International Journal *of* Designs for Learning
2026 | Volume 17, Issue 1 | Pages 1-13

NAVIGATING THROUGH MULTIMEDIA PRINCIPLES TO DESIGN PSYCHOMOTOR NURSING SKILL DEMONSTRATION VIDEOS

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In health professions education, real-life demonstrations are a common method for teaching psychomotor skills on campus. However, they present challenges such as limited visibility and time constraints. For Generation Z students, who prefer visual learning environments, demonstration videos offer a promising alternative, benefiting from the ease of production, sharing, and access to video-based content. Mayer's Cognitive Theory of Multimedia Learning provides a foundational framework for designing instructional videos, emphasizing multimedia principles to enhance learning. However, the concrete application of these principles to demonstration videos for psychomotor skills in health professions education remains underexplored. This design case details the design and production process of demonstration videos for novice nursing and midwifery students to learn new psychomotor nursing skills, such as venipuncture. We developed a series of videos that integrate multimedia principles to minimize cognitive overload, optimize essential processing, and support generative processing. The challenges encountered during this process are discussed, emphasizing the importance of collaboration with audiovisual experts for technical support and content experts for refining script-writing and recordings of the skill demonstrations. Through this design process, we gained insight into how multimedia principles were operationalized within the development of psychomotor skill demonstration videos. We developed a series of videos informed by multimedia principles to reduce cognitive overload and support meaningful processing. The resulting checklist continues to guide our ongoing video production and informs our internal evaluation of design decisions.

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A publication of the Association for Educational Communications & Technology (AECT), published by Indiana University Libraries Journals.

https://doi.org/10.14434/ijdl.v17i1.41167

INTRODUCTION

Teaching psychomotor nursing skills (PNS), such as venipuncture and injections, is a core component of nursing and midwifery education. These skills require structured instructional approaches that integrate foundational knowledge with guided demonstration practice (Nicholls et al., 2016; Sawyer et al., 2015). Traditionally, PNS instruction combines evidence-based step-by-step procedures (Vermeulen, 2019) with synchronous, real-life demonstrations in which lecturers model the skill and students observe and imitate the procedure (Bandura, 1986). While real-life demonstrations enable interaction and immediate clarification (Ali & John, 2019), they also present practical and pedagogical constraints, including limited visibility, time-intensive preparation, risk of performance errors, and potential cognitive overload (Kestin et al., 2020; Thilakumara et al., 2018).

At Thomas More University of Applied Sciences (Lier, Belgium) institutional constraints, such as limited classroom availability and increasing costs, have reduced opportunities for synchronous demonstrations. Concurrently, students report that paper-based procedures (Vermeulen, 2019) are insufficiently supportive of their learning. This may be related to the characteristics of Generation Z healthcare students, who are often described as digitally oriented learners preferring visual formats (Shorey et al., 2021). Video-based instruction allows learners to regulate pace, pause, and replay content, and benefit from optimal camera positioning (Ali & John, 2019; Brame, 2016; Clerkin et al., 2022; Forbes et al., 2016; Köster, 2018; Mayer, 2014; Sugathapala & Chandrika, 2021).

Although video demonstrations are widely adopted in health professions education, their instructional design is often insufficiently grounded in learning theory. As designers engaged in a theory-informed design process, we approached video development not as a simple technological substitution for live teaching, but as a pedagogical design challenge. Our work is situated within the Cognitive Theory of Multimedia Learning (CTML), which posits that meaningful learning occurs when learners actively process words and pictures through dual cognitive channels under limited working-memory capacity (Mayer, 2014; Mayer & Fiorella, 2022). CTML proposes empirically supported multimedia principles (MPs) that guide the design of instructional materials. However, applying these principles to dynamic demonstration videos requires careful adaptation, as video introduces temporal, attentional, and perceptual complexities not present in static media (Fyfield et al., 2022; Mayer, 2021).

Demonstration videos represent a specific subtype of instructional videos in which *"the instructor demonstrates how to do something"* (Köster, 2018; Mayer et al., 2020). While evidence indicates that instructional videos can produce stronger learning outcomes than static images (Castro-Alonso et al., 2019), limited research explicitly addresses how multimedia principles should be operationalized in demonstration videos for psychomotor skill acquisition. Moreover, emerging evidence suggests that design features such as camera perspectives may influence learning processes, with first-person perspectives potentially facilitating sensorimotor alignment more effectively than third-person perspectives (Fiorella et al., 2017; Jackson et al., 2006; Mayer et al., 2020).

