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Navigating the Expertise Reversal Effect in Inclusive 3D Animation Classrooms: A Cognitive Load Analysis of Blender NLA Adoption

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Abstract

Conventional keyframe manipulation in 3D animation revisions often causes timing distortions and substantial procedural demands. This study examined barriers to adopting Blender's Nonlinear Animation (NLA) workflow and explored how instructional scaffolding related to differences in prior animation expertise. An exploratory qualitative case study involved five interns at Mari Nganimasi during August–September 2026, including four with foundational keyframe experience and one without previous 3D animation experience. Participants completed conventional walk-cycle revisions on August 25 and a multi-track NLA revision assignment on September 3, requiring at least 300 frames within three hours. Data were obtained through participatory observation, analysis of animation outputs and Blender project files, and semi-structured feedback. Interpretation drew on cognitive load theory and the expertise reversal framework. Conventional editing generated reported difficulties with timing, spacing, and repeated pose corrections. All five interns completed the NLA assignment, although two struggled with unfamiliar interface functions. Participants described NLA revisions as more convenient and less mentally demanding. Subsequent instruction differentiated advanced storyboard tasks from foundational walk-cycle practice according to observed readiness. These findings support expertise-sensitive instructional scaffolding but do not establish a causal reduction in cognitive load or demonstrate expertise reversal conclusively, given the small cohort and absence of standardized workload measurements.

Keywords: *Blender NLA, Cognitive Load Theory, Expertise Reversal Effect, Inclusive Education, Instructional Scaffolding.*

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INTRODUCTION

The increasing integration of digital technologies into creative and vocational education has transformed 3D animation from a primarily technical production skill into a learning domain that requires procedural accuracy, computational understanding, and adaptive problem-solving. Contemporary animation education increasingly incorporates project-based digital learning environments to strengthen students' ability to connect creative concepts with practical production processes, although instructional effectiveness remains dependent on the alignment between technological complexity and learner readiness (Aini et al., 2026). Blender provides an accessible production environment for developing three-dimensional characters and animations, yet its extensive technical functions require learners to coordinate multiple operations involving keyframes, timelines, animation sequences, and motion adjustments. The development of Blender-based instructional media demonstrates the educational relevance of animation software while highlighting the need for structured learning resources that make complex digital procedures more accessible to students with different levels of technical proficiency (Sari et al., 2025). Conventional keyframe manipulation presents particular instructional challenges when learners must repeatedly modify animation timing, coordinate movement sequences, and maintain motion continuity across interconnected frames. Multimedia learning theory establishes that the effectiveness of visual and interactive instructional materials depends on how information is organized and processed rather than merely on the availability of sophisticated technological features (Mayer, 2024). The introduction of Blender's Nonlinear Animation (NLA) system, which enables the arrangement and reuse of animation actions through a track-based workflow, consequently raises questions about how learners with heterogeneous technical backgrounds

manage procedural complexity and cognitive demands during the transition from conventional animation editing (Chen et al., 2023).

Contemporary research on cognitive load and instructional adaptation establishes that learning effectiveness is influenced by the interaction between task complexity, instructional guidance, and the learner's existing knowledge structures. Cognitive load theory explains that instructional tasks become more demanding when learners must simultaneously process multiple interacting elements that have not yet been integrated into organized cognitive schemas (Chen et al., 2023). Research on the expertise reversal effect further demonstrates that instructional approaches beneficial to learners with limited prior knowledge may lose their effectiveness or become counterproductive as expertise develops, indicating that instructional guidance cannot be assumed to produce equivalent outcomes across different proficiency levels (Tetzlaff et al., 2025). The relationship between prior knowledge and instructional support is particularly relevant in technology-mediated learning environments, where additional explanations, interface assistance, and procedural demonstrations may influence cognitive processing differently depending on learners' expertise. Investigations involving pen-tablet learning environments indicate that task complexity, learner expertise, and learning-related emotions interact in shaping instructional experiences, extending the expertise reversal effect beyond conventional instructional materials (Schrader & Kalyuga, 2023). Evidence from visual learning environments also suggests that the value of instructional annotations depends on existing knowledge, supporting the need to distinguish between assistance that facilitates initial comprehension and assistance that becomes redundant after learners develop sufficient expertise (Zheng et al., 2022).

The application of these theoretical developments to inclusive 3D animation instruction remains insufficiently specified within the literature considered in this study, particularly regarding how prior technical knowledge influences the cognitive demands of adopting Blender's NLA workflow. Existing research on technology-based cognitive load has examined instructional models in vocational computer programming, providing relevant insights into the relationship between learning activities, problem-solving requirements, and the cognitive demands associated with technically complex tasks (Herlambang et al., 2024). Such evidence does not directly establish whether comparable instructional mechanisms operate when learners must reorganize existing animation procedures into a nonlinear system involving reusable action strips, multiple tracks, and coordinated timing adjustments. Research addressing neurodiversity and cognitive load in digital education identifies the importance of accounting for differences in cognitive processing and learning requirements, although its conceptual scope does not specifically resolve the challenges associated with professional animation software (Le Cunff et al., 2025). Studies integrating cognitive load theory into immersive learning environments further demonstrate the relevance of prior knowledge, learner engagement, and instructional content, but their technological conditions differ from desktop-based animation workflows that require continuous procedural manipulation (Sulisworo et al., 2024). The resulting empirical gap concerns the limited understanding of whether instructional scaffolding supports novice Blender users while generating unnecessary processing demands for learners who already possess established animation schemas. The theoretical gap concerns the insufficient articulation of how expertise reversal principles interact with inclusive instructional requirements during the adoption of nonlinear animation procedures, rather than the absence of established explanations of expertise-dependent learning effects (Tetzlaff et al., 2025).

