & Administrative Clearance	Approval from CHRPE and Department of Nursing	**Accountability & Transparency**	Establishes credibility, ensuring that the design process is grounded in responsible research practices.
Informed Consent	Participants received clear information and voluntarily agreed to take part	**Respect for Autonomy**	Empowers learners as decision-makers, fostering trust and willingness to provide authentic feedback.
Right to Withdraw	Participants could discontinue at any time without penalty	**Empowerment & Participation**	Reinforces participants' agency, positioning them as collaborators rather than passive subjects.
Anonymity & Confidentiality	Data reported without identifying information	**Privacy & Equity**	Ensures participants' voices are valued while protecting identity, encouraging honest and open responses.
Voluntary Participation	No coercion or pressure applied to join	**Human-Centered Engagement**	Builds a safe and inclusive environment for co-creating knowledge through design research.

4. Results

4.1 Demographic Characteristics of Participants

Fifty undergraduate nursing and midwifery students participated in the study, with ages ranging from 16 to 30 years. The largest group of respondents (70%, n=35) were between 21 and 25 years, while 18% (n=9) were aged 16–20 and 12% (n=6) were in the 26–30 age group. In terms of year of study, representation was fairly distributed, with 30% (n=15) in their final year, another 30% (n=15) in their third year, 22% (n=11) in the second year, and 18% (n=9) in the first year.

When asked about their preferred mode of communication in classroom teaching, a significant majority (76%, n=38) expressed a preference for ***multimedia-based instruction.*** Visual-only approaches were favored by 20% (n=10), while 4% (n=2) mentioned advertising or promotional methods. The strong preference for multimedia underscores the growing relevance of ***interactive and digital formats*** in higher education, particularly among health professional students who must bridge theoretical and practical knowledge.

These characteristics highlight not only the youthful demographic of the participants but also their alignment with contemporary digital learning trends. The data suggests that this cohort is well-positioned to engage with ***3D animation as an instructional medium,*** reinforcing the value of designing learning resources that are both technologically immersive and pedagogically effective (see Table 3).

Table 3: Participants' background characteristics.
(Source: Authors' survey data)

Variable	Frequency (%)
Age Group	
16–20	9 (18.0)
21–25	35 (70.0)
26–30	6 (12.0)
Year Group	
First Year	9 (18.0)
Second Year	11 (22.0)
Third Year	15 (30.0)
Fourth Year	15 (30.0)
Preferred Mode of Communication in Teaching	
Multimedia	38 (76.0)
Visual	10 (20.0)
Advertising	2 (4.0)

4.2 Visual and Colour Psychology

Participants' responses revealed a strong alignment between the animation's visual design choices and their intended instructional purposes. An overwhelming majority (92%, n=46) agreed that the colours used in the animation accurately represented their natural counterparts, reinforcing ecological validity and making the scenes appear more authentic. This authenticity is crucial in healthcare education, where learners need to perceive instructional materials as both credible and realistic.

In terms of perceptual clarity, 88% (n=44) indicated that subjects were well distinguished from their backgrounds. Clear figure–ground separation is an important design principle, as it reduces cognitive load and ensures that learners focus on key instructional actions rather than being distracted by visual clutter. Additionally, most participants (86%, n=43) reported that the colour palette created a **cooling effect**, which may have contributed to a calming and professional tone suitable for demonstrating a clinical intervention such as paediatric massage. A smaller group (12%, n=6) perceived a warming effect, while one participant (2%) found it difficult to interpret. This variability highlights the subjective nature of colour perception and suggests opportunities for further refinement in balancing emotional and functional aspects of design.

Perhaps most importantly, nearly all participants (98%, n=49) felt that the colours successfully portrayed the environment as a **medical scene**. This finding underscores the effectiveness of visual cues in establishing contextual realism, which is essential for bridging theory and practice in nursing and midwifery education.

Collectively, these results affirm that **colour and visual psychology are not merely aesthetic choices but instructional strategies**. When carefully applied, they enhance learner focus, foster emotional engagement, and reinforce the authenticity of simulated clinical environments (see Table 4).

Table 4: Perspectives on visual and colour psychology.
(Source: Authors' survey data, 2023)

Variable	Frequency (%)
Do the colours used represent what they stand for in nature?	
Yes	46 (92.0)
No	4 (8.0)
Are subjects well distinguished from their background?	
Yes	44 (88.0)
No	6 (12.0)
What effect do the colours portray at a glance?	
Cooling effect	43 (86.0)
Warming effect	6 (12.0)
Hard to tell	1 (2.0)
Do the colours help to portray the environment as a medical scene?	
Yes	49 (98.0)
No	1 (2.0)

4.3 Audio and Sound Effects

Participants' responses highlighted the central role of sound design in shaping the instructional quality of the animation. A strong majority (88%, n=44) reported that the voiceover was sufficiently audible, confirming that the narration achieved basic intelligibility. However, six participants (12%) indicated challenges with audibility, suggesting opportunities for refinement in future iterations.