This manuscript presents a design case documenting the theory-informed development of psychomotor nursing skill demonstration videos. We explicate the pedagogical rationale, theoretical grounding, design decisions, production processes, and challenges encountered while translating multimedia principles into a health professions context. The design work was conducted in preparation for an ongoing research trajectory examining didactic success factors in video-based PNS instruction (Leysens, 2022-2026).

DESIGN PROCESS

In developing our demonstration videos for novice nursing and midwifery students, we identified several key aspects that required explicit design decisions across different phases (see Figure 1).

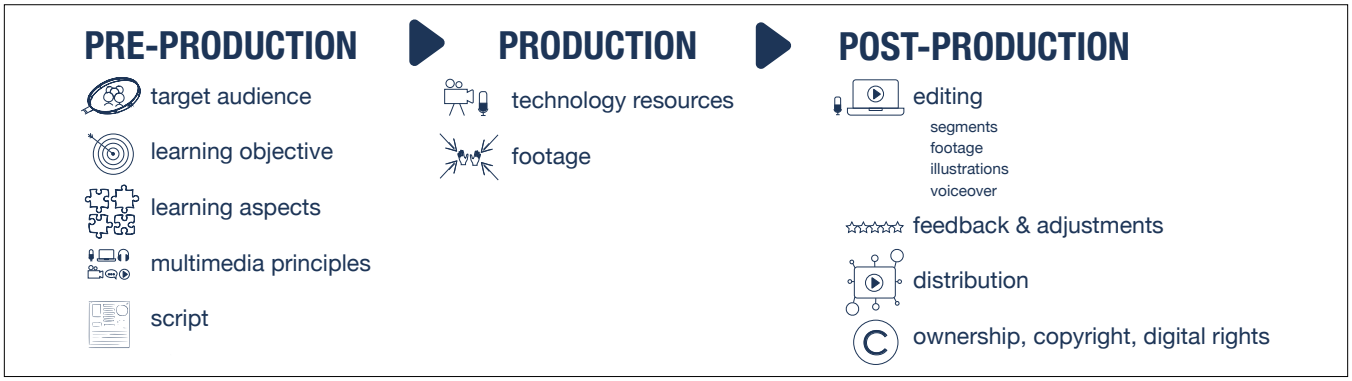

FIGURE 1. Phases of the video designing and production process.

The design process took place between January 2022 and April 2023. From January to June 2022, we conducted an extensive literature review, explored technological resources, and familiarized ourselves with editing software. From August 2022 to April 2023, our focus was on creating videos, which included scriptwriting, recording, editing, and incorporating stakeholder feedback. More details are described in the following paragraphs.

Phase 1: Pre-Production

Target Audience

Nursing and midwifery students learning new PNS are considered novices. According to Benner (1982), students progress from novice to expert, noting that *"since novices have no experience with the situations they face, they must rely on context-free rules to guide their task performance."* Because our target audience consisted of novice learners, who rely heavily on context-free rules, we deliberately structured the videos to be visually guided and stripped of unnecessary contextual complexity.

Learning Objective

PNS are movement-oriented and vary in complexity (Oermann et al., 2016), such as hand disinfection, subcutaneous or intramuscular injections, various types of wound care, venipuncture, peripheral catheterization, and bladder catheterization (Vermeulen, 2019). Performing these skills requires *"the ability to carry out a predetermined task efficiently and effectively using correct movements. It is more than the ability to perform; it also includes the ability to perform proficiently and consistently under varying conditions"* (Martins et al., 2018). While nursing skills encompass not only technical proficiency but also affective competencies, such as patient communication and teamwork, this research project specifically focuses on the psychomotor component of nursing skill acquisition. This initial focus on task execution for novice students precedes the clinical reasoning process ultimately required to apply PNS in the authentic real-world healthcare settings (Oermann et al., 2016). The automation of the psychomotor component is crucial in nursing and midwifery practice, as it allows students to perform efficiently under pressure.

When introduced to a new PNS, students first develop an understanding of its purpose, required equipment, and procedural steps (Vermeulen, 2019). This fundamental knowledge is acquired by observing live or recorded demonstrations by experts, who explain the rationale, implications, and correct execution of the PNS. We therefore designed the videos to provide a clear and highly visible demonstration, breaking each skill into manageable sequential steps (Burgess et al., 2020). By choosing an asynchronous video format, we enabled repeated exposure and structured guidance, which we expect will support automation of PNS acquisition.

Learning Aspects

Mastering new PNS imposes a significant intrinsic cognitive load, as learners must process multiple elements simultaneously in their working memory (Sweller, 1988). To reduce extraneous cognitive load, we deliberately minimized visual and auditory elements that did not directly support task execution. Novice students, with limited clinical experience, lack schemas in long-term memory (Benner, 1982), making effective instructional guidance essential to support learning while reducing cognitive load. We aimed to support transfer to long-term memory, as retention depends on learners being able to retrieve stored information efficiently (Bennett & Rebello, 2012). Mayer's CTML (Mayer, 2014; Mayer & Fiorella, 2022) provides a powerful framework for optimizing meaningful learning by applying MPs that enhance instructional effectiveness.