The unresolved relationship between learner expertise, cognitive load, and NLA instruction has practical implications for vocational animation classrooms where students are expected to complete common production objectives despite substantial differences in their initial technical competencies. Instructional materials that provide extensive procedural guidance may assist beginners in identifying unfamiliar interface functions, understanding dependencies between animation operations, and reducing avoidable difficulties during initial skill acquisition. Research on cognitive load in vocational programming education reinforces the need to consider how instructional organization and task demands affect learning processes within technology-intensive educational settings (Herlambang et al., 2024). Learners with established animation experience may require different forms of assistance because repeated explanations of familiar operations can introduce additional instructional processing without proportionate learning benefits. Multimedia learning principles support the organization of instructional information according to relevant cognitive processes, emphasizing that visual demonstrations and procedural explanations should serve identifiable learning functions rather than

increase informational density without justification (Mayer, 2024). Inclusive instructional design also requires attention to heterogeneous cognitive characteristics that cannot be adequately represented by a simple distinction between technically competent and technically inexperienced students (Le Cunff et al., 2025). Failure to examine these differences may encourage uniform NLA instruction that either places excessive demands on novices or provides unnecessarily restrictive assistance to experienced learners, limiting the development of instructional arrangements responsive to changing levels of expertise.

This study positions Blender NLA adoption at the intersection of cognitive load theory, expertise reversal research, and inclusive vocational animation education to examine an instructional problem that is not directly addressed by the selected empirical literature. Previous work on project-based animation learning has emphasized the implementation of digital learning media and the educational organization of animation activities, providing an instructional foundation without specifically examining expertise-dependent cognitive demands during nonlinear workflow adoption (Aini et al., 2026). Research involving Blender-based tutorial development has similarly addressed the preparation of animation learning resources, but its focus differs from an analysis of how learners with unequal prior experience respond to differentiated guidance when managing NLA actions and tracks (Sari et al., 2025). Expertise reversal research provides a theoretical basis for anticipating that the effectiveness of instructional support may change as technical proficiency develops, although findings from other learning environments cannot automatically be generalized to Blender animation tasks (Schrader & Kalyuga, 2023). The proposed contribution therefore involves examining learner expertise as a condition that may alter the cognitive consequences of instructional guidance during the transition from direct keyframe manipulation to nonlinear animation management. Evidence concerning expertise-sensitive visual annotations strengthens the rationale for distinguishing useful instructional support from potentially redundant guidance, particularly when the same interface explanations are presented to learners with substantially different cognitive schemas (Zheng et al., 2022). The study's proposed novelty lies in integrating NLA-specific workflow demands, variation in prior animation expertise, and inclusive instructional scaffolding into a focused cognitive load analysis, rather than treating software adoption as a uniform technical adjustment or assuming that identical guidance is appropriate for all learners.

This study aims to analyze how differences in prior animation expertise relate to cognitive load and instructional support requirements during the adoption of Blender's Nonlinear Animation system in inclusive 3D animation classrooms. The investigation focuses on the cognitive demands associated with understanding NLA operations, organizing animation actions, managing track-based sequences, and transitioning from conventional keyframe editing to nonlinear workflow procedures. It further seeks to examine whether instructional guidance that supports learners with limited technical experience may become less beneficial or cognitively redundant for learners with more established animation knowledge. The analytical framework considers the relationship between learner proficiency, procedural task complexity, and instructional scaffolding to clarify the conditions under which differentiated support may be educationally appropriate. The anticipated theoretical contribution is a more context-specific understanding of the expertise reversal effect within creative software education, particularly where heterogeneous technical abilities intersect with complex animation production procedures. The practical contribution is to inform the development of inclusive Blender NLA instruction that adjusts procedural explanations, demonstrations, and learning assistance to learners' existing competencies while maintaining common learning objectives. The study is expected to provide an analytical foundation for evaluating expertise-sensitive instructional strategies in 3D animation education without presupposing that nonlinear animation tools or additional scaffolding necessarily improve learning outcomes.