When asked to rate the clarity of the voiceover using a 5-point scale (1 = very poor, 5 = very good), most participants (70%, n=35) rated it as **very good**, while 22% (n=11) rated it as **good**, and only 8% (n=4) rated it as **intermediate quality**. This distribution produced a **median score of 5** with a **range of 3–5**, indicating that while the majority experienced optimal clarity, a small subset found it less effective. The median score reinforces that clarity was consistently perceived at a high level, yet the range suggests variability in user experiences as an important insight for refining voice modulation and audio balancing.

Equally important, 92% (n=46) reported that no **environmental noise** was present, confirming the technical cleanliness of the recording. Similarly, 92% (n=46) indicated there was no interference between the voiceover and background music, suggesting that the layering of audio elements was well balanced and did not distract from instructional delivery. Finally, almost all participants (92%, n=46) confirmed that no familiar or external sounds from other creators were detected, affirming the originality of the production.

Overall, these findings demonstrate that **sound design in educational animation extends beyond audibility, it functions as a design strategy to guide attention, reduce cognitive load, and enhance learner immersion**. The overwhelmingly positive responses suggest that the animation successfully adhered to key principles of **multimedia learning theory** (Mayer, 2001), where *narration, sound effects*, and *background music* must complement rather than compete with visual information (Table 5).

Table 5: Perspectives on audio and sound effects.
(Source: Authors' survey data, 2023)

Variable	Frequency (%)
Is the voiceover in the video audible enough?	
Yes	44 (88.0)
No	6 (12.0)
Rate the clarity of the words pronounced in the voiceover (1–5)	
3 (Intermediate quality)	4 (8.0)
4 (Good quality)	11 (22.0)
5 (Very good quality)	35 (70.0)
Do you notice any environmental noise in the audio?	
Yes	4 (8.0)
No	46 (92.0)
Interference between the voiceover and the background music?	
Yes	4 (8.0)
No	46 (92.0)
Is there any familiar sound from another creator in this animation?	
Yes	4 (8.0)
No	46 (92.0)

4.4 Total Evaluation of Animation

Participants' overall assessments of the animation highlight both the technical quality and its effectiveness as an instructional design resource. When asked to rate **sound quality**, the majority (70%, n=35) gave the highest score of "5" (very good), while 22% (n=11) rated it as "4" (good) and 8% (n=4) rated it as "3" (intermediate). This distribution produced a **median of 5** with a **range of 3–5**, confirming that sound quality was consistently perceived as high, though a few participants experienced it as less than optimal.

Similar patterns were observed for **modelling and overall quality**. Both categories received a median score of **5**, with the same range of **3–5**. The predominance of top ratings indicates that the animation's technical execution, covering aspects such as character modelling, textures, and environmental design was well-received, while the range suggests opportunities for refinement to achieve greater uniformity in user experience.

In terms of motion design, almost all participants (98%, n=49) affirmed that the **motions followed animation principles**, such as timing, exaggeration, and ease-in/ease-out. Likewise, 98% (n=49) confirmed that the **actions in the animation were easily interpretable**. These findings are especially important within the context of design research, as they validate the effectiveness of the **animation production pipeline** in producing sequences that are both visually coherent and pedagogically meaningful.

Collectively, the results affirm that the animation achieved its intended purpose as a **high-fidelity instructional prototype**. Strong evaluations across sound, modelling, and motion confirm that design decisions made during pre-production, production, and post-production effectively translated into a tool that was technically polished and educationally clear. This convergence of **aesthetic quality, design principles, and instructional clarity** underscores the potential of 3D animation to serve as an immersive and reliable medium for healthcare education (see Table 6).

Table 6: Total evaluation of the animation.
(Source: Authors' survey data, 2023)

Variable	Frequency (%)
Rate the sound quality in the animation	
3 (Intermediate)	4 (8.0)
4 (Good)	11 (22.0)
5 (Very good)	35 (70.0)
Rate the modelling made in this animation	
3 (Intermediate)	4 (8.0)
4 (Good)	11 (22.0)
5 (Very good)	35 (70.0)
Do the motions in this video follow animation principles?	
Yes	49 (98.0)
No	1 (2.0)
Can the actions in this video be easily interpreted by the viewer?	
Yes	49 (98.0)
No	1 (2.0)
Rate the overall quality of this animation	
3 (Intermediate)	4 (8.0)
4 (Good)	11 (22.0)
5 (Very good)	35 (70.0)

5. Discussion

This study set out to examine the perspectives of undergraduate nursing and midwifery students on the use of 3D animation as an instructional resource for paediatric massage, a non-pharmacological pain management intervention for children. Findings consistently suggest that well-designed multimedia elements such as visuals, colour, sound, and motion contributed to positive learning experiences and reinforced the animation's educational value.