Multimedia Principles

Recent evidence provides 31 relevant MPs to design instructional videos (Fyfield et al., 2022; Mayer, 2021); however, many studies lack comprehensive descriptions of the media used (Fyfield et al., 2022). This gap can lead to varied interpretations when applying MPs to educational videos. Application of MPs specifically for PNS demonstration videos remains underexplored. As demonstration videos are a specific type of instructional videos, we encountered challenges in applying the 31 MPs, originally designed for instructional videos, to our PNS demonstration videos. To translate these principles into concrete design decisions, we developed a checklist as a working guide for our own video development process. In the first phase, we listed and formulated the 31 MPs into clear, structured propositions, ensuring consistency with their original formulation. In the second phase, we sought content validity by gathering feedback from eight experts at KU Leuven University (Belgium), leading to refinement or omission of certain propositions. As a result, our final checklist comprises 24 MPs specifically tailored for PNS demonstration videos (see Table 1).

Throughout the design process, we used this checklist to guide our decisions during scripting, recording, and editing. A detailed overview of how the 24 MPs were applied is shown in Appendix A. To illustrate their application, relevant MPs will be referenced in parentheses throughout the text.

Script

We used a detailed script as a blueprint to structure each video's timeline, detailing both audio and corresponding visual elements (Castillo et al., 2021). Using a script reduced errors and retakes during recording and ensured consistency across similar PNS demonstrations. The script now provides a structured foundation should future revisions be required (Norman, 2017).

EXTRANEOUS PROCESSING PRINCIPLES*			APPLIED? (YES, NOT ALWAYS, NO)
1	Coherence	Irrelevant spoken or written words and images are excluded.	
2	Signaling	Cues are added to highlight or spotlight key information.	
3	Redundancy	The same information is not presented in written sentences and spoken narration simultaneously.	
4	Spatial contiguity	Related written words and images are presented in close physical proximity.	
5	Temporal contiguity	Related spoken words and images are presented simultaneously.	
6	Segmenting	The message is presented in learner-paced, meaningful segments.	
7	Background music	Irrelevant background music is excluded.	
8	Audio quality	Audio is clear, with no hissing or interference.	
9	Video length reduction	The video is as concise as possible while maintaining clarity.	
10	Perspective (1st superior)	The video is shot from the learner's point of view.	
11	Presenter's face	When alternative complex visuals are displayed, the presenter's face is excluded.	
12	Sound effects	Irrelevant sound effects are excluded.	
ESSENTIAL PROCESSING PRINCIPLES *			
13	Pre-training	Key vocabulary is presented at the beginning of the video.	
14	Modality	Written words are used exclusively for key definitions, lists, and directions.	
15	Multimedia	Relevant words and images are combined meaningfully and logically.	
16	Speech rate (fast superior)	Speech rate is faster than common conversational speaking rates.	
17	Transience	Relevant words and images are presented at the right time and pace.	
18	Learner control	The learner has control over playback, pause, and play forward.	
19	Reviews	The video concludes with a summary of the content.	
GENERATIVE PROCESSING PRINCIPLES *			
20	Personalization	A personal conversational style is employed in the narration.	
21	Voice principle	Spoken words are recorded in an appealing, natural voice.	
22	Embodiment principle	If relevant, human-like gestures and movements are displayed.	
23	Self-explanation	The video prompts the learner to explain the learning goal.	
24	Integrated learning activities	Practice activities are integrated either during pauses in the presentation or following the video.	

TABLE 1. Checklist to evaluate the design of asynchronous PNS demonstration videos.
* Based on multimedia principles of Mayer (2021) and Fyfield et al. (2022).

Guided by insights from the online training platform Multimedia and Learning (KU Leuven Multimedia and Learning, 2025), a script protocol was developed. A template was created (Appendix B) to provide a standardized framework for developing all the PNS video scripts, ensuring coherence and instructional effectiveness. The 24 MPs were kept in mind during the scriptwriting process. For each PNS, a narrative text was prepared based on the existing paper-based step-by-step procedures of Thomas More (Vermeulen, 2019). We adopted a conversational tone, directly addressing students using 'you' rather than impersonal phrasing (MP 'personalization'). Preparing a

well-structured narrative text in advance allows for narration during recordings, ensuring that the footage and narration align effectively. It also facilitates a smooth and well-paced voiceover delivery (MP 'coherence'; MP 'speech rate').