RESEARCH METHODS

This study employed an exploratory qualitative case study design to investigate barriers to adopting Blender's Nonlinear Animation (NLA) system and examine animation revision workflows through cognitive load theory, particularly the processing demands associated with interacting procedural elements (Chen et al., 2023). The expertise reversal effect served as an interpretive framework for examining how differences in prior technical knowledge may influence learners' responses to instructional scaffolding and complex animation tasks (Tetzlaff et al., 2025). The research

was conducted at Mari Nganimasi during an internship program from August to September 2026, involving five interns selected through purposive sampling based on their educational backgrounds and previous animation experience. Four participants originated from the same educational institution and possessed foundational knowledge of conventional keyframe animation, whereas one participant came from a different institution without previous experience in 3D animation. The research focused on Blender-based animation revision processes, considering the instructional relevance of software-supported animation activities and the procedural competencies required for producing and modifying animated content (Sari et al., 2025). The observation involved two operational assignments: conventional manual keyframe editing of a walk cycle on August 25, 2026, followed by multi-track NLA revision on September 3, 2026, requiring modifications to body mechanics, animation timing, and secondary motion within a 300-frame sequence under a three-hour time constraint.

Data were collected through participatory observation, artifact analysis, and semi-structured qualitative feedback to document participants' animation revision procedures, perceived mental workload, familiarity with Blender functions, and operational difficulties encountered during task completion. Participatory observations focused on procedural execution and workflow adjustments, while artifact analysis examined rendered animation outputs and Blender project files, particularly the arrangement of NLA tracks and animation actions used in revision activities. The collected information was examined through cognitive load constructs to identify procedural complexity, interacting task elements, and potential sources of mental workload associated with technology-intensive learning activities (Herlambang et al., 2024). Differences in participants' responses to technical guidance were interpreted using the expertise reversal framework, particularly the potential redundancy of instructional assistance when learners already possessed sufficient procedural knowledge (Schrader & Kalyuga, 2023). Theoretical triangulation was conducted by comparing observational evidence, participant feedback, and animation artifacts against cognitive load constructs encompassing element interactivity, working memory limitations, cognitive efficiency, and guidance fading to assess the consistency of qualitative interpretations. Comparisons across participants considered their initial technical knowledge and observed adaptation to NLA procedures, reflecting the relevance of prior knowledge to cognitive demands in technology-supported learning without assuming that qualitative differences constituted statistically established effects (Sulisworo et al., 2024).

RESULTS AND DISCUSSION

Conventional Keyframe Editing and Initial Blender NLA Adoption in Mixed-Ability Classrooms

The qualitative case study conducted at Mari Nganimasi examined five interns undertaking three-dimensional animation revision activities during August and September 2026. The participants comprised four interns from the same educational institution with foundational experience in conventional keyframe animation and one intern from another institution without previous experience in 3D animation. This composition established a mixed-expertise learning environment in which participants approached similar production objectives with different levels of technical familiarity and prior procedural knowledge. The educational relevance of such variation is consistent with vocational animation research emphasizing the integration of digital production activities with learners' existing competencies and instructional readiness (Aini et al., 2026). Initial observations focused on participants' procedural behavior, animation revision difficulties, and adaptation to unfamiliar software functions rather than standardized assessments of technical proficiency. Educational backgrounds and previous animation experience consequently served as contextual indicators of prior knowledge without constituting independently validated classifications of expertise. This distinction was necessary because the limited number of participants supported detailed qualitative examination of individual learning experiences but did not permit statistical generalization concerning differences in technical competence or instructional effectiveness.

Differences in previous animation experience influenced the initial conditions under which participants encountered conventional keyframe editing, although the available records did not establish separate proficiency assessments before the instructional activities. Four participants possessed foundational familiarity with manual keyframe procedures, whereas the remaining participant had no previous experience operating three-dimensional animation software. Existing procedural knowledge could reduce the instructional explanations required for basic timeline manipulation, pose construction, and movement adjustment, but shared educational backgrounds did not necessarily indicate identical

technical capabilities. Research concerning the expertise reversal effect demonstrates that the effectiveness of instructional guidance can vary according to the learner's existing knowledge and the complexity of the learning task (Tetzlaff et al., 2025). These differences provided an analytical foundation for examining participants' responses to software instructions without assuming that initial educational experience independently determined their performance. Attention to heterogeneous cognitive characteristics was particularly relevant because inclusive digital learning requires instructional arrangements that accommodate different processing demands rather than treating learners as a homogeneous group (Le Cunff et al., 2025).

The initial animation assignment was conducted on August 25, 2026, using conventional keyframe editing to develop and revise foundational walk-cycle movements. Participants worked on short-duration animations of less than ten seconds, concentrating on body mechanics, facial expressions, and the coordination of character movements during a single-day revision activity. The assignment required direct adjustments to existing keyframes and character controls to refine pose transitions, temporal spacing, and movement continuity across successive animation frames. Observational findings identified difficulties in maintaining consistent timing and spacing, particularly when modifications to individual control bones affected adjacent poses and altered established motion trajectories. These procedural interactions illustrate how apparently localized editing decisions can impose substantial processing demands when multiple animation elements require simultaneous coordination (Chen et al., 2023). Participants described repeated corrective actions after individual modifications disrupted previously arranged motion sequences, creating operational frustration during the revision process. These observations established the baseline conditions for examining how participants subsequently adapted to Blender NLA, particularly in relation to procedural complexity, animation revision difficulties, and differences in prior technical experience.