Visual and colour design played a critical role in shaping learners' perceptions. The majority of participants confirmed that colours reflected their natural counterparts and effectively distinguished subjects from their backgrounds. This aligns with ***Merrill's demonstration principle***, which stresses the importance of showing learners clear, authentic representations of concepts. When visual cues are distinct, learners can direct their attention more efficiently, reducing extraneous cognitive load and improving comprehension (Mayer, 2014). The reported *"cooling effect"* of the visuals also suggests that colour design supported a calming and professional atmosphere, reinforcing the authenticity of the medical setting. Such affective qualities of design are particularly important in healthcare education, where realism and contextual accuracy help bridge theory and practice (Dhar et al., 2021; Wang & Ji, 2021).

Audio and sound effects also emerged as vital contributors to instructional effectiveness. Most participants rated the voiceover as clear and free from interference with background music, with median ratings of **5** across sound quality measures. This outcome reinforces ***Merrill's activation and application principles***, as clear narration helps learners build on prior knowledge while engaging with new skills. Balanced audio ensures that learners process verbal explanations alongside visual demonstrations without distraction, a finding consistent with multimedia learning theory (Yang, Jiang, & Zhao, 2017; Lange & Costley, 2020).

Evaluation of technical quality including sound, modelling, and overall animation, was also highly positive, with a strong majority assigning the highest possible rating. Such consistency reflects that the design pipeline successfully operationalized the ***application principle,*** enabling learners to engage with accurate, high-fidelity representations of paediatric massage. Furthermore, nearly all participants reported that the animation's motions adhered to animation principles and were easily interpretable. This is significant, as ***Merrill's integration principle*** emphasizes reflection and transfer of skills to real-world contexts (Figure 7). Clear and interpretable animations allow learners to mentally rehearse procedures and apply them in clinical practice (Chiou, Tien, & Lee, 2014; Rekik et al., 2020).