Whereas phase 1 focused on conceptual and theoretical design decisions, phase 2 represents the translation of those decisions into concrete production choices. In phase 2, the checklist functioned as an operational design guide, informing camera position, editing, pacing, signaling, and graphical elements.

Phase 2: Production

In this phase, we enacted the theoretical and conceptual decisions from phase 1 through concrete production choices.

Technology Resources

To record the PNS footage, two Marshall miniature full-HD cameras (Marshall, 2023) are strategically positioned to capture both front and top views of the lecturer demonstrating the PNS on a task trainer in the skills lab. The footage from both cameras is recorded using an Epiphan Pearl mini system (Epiphan Systems Inc., 2023). We deliberately chose to work with the existing technological resources already available within the institution. This decision ensured technical feasibility, compatibility with campus infrastructure, and ongoing support from audiovisual staff. Figure 2 shows the setup for recording the venipuncture video. Audio is not recorded during the demonstrations, as we opted for a scripted voiceover in the final version. This choice eliminates background noise and ensures clear narration (MP 'sound effects').

Footage

Each PNS is demonstrated by a nursing lecturer who teaches the specific skill to first-year bachelor's students in nursing or midwifery at Thomas More. We intentionally excluded the lecturer's face to keep visual attention on the psychomotor hand movements (MP 'embodiment principle'; MP 'presenter's face') and to avoid unnecessary visual competition.

As part of our broader research trajectory (Leysens, 2022-2026), we designed variations of selected PNS videos. For intramuscular (IM) injection and venipuncture, we produced videos filmed from the lecturer's perspective, closely replicating the positioning typically used during live classroom demonstrations. For hand disinfection and wound care, we created both first-person and third-person versions. This decision allowed us to operationalize the multimedia perspective principle within our own design work and to reflect on how camera viewpoint shapes the learner's visual experience.

Additionally, we accounted for left- and right-handed students. Observing a demonstration by a same-handed or opposite-handed lecturer may influence learning, because cognitive load may increase, as students must mentally mirror the steps (Rohbanfard & Proteau, 2011). To minimize this effect, we produced separate versions of each PNS demonstration, performed by both a left-handed and a right-handed lecturer. The venipuncture videos (see Figure 3) demonstrating left-handed and right-handed performance are available online as examples.

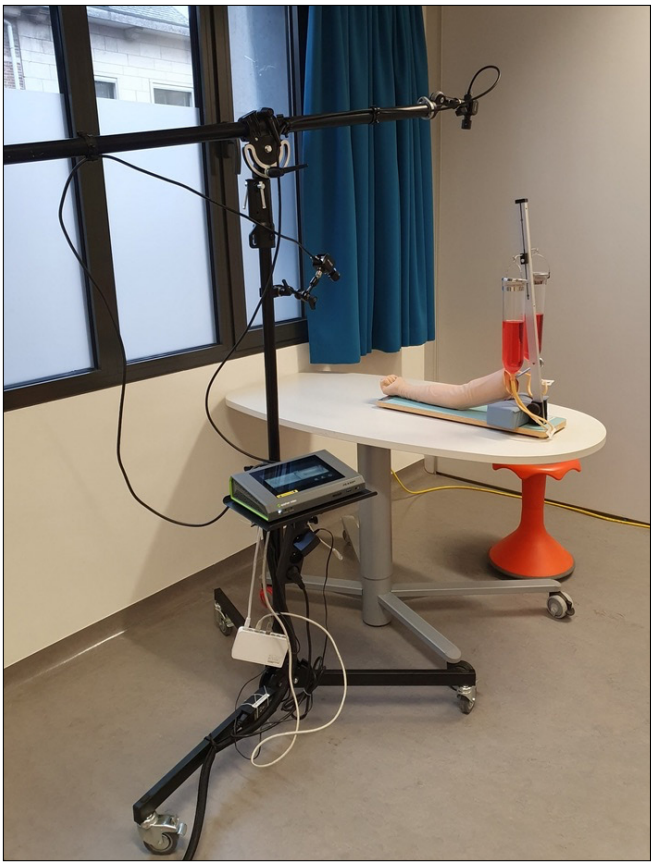

FIGURE 2. Camera set-up venipuncture.

FIGURE 3. QR video left-handed (left) and right-handed (right) demonstration venipuncture (Leysens, 2023a, 2023b).