Conventional animation revision difficulties were concentrated in the coordination of character poses, temporal spacing, control-bone transformations, and neighboring keyframe trajectories. Participants reported operational frustration when modifications intended to improve particular movements introduced irregularities requiring additional manual corrections. Repeated adjustments represented interacting procedural demands that could increase the complexity of animation editing, although the study did not obtain standardized measurements of mental effort during the baseline assignment. Research examining cognitive load in vocational technology education similarly emphasizes the relevance of instructional structure and interacting technical operations when learners engage with complex procedural activities (Herlambang et al., 2024). The documented problems indicated workflow friction associated with conventional keyframe manipulation rather than establishing that manual animation editing was inherently inefficient across different production environments. These observations provided the practical basis for introducing the NLA workflow as an alternative approach to organizing animation revisions through reusable actions and track-based editing.

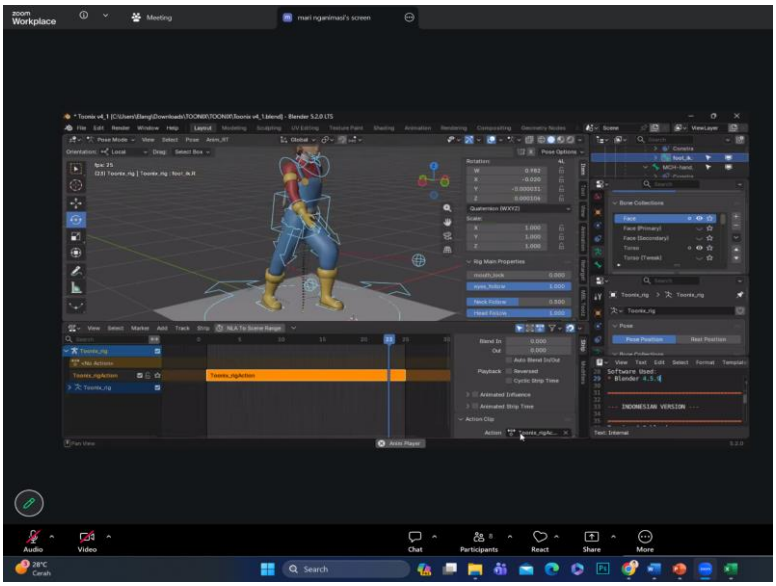


Figure 1. First Time Introducting NLA

On September 3, 2026, the five interns were introduced to Blender's Nonlinear Animation system as an alternative procedure for modifying previously developed walk-cycle animations. The practical assignment required participants to revise their original animation projects by introducing additional secondary poses, adjusting character movement speed, or extending animation sequences through NLA operations. Each participant was expected to produce a modified animation containing at least 300 frames within a three-hour working period. The NLA environment allowed animation actions to be organized and manipulated through separate tracks, reducing dependence on continuous direct modification of the original keyframe sequence. Research on interactive animation editing demonstrates the relevance of interface organization and keyframe manipulation procedures to the technical processes involved in constructing and revising animated movements (Shi et al., 2026). The assignment shifted participants' operational attention from individual pose corrections toward the coordination of reusable movement sequences and their temporal relationships. The observations examined how participants with different initial technical backgrounds responded to this revised production procedure without treating the activity as a controlled experimental comparison between equivalent instructional conditions.

All five interns completed and presented their modified walk-cycle animations within the three-hour period established for the NLA assignment. Initial previews indicated satisfactory visual quality, although minor technical adjustments remained necessary to improve movement refinement and motion agility. Qualitative feedback suggested that participants perceived NLA tracks as more convenient for generating additional movements and revising animation sequences than repeated manipulation of conventional keyframes. Two participants nevertheless experienced initial confusion when encountering unfamiliar NLA interface functions, indicating that the alternative workflow did not eliminate the need for procedural adaptation. Research on Blender-based animation learning materials highlights the educational importance of accessible demonstrations and instructional resources when learners are introduced to software-supported production activities (Sari et al., 2025). Completion of the assigned animation sequences demonstrated the feasibility of NLA-based revisions within this internship cohort, but it did not establish a quantified improvement in editing speed because comparable task-completion measurements were unavailable for the initial assignment.

The combination of successful task completion and uneven initial familiarity revealed a distinction between the ability to produce an animation output and the cognitive demands associated with learning a new editing interface. Two interns required an initial period of adjustment to unfamiliar tools, although both ultimately completed the required animation revisions within the designated time. One participant demonstrated interest in developing more advanced movement variations and requested additional technical guidance concerning inverse kinematics and forward kinematics blending. The observational records did not establish whether this participant belonged to the initially confused group or whether the request reflected a systematically measured difference in previous animation expertise. These behavioral differences nevertheless indicated that participants' instructional requirements were not identical, particularly when some difficulties concerned unfamiliar interface operations and other inquiries involved advanced motion-control techniques. Research on visual representations and instructional annotations indicates that the usefulness of additional explanations depends partly on learners' existing knowledge structures and the cognitive demands of the task (Zheng et al., 2022). The observed variation supported further examination of differentiated instructional assistance, although it did not independently demonstrate that particular guidance procedures had become redundant or counterproductive for more experienced participants.