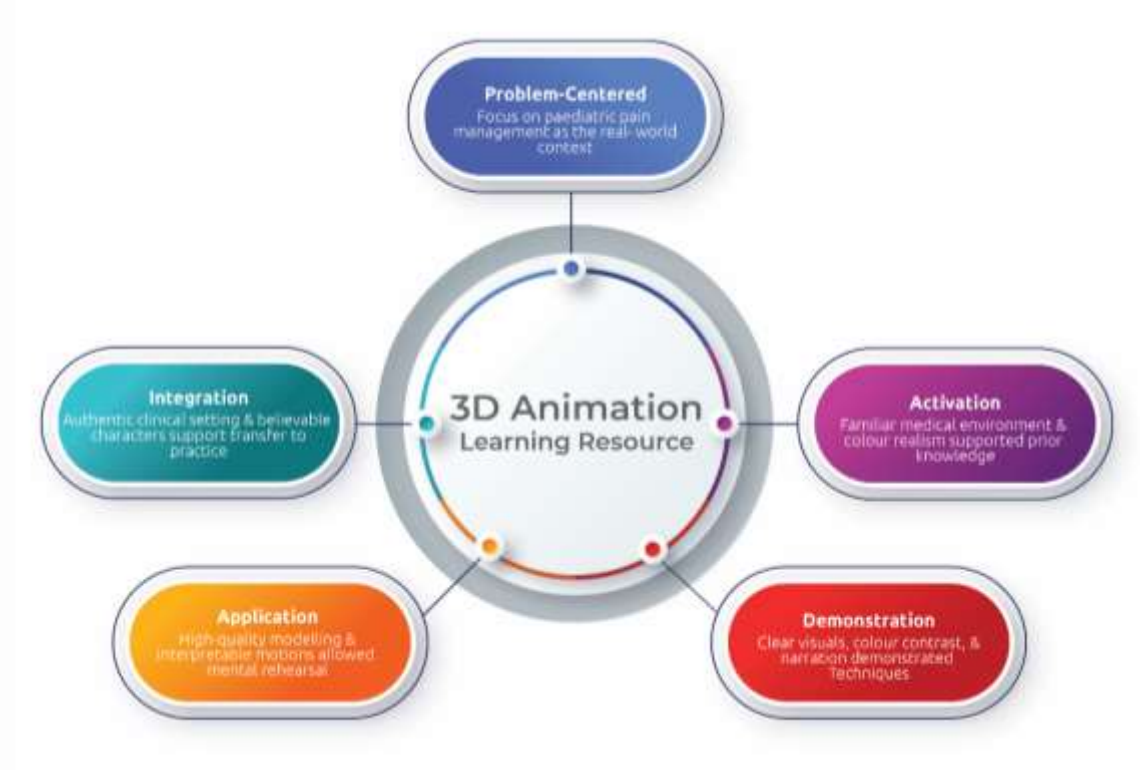

Figure 7: Conceptual framework – mapping study findings onto Merrill's First Principles of Instruction. Source: Authors' own construct, adapted from Merrill (2013).

In summary, these findings position 3D animation as more *than* an engaging medium, it serves as a ***design-driven educational intervention*** that embodies Merrill's First Principles of Instruction (Figure 7). The resource was problem-centered (addressing paediatric pain), activated prior learning (through familiar settings), demonstrated skills (via clear visuals and narration), allowed mental application (through interpretable motions), and supported integration (through contextual realism).

Overall, the study highlights the value of integrating design research into healthcare education. Well-executed multimedia does not simply enhance aesthetics; it directly contributes to ***learner engagement, comprehension, and skill transfer.*** The overwhelmingly positive reception among students suggests that 3D animation can be a powerful instructional tool for nursing and midwifery education, particularly in bridging the gap between classroom learning and clinical application.

5.1 Limitations

Several limitations should be considered in interpreting the findings of this pilot study. First, the study engaged only 50 participants, which, while sufficient for an exploratory pilot, restricts the generalizability of the results to wider nursing and midwifery populations. A larger, more diverse sample would be necessary to validate the findings.

Second, the study was conducted at a single university site. Contextual differences across other nursing programs, healthcare institutions, and cultural settings may influence perceptions of 3D animation as a teaching tool, limiting external validity.

Third, the absence of a control group prevented direct comparison between 3D animation and other instructional approaches (e.g., lectures, demonstrations, or traditional videos). A comparative design could have more clearly demonstrated the relative effectiveness of animation as a pedagogical intervention.

6. Conclusion and Recommendations

This study demonstrates that 3D animation was positively received by undergraduate nursing and midwifery students as an educational resource for paediatric massage. Students affirmed the importance of ***colour realism, visual clarity, sound quality, and motion design*** in enhancing comprehension, emotional engagement, and contextual authenticity. These findings align with ***Merrill's First Principles of Instruction,*** showing how animation can (1) situate *learning in real-world problems (paediatric pain),*

(2) activate prior knowledge through familiar environments, (3) demonstrate techniques clearly, (4) enable learners to mentally rehearse and apply concepts, and (5) support integration into future clinical practice.

The study contributes to the growing body of evidence on multimedia in healthcare education and highlights the potential of ***design-driven instructional resources*** in improving training for non-pharmacological interventions such as paediatric pain management (Figure 8).

Figure 8: Design–Instruction–Education model for 3D animation in nursing and midwifery education. Source: Authors' own construct.

Future research should:

- Employ larger and more diverse samples, including professional nurses, midwives, and patients.
- Introduce control or comparison groups to evaluate the relative effectiveness of animation.
- Conduct longitudinal studies to assess knowledge retention, skill transfer, and clinical application.
- Explore co-design approaches with learners and practitioners to refine animation aesthetics, interactivity, and cultural adaptation.

6.1 Practical Implications for Nursing Education and Design

The findings of this study have several practical implications:

1. For Nursing Education:

    - 3D animation can serve as a ***supplementary teaching resource*** to traditional methods, offering visual clarity and emotional resonance that support knowledge transfer.

- Multimedia resources enhance learners' engagement, reduce cognitive overload, and provide memorable learning experiences in complex areas such as paediatric pain management.
- Nursing curricula could integrate animation into skills laboratories and blended learning modules to better bridge theoretical knowledge with clinical practice.

2. For Design Practice:

- The study demonstrates the value of **design research methodologies** such as storyboarding, animatics, iteration, and evaluation in creating healthcare education tools.
- Animation designers must pay attention ***to colour psychology, sound balance, and motion fidelity,*** as these design choices directly impact learners' comprehension and trust in instructional resources.
- Collaborative, interdisciplinary design teams (educators, healthcare experts, and animators) should be encouraged to ensure that multimedia tools are both pedagogically effective and contextually relevant.

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