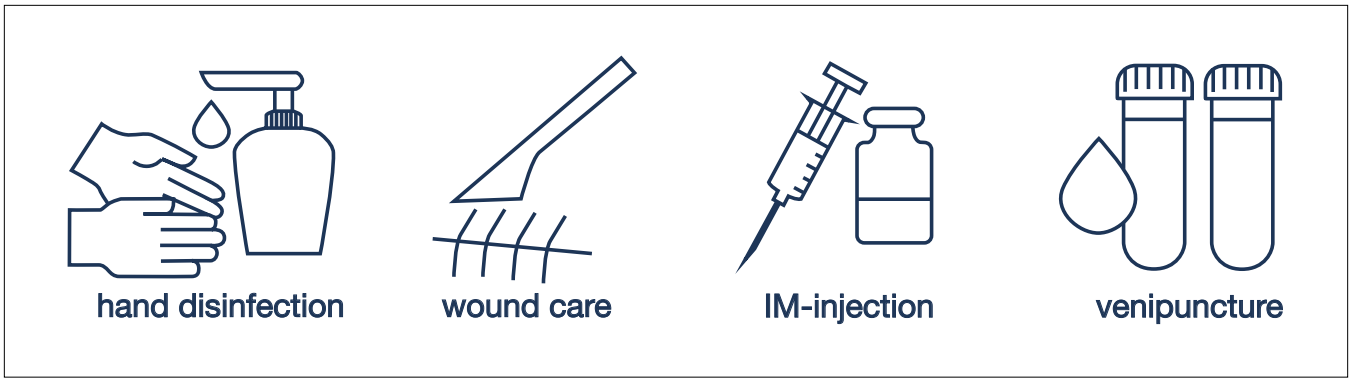

FIGURE 4. Line drawings of PNS.

Phase 3: Post-Production

Editing

To edit the videos, we used Adobe Premiere Pro (Adobe Inc, 2023b), and we used Adobe Illustrator (Adobe Inc, 2023a) to create line drawings. We deliberately opted for simplified line drawings to reduce visual complexity and prevent cognitive overload (MP 'coherence') (see Figure 4).

The voiceovers are recorded at a sound-insulated media room with a qualitative microphone (KU Leuven Mediarooms, n.d.) (MP 'audio quality'; MP 'voice principle'). Each video is structured into the same distinct segments, providing students with a clear and organized learning flow (MP 'transience'): intro, preparation, materials, execution, aftercare, summary and outro segment (MP 'segmenting'), which allows students to control playback, enabling them to pause, rewind, or skip to specific segments as wanted (MP 'learner control').

The next illustrations in the text are based on the video venipuncture for right-handed students (Leysens, 2023b).

The intro features the name of the PNS alongside a line drawing of the PNS, the handedness, and the logos of KU Leuven and Thomas More, indicating the ownership of the videos (see Figure 5).

In the preparation segment, we combined line drawings with spoken narration (MP 'redundancy') to guide students on key preparation aspects related to the caregiver, caretaker, materials, and room, with focus on essential considerations in general (see Figure 6).

The materials segment presents individual images of each required item for performing that specific PNS (see Figure 7), accompanied by spoken narration identifying each material (MP 'redundancy'). The segment concludes with an image displaying all materials together (MP 'pre-training').

In the execution segment, footage from both camera angles is uploaded to Adobe Premiere Pro. To present the

FIGURE 5. Intro video venipuncture (righthanded demonstration) Logos of KU Leuven and Thomas More, used with permission.

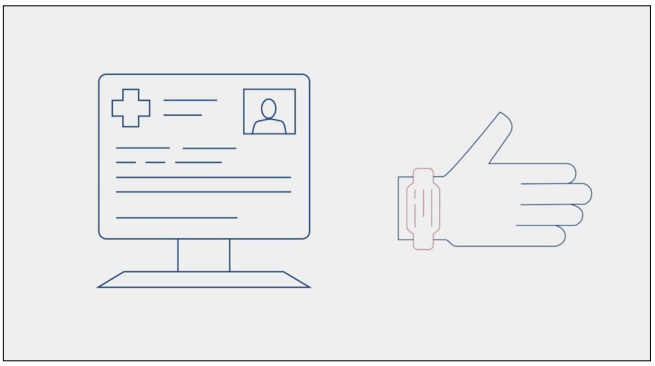

FIGURE 6. Example of line drawings to illustrate the preparation of the caretaker.

FIGURE 7. Example of an image of the material tourniquet.

FIGURE 8. Examples of footage from the top and front views.

consecutive steps of the PNS, the clearest view is selected for each step and edited chronologically (see Figure 8).

We accelerated steps that were not central to the learning objective (e.g., putting on gloves) to maintain attention and reduce unnecessary video length to keep the demonstration engaging (MP's video length reduction). A recurrent step in most PNS is hand disinfection, which is the first PNS that students acquire. The full performance is not shown, as it would unnecessarily extend the video (MP's video length reduction). Instead, a line drawing of hand disinfection symbolizes this step across all PNS videos (see Figure 9) and is shown at each time this step needs to be performed.