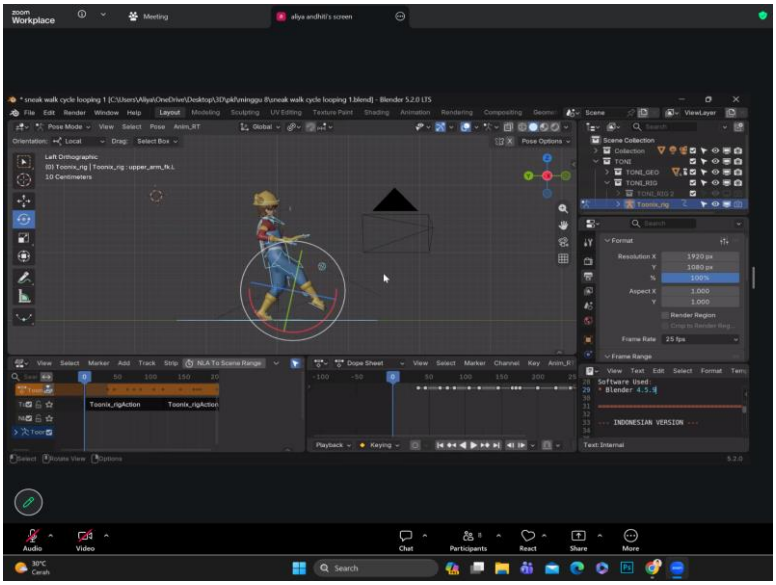


Figure 2. Walk Cycle Review

The initial comparison between conventional keyframe manipulation and NLA-based editing identified differences in how participants experienced animation revision procedures and organized technical operations. Reports of repeated corrections during conventional editing contrasted with participants' descriptions of greater convenience when manipulating reusable animation actions through NLA tracks. These findings suggested a potential reduction in operational friction, although subjective feedback and differences between the two assignments prevented a definitive conclusion regarding comparative workflow efficiency. Cognitive load theory provides an explanatory basis for interpreting how the organization of interacting procedural elements may influence working memory demands, but direct cognitive load measurements would be required to establish the magnitude of such differences (Sweller, 2023). The successful completion of NLA assignments by participants with heterogeneous previous experience demonstrated that the track-based workflow was manageable within the observed learning environment while retaining the need for individualized instructional assistance. Evidence of an expertise reversal effect remained preliminary because the available observations did not establish systematic differences in guidance exposure, cognitive workload, or learning outcomes attributable to participants' initial expertise.

Cognitive Load, Procedural Complexity, and Workflow Efficiency in NLA-Based Animation Revision

The transition from conventional keyframe editing to Blender's Nonlinear Animation (NLA) system introduced a different organization of procedural demands within the animation revision activities conducted at Mari Nganimasi. Conventional editing required participants to manipulate individual keyframes while maintaining relationships between character poses, interpolation sequences, and temporal movement structures. Cognitive Load Theory explains that complex instructional activities impose substantial processing demands when multiple interacting elements must be coordinated within the limited capacity of working memory (Chen et al., 2023). The initial animation assignment exposed participants to these demands through repeated adjustments involving body mechanics, facial expressions, movement timing, and spatial consistency. NLA-based revision reorganized the editing process around reusable animation actions and track-based sequences, potentially reducing the need to reconstruct previously established movements. This distinction is relevant to cognitive architecture because changes in procedural organization may affect the amount of information that learners must actively coordinate during complex technical operations (Sweller, 2023).

The conventional keyframe workflow presented operational difficulties associated with maintaining animation continuity while introducing changes to individual character movements. Participants reported that adjustments to control bones frequently affected adjacent poses, producing irregular motion trajectories that required additional corrections before the revised animation could be accepted. These difficulties were particularly apparent when participants modified movement timing or

spacing because the revised keyframe positions needed to remain consistent with surrounding animation sequences. The interaction between local editing decisions and broader animation structures reflects the problem of element interactivity, in which several technical components must be processed together to achieve the intended outcome (Chen et al., 2023). Repeated correction procedures increased the number of operations involved in completing relatively localized revisions, contributing to the frustration documented during the initial assignment. Research on cognitive demands in vocational programming education similarly identifies the instructional relevance of managing interconnected procedural operations when learners engage with technically complex activities (Herlambang et al., 2024). The observed editing difficulties therefore indicated a relationship between workflow organization and perceived procedural complexity, although the available evidence did not permit the independent quantification of intrinsic or extraneous cognitive load.

The complexity of conventional animation editing was also associated with the limited separation between previously established movements and subsequent revisions. Changes intended to refine one movement component could alter the continuity of neighboring poses, requiring participants to reconsider earlier editing decisions and repeat corrective procedures. Interactive animation research identifies keyframe construction and modification as important components of digital animation workflows, particularly when editing operations must preserve relationships between movement states (Shi et al., 2026). The documented difficulties suggest that some processing demands arose from the interaction between necessary animation decisions and the procedures used to implement those decisions. Cognitive load considerations distinguish complexity inherent in the learning task from additional processing demands associated with instructional presentation or inefficient operational arrangements (Sweller, 2023). Figure 3 provides the original visual reference for the conventional keyframe and timing complexity discussed in the observational findings.

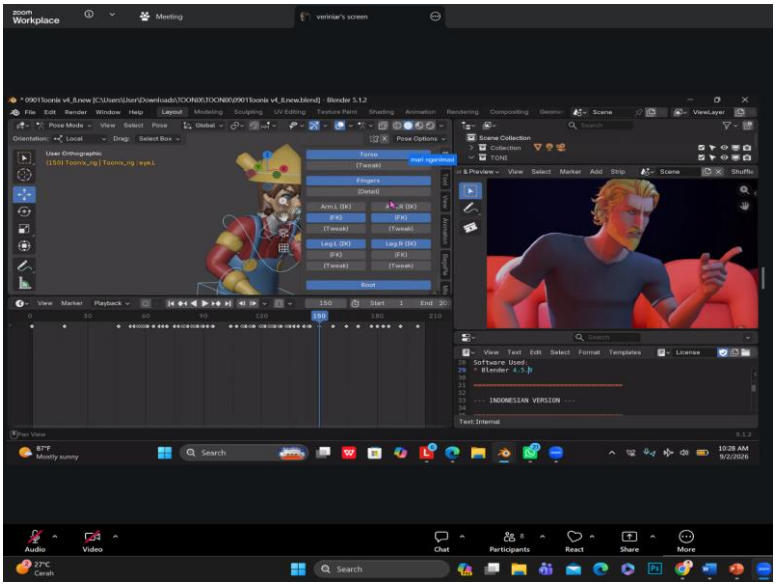


Figure 3. Complexity Keyframe and Timing Conventionally

Blender NLA introduced an alternative revision structure by allowing participants to organize existing animation actions into tracks and modify their temporal relationships without repeatedly reconstructing the original keyframe sequence. During the September 3, 2026 assignment, participants used this workflow to revise walk-cycle animations through movement extensions, timing adjustments, and additional secondary motion. The required output comprised at least 300 frames within a three-hour working period, providing a defined operational task for observing the adoption of the alternative editing procedure. The use of reusable animation actions allowed participants to approach revision through the arrangement and modification of movement sequences rather than relying exclusively on direct keyframe manipulation. Research on animation production demonstrates the relevance of organizing three-dimensional movement procedures into manageable production stages, although particular workflow advantages remain dependent on the technical characteristics of the animation task (Bie et al., 2026). All five interns completed and presented the assigned animations within the specified

period, indicating that the NLA workflow was operationally accessible to participants with different levels of previous animation experience. The successful completion of these tasks established practical feasibility within the observed cohort but did not independently demonstrate superiority over conventional editing because the baseline and NLA assignments differed in their operational requirements.

The instructional introduction of NLA involved a sequential arrangement of technical explanations, practical demonstrations, and independent animation revision activities. Participants initially received concise tutorials explaining NLA concepts, track organization, and the procedures required to manipulate layered animation actions. The instructional sequence then incorporated a worked demonstration showing how an existing walk cycle could be extended and supplemented with additional body mechanics without directly reconstructing its original keyframe structure. Multimedia learning theory supports the organization of instructional information around relevant cognitive processes, particularly when visual demonstrations and procedural explanations are designed to clarify unfamiliar operational relationships (Mayer, 2024). The demonstration provided participants with an observable procedural reference before they attempted independent revisions, reducing the immediate requirement to determine each technical operation without guidance. Research on attentional guidance in technology-supported learning further indicates that appropriately directed attention can help learners manage complex visual information, although findings from virtual reality environments cannot be transferred directly to Blender-based animation production (Wen et al., 2024).

The instructional sequence subsequently incorporated guidance fading as participants moved from demonstrated procedures toward the independent execution of NLA revision tasks. During the three-hour practical activity, participants were permitted to organize their animation actions while receiving technical assistance through open preview sessions. Feedback was provided individually but remained accessible to other participants, allowing learners to observe explanations relevant to difficulties encountered during their own animation revisions. This arrangement created opportunities for independent problem-solving and peer observation without requiring every participant to receive identical explanations at the same moment. Research concerning expertise-dependent instructional effectiveness indicates that guidance requirements may change as learners develop sufficient knowledge to manage task demands more independently (Tetzlaff et al., 2025). The preview sessions therefore constituted a flexible instructional arrangement in which assistance could respond to emerging technical difficulties while preserving opportunities for autonomous task execution. The observations did not establish the frequency or duration of assistance received by each intern, preventing a definitive assessment of whether the implemented guidance-fading process reduced cognitive load differently across expertise levels.

Qualitative feedback indicated that all five interns perceived the NLA workflow as less mentally demanding than conventional single-keyframe manipulation. Participants associated this perception with the ability to organize new movements through NLA tracks while preserving previously established animation actions, reducing concerns about disrupting foundational movement timing during revision. The reported convenience was consistent with their completion of the extended walk-cycle assignment, although successful production and perceived mental effort represent distinct dimensions of instructional performance. Research on cognitive load measurement distinguishes subjective assessments of mental effort from other dimensions of cognitive processing, demonstrating the importance of clearly defined instruments when evaluating different forms of cognitive load (Krieglstein et al., 2023). The present study collected qualitative feedback rather than standardized workload ratings, preventing the calculation of cognitive load scores or a quantitative cognitive efficiency index. The findings consequently support an interpretation of reduced perceived procedural burden within the observed activities rather than a statistically demonstrated reduction in cognitive load attributable to NLA adoption.