We combined footage and illustrations to maintain visual focus while reducing unnecessary complexity. We carefully selected concise signaling words (MP 'signaling') and positioned them close to the corresponding visual elements for clear and immediate association (MP 'spatial contiguity') (see Figure 10).

They appear simultaneously with the appropriate step (MP 'temporal contiguity'). We added lines and circles to direct students' attention to specific elements on the screen (MP 'signaling'). For guiding information that is relevant to the procedure but is not a psychomotor skill, we use a combination of illustrations, key words, and narration (MP 'modality') (see Figure 11).

In the aftercare segment, the same line drawings from the preparation segment are used, but now in combination with written words (MP 'redundancy') to pay attention to key aftercare aspects in general, related to the room, materials, caregiver, and caretaker.

In the summary segment, students are first prompted to recall the required materials (MP 'self-explanation'). This is followed by an image displaying all materials, as previously shown in the materials segment (MP 'reviews') (see Figure 12).

FIGURE 9. Line drawing of hand disinfection as a recurrent step in videos.

FIGURE 10. Example of a signaling word ('tube plaatsen' / 'insert blood tube').

FIGURE 11. Example of guiding information ('keuze arm' / 'choice of arm').

FIGURE 12. Example of MP 'self-explanation'.

FIGURE 13. Example of MP 'self-explanation' and MP 'reviews'.

FIGURE 14. Example of MP's integrated learning activities.

FIGURE 15. Outro video.

Next, students are asked to summarize all steps of the PNS based on the signaling words highlighted in the execution segment (MP 'self-explanation'). An overview of these words is then presented on the next screen (MP 'reviews') (see Figure 13).

Finally, students are encouraged to rewatch the video while using the practice materials provided by the campus (MP 'integrated learning activities') (see Figure 14).

The outro segment closely resembles the intro segment, but instead of displaying the name of the PNS, the word 'Success!' appears as an encouragement for the student to start practicing the PNS (see Figure 15).

Feedback & Adjustments

We created the PNS videos keeping in mind the 24 principles. To reduce subjective interpretation of the MPs within our team, we invited eight external experts from KU Leuven University (Belgium) and 24 fellow nursing and midwifery lecturers from Thomas More to review each video. To facilitate this process, we created an online version of the checklist using Microsoft Forms (Microsoft Corporation, 2023). This checklist was linked to a specific PNS demonstration video and shared with colleagues via email. Participants could watch the video and complete the online checklist simultaneously, selecting 'yes,' 'not always,' or 'no,' and provide qualitative suggestions in open fields. We tabulated the collected responses in Excel and discussed the necessary adjustments, such as simplifying signal words, clarifying pacing, and repositioning keywords. Several colleagues pointed out that "sometimes words are not identical or too long" and that "the steps in the review should use the same words as those shown earlier in the video." We therefore simplified the signal words to consistent keywords and ensured they could be concisely replayed at the end of each video (MP 'Reviews'). One colleague noted that "the keywords are mostly positioned in the bottom left corner of the video. To better align with MP's spatial contiguity, we repositioned keywords closer to the corresponding visuals. With the MP's 'video length reduction' in mind, we presented some materials too quickly. Colleagues commented that "sometimes images are presented without words, and this is done too quickly to optimally grasp the meaning," and that "the beginning of the video (materials) is way too fast, also at the end with the recap." To improve clarity, we extended their display time.

Distribution

The final PNS demonstration videos are published on the Kaltura platform (Kaltura, 2024), which seamlessly integrates with the learning management system (LMS) of KU Leuven and Thomas More, ensuring students have easy access to the videos.

Ownership, Copyright, and Digital Rights

Ownership of the videos is shared between KU Leuven and Thomas More, ensuring institutional access and long-term availability. All videos are protected by copyright and may not be reproduced, modified, or distributed without permission. Access is restricted to students via the Kaltura platform, integrated with the institution's LMS system, in compliance with digital rights management policies.

CHALLENGES

Navigating MPs to design effective PNS demonstration videos has been an insightful process. A key challenge was the limited evidence with a specific focus on demonstration videos as a distinct subtype of instructional videos. Most available research centers on general instructional videos, making it necessary to critically evaluate which MPs are truly relevant to PNS demonstration videos. We recognize that not all commonly accepted MPs apply equally to this format. Through careful evaluation and refinement, we developed a practical checklist that serves as a facilitative tool for evaluating the instructional quality of demonstration videos. Beyond its evaluative function, the checklist continues to guide our own ongoing video development.