The relationship between perceived workload and task completion suggests that NLA may provide a more manageable revision structure when learners must coordinate previously established movements with additional animation requirements. Participants' favorable assessments reflected their experience of editing through reusable tracks, while the successful presentation of modified animations demonstrated that the required production objectives were achievable under the assigned time constraint. Cognitive load research indicates that the relationship between processing demands and learning performance requires careful interpretation because increased cognitive load does not

necessarily produce a corresponding decline in task outcomes (Skulmowski, 2024). The difference between the initial conventional editing assignment and the subsequent NLA task also introduced potential influences associated with accumulated practice, familiarity with character rigs, and exposure to instructional demonstrations. Peer observation during open preview sessions represented another possible source of learning support that could have affected the ease with which participants resolved technical difficulties. Evidence from technology-enhanced learning research supports evaluating instructional performance alongside cognitive demands rather than treating successful task completion as sufficient evidence of reduced mental workload (Poupard et al., 2025). The findings therefore indicate that track-based animation revision was associated with favorable subjective experiences and successful task execution within the observed cohort, while the contribution of NLA itself remains inseparable from the instructional support and sequential learning conditions under which adoption occurred.

Expertise Reversal Effect and Differentiated Instructional Scaffolding in Inclusive Animation Training

The implementation of Blender's Nonlinear Animation (NLA) system at Mari Nganimasi revealed differences in participants' instructional requirements despite their successful completion of the assigned animation revisions. The five interns entered the learning activities with heterogeneous technical backgrounds, including four participants possessing foundational keyframe animation experience and one participant without previous experience in three-dimensional animation. Although all participants completed the required NLA assignments, their responses to unfamiliar interface functions and subsequent technical guidance were not identical. Two interns experienced initial confusion when operating NLA tools, while one participant demonstrated interest in advanced movement manipulation through inverse kinematics and forward kinematics techniques. These differences indicated that successful task completion did not necessarily reflect equivalent procedural understanding, technical confidence, or requirements for instructional assistance. Research on the expertise reversal effect establishes that instructional effectiveness depends partly on the relationship between learners' existing knowledge and the guidance provided during complex learning activities (Tetzlaff et al., 2025). The observed variation therefore provided a basis for examining expertise-sensitive instruction, although the qualitative evidence did not independently establish a complete expertise reversal effect among the participants.

Differences in prior animation experience created distinct instructional starting points that required consideration when introducing complex NLA operations. Participants with foundational keyframe knowledge possessed previous experience in constructing movement sequences, adjusting temporal relationships, and controlling character poses, whereas the inexperienced participant lacked comparable exposure to three-dimensional animation procedures. The introduction of action strips, track organization, and nonlinear movement adjustments consequently presented different potential learning demands depending on participants' existing procedural familiarity. Research on cognitive load and neurodiversity emphasizes the importance of recognizing heterogeneous cognitive processing requirements when designing learning experiences intended to accommodate diverse learners (Le Cunff et al., 2025). Evidence concerning expertise-dependent instructional effectiveness further indicates that guidance beneficial for learners with limited knowledge may become redundant when equivalent explanations are presented to more experienced individuals (Schrader & Kalyuga, 2023). These theoretical considerations supported differentiated instructional attention without establishing that the participant groups experienced systematically different levels of cognitive load.

The instructional process incorporated several forms of technical scaffolding intended to support participants during their transition from conventional keyframe manipulation to the NLA workflow. Initial tutorials introduced essential NLA concepts and track-management procedures before participants observed demonstrations of animation extension and additional body mechanics. Worked examples provided procedural references that participants could consult when organizing existing animation actions and constructing revised movement sequences. Individual feedback during open preview sessions allowed participants to address emerging technical difficulties while observing solutions communicated to other members of the internship cohort. Research examining visual annotations and the expertise reversal effect demonstrates that additional instructional information must be evaluated in relation to learners' existing knowledge rather than assumed to provide equal benefits

across proficiency levels (Zheng et al., 2022). Studies on mental imagery scaffolding similarly emphasize that instructional detail and informational demands can influence learning processes, providing a conceptual basis for adjusting explanations according to task complexity (Zhou et al., 2024). The observed instructional arrangement combined structured demonstrations with opportunities for independent practice, although the available records did not establish the independent contribution of each scaffolding component to participants' learning outcomes.

Following two days of NLA training covering body mechanics and facial expressions, instructional activities were differentiated according to participants' demonstrated progress in operating animation tools. Interns who displayed relatively rapid technical mastery and smooth animation execution were directed toward subsequent story-driven animation projects involving storyboard briefs and more complex movement requirements. These assignments provided opportunities to apply previously acquired NLA procedures to production tasks requiring additional creative decisions and independent technical organization. The transition reduced reliance on repeated foundational explanations while increasing the complexity of the animation objectives assigned to participants demonstrating greater procedural readiness. Research on instructional design innovation identifies the organization of learning activities and the alignment of instructional strategies with learning requirements as relevant considerations in technology-supported education (Sagoro et al., 2025). The use of differentiated animation assignments also corresponded with broader vocational education research examining how instructional approaches can accommodate practical learning objectives and support the development of animation-related competencies (Budianto et al., 2025).