Another challenge was ensuring the production process of high-quality demonstration videos, which required strong interdisciplinary collaboration. Fortunately, we could rely on the support networks of KU Leuven and Thomas More to tackle this challenge effectively. We benefited from the technical guidance provided by colleagues from the audiovisual departments. Their expertise helped us with selecting high-quality cameras and a tripod for recording, training in Adobe Premiere and Adobe Illustrator for video editing, and utilizing the media room for qualitative voice-overs. For PNS content development, we collaborated with expert colleagues of Thomas More on scriptwriting based on existing paper-based PNS procedures and recording left- and right-handed demonstrations. To ensure the effective integration of MPs in the videos, we sought expert feedback from colleagues at KU Leuven and Thomas More. This collaborative effort aimed to maximize the learning outcome in alignment with CTML.

Importantly, these challenges and solutions should be considered in light of our initial video design goals of minimizing cognitive overload, optimizing essential processing, and supporting generative processing. While we applied strategies such as careful pacing, signaling, coherence between visuals, keywords, and narration, and opportunities for replay, the impact on cognitive load and learning outcomes in nursing and midwifery education remains to be empirically examined.

CONCLUSION

This project highlighted for us the value of a structured, theory-informed design approach to video-based learning in health professions education. Designing effective PNS demonstration videos by applying MPs has been both insightful and challenging. A key hurdle was the lack of research on demonstration videos as a distinct instructional format, requiring careful evaluation of relevant MPs. This led to the development of a practical checklist for assessing the quality of PNS videos. The checklist continues to support our own evaluation and refinement of PNS demonstration videos.

The production process also presented challenges for us. It taught us the importance of interdisciplinary collaboration. On one hand, we learned that audiovisual experts are crucial for technical support to ensure high-quality recording, editing, and voiceovers. On the other hand, we learned that content experts are essential to refine, perform, and evaluate scriptwriting, demonstrations, and integration of MPs to maximize students' learning outcomes.

Importantly, the videos are not only theoretically grounded but also aligned with the learning preferences of Generation Z healthcare students. This alignment was achieved by integrating MPs with learner characteristics typically associated with this cohort, such as concise signaling, coherence between visuals, keywords, and narration, clear pacing adapted to shorter attention spans, and summary sections that can be flexibly reviewed and repeated as needed.

By carefully navigating MPs, we demonstrated to our satisfaction that video design can move beyond simple recordings to become a purposeful and effective pathway for teaching PNS to a new generation of healthcare students. The next step is to evaluate their impact on learning outcomes, ensuring that these theory-informed resources translate into measurable educational benefits in health professions education.

ACKNOWLEDGMENTS

We sincerely thank the nursing and midwifery lecturers from Thomas More University of Applied Sciences (Lier, Belgium) for their expertise and support in scriptwriting and demonstrating PNS. We also appreciate the colleagues from the audiovisual department for their assistance with camera setup. Additionally, we extend our gratitude to our colleagues from KU Leuven University Teaching & Learning Development for their valuable guidance on applying multimedia principles and their advice and training on multimedia tools essential for creating high-quality demonstration videos.

AUTHORS' CONTRIBUTION

The creation of the videos was a collaborative effort involving all four authors, with clearly delineated roles and responsibilities. None of the authors has professional expertise in video recording or editing. Fortunately, we benefited from the technical guidance provided by colleagues from the audiovisual departments. Greet Leysens, as a doctoral researcher, focused on the literature review, exploration of technological resources, and the preparation and (post)production of the videos. Emma Van Den Corput contributed to the literature review, prepared the MP checklist, assisted with piloting the video creation, and participated in the stakeholders' feedback rounds. Wim Van Petegem (PhD co-promoter) and Nathalie Charlier (PhD promoter) played a crucial role in guiding and supervising the entire process. They provided continuous feedback on the design and implementation, challenged assumptions, and ensured the integration of theoretical and pedagogical accuracy. Drawing on their expertise in instructional design, technology integration, and health professions education, they helped refine the research approach, validated design decisions, facilitated access to their professional networks, and ensured the educational relevance of the final videos. The creation of the videos was carried out within the regular time and resources provided by KU Leuven and Thomas More.

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APPENDICES

Appendix A: Application of 24 MPs to PNS Demonstration Videos (Leysens, 2022-2026)

	EXTRANEOUS PROCESSING MPS	HOW APPLIED?
1	Coherence	Only relevant images or line drawings are shown separately, with narration carefully selected to convey essential instructions and key information.
2	Signaling	Relevant signaling words are thoughtfully chosen and appear simultaneously with the appropriate step. Lines or circles appear to draw students' attention to a particular part of the screen.
3	Redundancy	Images, line drawings, or footage are combined with either narration or written keywords, depending on the substep or segment of the video.
4	Spatial contiguity	Signaling words are placed in close proximity to the corresponding footage for clear and immediate association.
5	Temporal contiguity	The spoken text is synchronized with the corresponding footage for clarity and coherence.
6	Segmenting	The videos are divided into an intro, preparation, materials, execution, aftercare, summary, and outro segments.
7	Background music	No music is added to the videos.
8	Audio quality	The voiceovers are recorded in a sound-insulated room using a high-quality microphone; any distracting sounds were cut out.
9	Video length reduction	The primary focus is on demonstrating and explaining psychomotor actions without additional context. Exceptions or alternatives are not included. To maintain students' attention, substeps that are not central to the PNS are sped up. The videos range in length, depending on the complexity of the PNS: hand disinfection takes 2 minutes, intramuscular injection 5 minutes, venipuncture 7.5 minutes, and wound care 8 minutes.
10	Perspective (1st superior)	Both first- and third-person perspectives are used in the hand disinfection and wound care videos, as these perspectives are the focus of the research. For the intramuscular injection and venipuncture videos, a third-person perspective is applied to closely mirror real-life demonstrations, aligning with the study on learning outcomes from real-life versus video-based instruction.
11	Presenter's face	The lecturer's face is intentionally excluded to minimize distractions, ensuring the primary focus remains on the demonstration of psychomotor actions with the hands.
12	Sound effects	No sound effects are added to the video.
	ESSENTIAL PROCESSING MPS *	
13	Pre-training	Since students are novices in performing this new PNS and may not yet be familiar with all the materials, the materials segment presents individual images of each required item. Each image is accompanied by spoken narration to clearly identify the materials.
14	Modality	In the summary segment, the essential steps of the PNS are listed.
15	Multimedia	Written key terms are integrated with the PNS footage and reiterated at the summary segment.
16	Speech rate (fast superior)	Providing a well-prepared narrative text in advance ensures a smooth and well-paced voice-over delivery.
17	Transience	Each PNS is structured into distinct segments, providing students with a clear and organized learning flow. Cognitive overload is minimized by carefully pacing the presentation of relevant words and visuals.
18	Learner control	The segmented structure of the videos allows students to control playback, enabling them to pause, rewind, or skip to specific segments as desired.
19	Reviews	In the summary segment, an overview of the materials from the materials segment and the essential steps highlighted as signaling words in the execution segment are reiterated.

	GENERATIVE PROCESSING MPS	
20	Personalization	A conversational style is used in the narrative text, replacing formal language with 'you' instead of third-person or imperative constructions.
21	Voice principle	The voice-over was recorded at a sound-insulated multimedia room of KU Leuven, using a natural, human voice; no computer-generated voice was applied.
22	Embodiment principle	Since the focus of the PNS demonstration videos is on psychomotor actions, hand movements were emphasized in the execution segment.
23	Self-explanation	At the end of each video, in the summary segment, students are first prompted to recall the required materials. This is followed by an image displaying all materials, as previously shown in the materials segment. Next, students are asked to summarize all steps of the PNS based on the signaling words highlighted in the execution segment. An overview of these words is then presented on the next screen.
24	Integrated learning activities	At the end of each video, in the summary segment, students are encouraged to rewatch the video while using the practice materials provided by the campus.

* Based on multimedia principles (MPs) of Mayer (2021) and Fyfield et al. (2022)

Appendix B: Template Script PNS Demonstration Videos

MPS * °	SEGMENT	SCENE		VISUALS	TEXT	SPEECH	DURATION
1, 3	1	intro	1	Line drawing	Text	/	5 seconds
1, 3, 8, 16, 20, 21	2	Preparation	2	Line drawing	/	Narration	12 seconds
1, 3, 8, 13, 16, 20, 21	3	Materials	3	Images	/	Narration	Minimum 2 seconds per material
1, 2, 3, 4, 5, 8, 11, 14, 16, 20, 21, 22	4	Execution	4a	Footage	Signaling words	Narration	Depends on the complexity of the PNS
			4b	Footage			
			4…	Footage			
1, 3	5	Post care	5	Line drawing	Text	/	12 seconds
1, 3, 14, 19, 23	6	Summary	6a	Materials: line drawing and image	Text	/	10 seconds
			6b	Steps: line drawing	Text	/	25 seconds
1, 3, 24			6c	Exercise: line drawing	Text	/	5 seconds
1, 3	7	Outro	7	Line drawing	Text	/	5 seconds

*Numbers Multimedia Principles (MPs): based on the numbers of the checklist (Table 1)
°Overall MPs: 6, 7, 9, 10, 12, 15, 17, 18