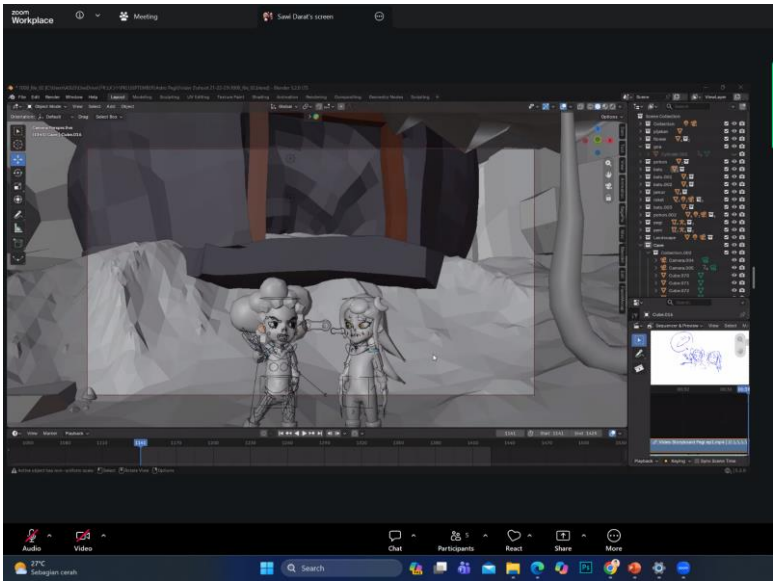


Figure 4. Next Project Experienced Learners

Participants requiring further technical consolidation continued practicing foundational animation procedures through additional walk-cycle exercises using different character rigs. These assignments retained familiar movement objectives while introducing variations in character structures, allowing participants to encounter technical differences without simultaneously managing the broader demands of advanced story-driven animation production. Worked examples remained available to support the interpretation of character movement, track organization, and procedural adjustments during repeated practice. The instructional distinction between foundational exercises and more complex animation projects reflected differences in observed procedural readiness rather than an attempt to separate learners permanently according to their initial educational backgrounds. Research on Blender-based instructional media supports the relevance of structured demonstrations and accessible learning resources when learners acquire software-related animation competencies (Sari et al., 2025). Cognitive load research also indicates that additional instructional support may assist learners facing unfamiliar interacting elements, although its effectiveness depends on how the guidance corresponds to their knowledge and task requirements (Chen et al., 2023). The differentiated practice arrangement

consequently represented an instructional response to observed learning needs, while its effectiveness in improving individual proficiency remained unquantified in the available research records.

One participant's request for additional guidance concerning inverse kinematics and forward kinematics blending provided further evidence of variation in the technical interests emerging during NLA training. These animation techniques involve different approaches to controlling character movement and require learners to understand relationships between skeletal transformations, movement constraints, and intended animation outcomes. The participant's inquiry extended beyond the immediate requirements of walk-cycle retiming and basic NLA track manipulation, indicating an interest in more complex movement construction. Research examining the interaction between learner expertise, task complexity, and learning-related emotions suggests that instructional experiences cannot be understood solely through the amount of guidance provided because individual responses to complex tasks may also differ (Schrader & Kalyuga, 2023). The expertise reversal framework provides a relevant explanation for considering whether participants demonstrating greater procedural readiness benefit from more challenging assignments rather than repeated introductory instruction (Tetzlaff et al., 2025). The available observations nevertheless did not establish that the participant requesting advanced guidance possessed the highest initial expertise or that additional foundational explanations had produced measurable cognitive interference.

The instructional workflow at Mari Nganimasi combined introductory demonstrations, independent animation revision, open preview sessions, and differentiated assignments to accommodate variation in participants' observed technical readiness. Initial procedural guidance provided a common foundation for understanding NLA operations, while subsequent activities allowed participants to apply these procedures with different levels of instructional assistance. Interns demonstrating rapid progress were assigned more demanding storyboard-based production activities, whereas those requiring further consolidation continued foundational walk-cycle practice using varied character rigs. Individualized feedback remained part of the learning environment, allowing participants to obtain technical clarification without requiring identical progression through every instructional activity. Research addressing inclusive digital education emphasizes that instructional accessibility depends on recognizing differences in cognitive processing and learning requirements rather than assuming that uniform instruction is equally suitable for heterogeneous learners (Le Cunff et al., 2025). Evidence synthesized in expertise reversal research similarly supports the principle that instructional assistance should be responsive to changes in learners' existing knowledge and task-related competence (Tetzlaff et al., 2025). The implemented workflow consequently illustrated an approach to differentiated scaffolding within animation training, although the available evidence was insufficient to establish whether each instructional adjustment independently improved cognitive efficiency or technical proficiency.

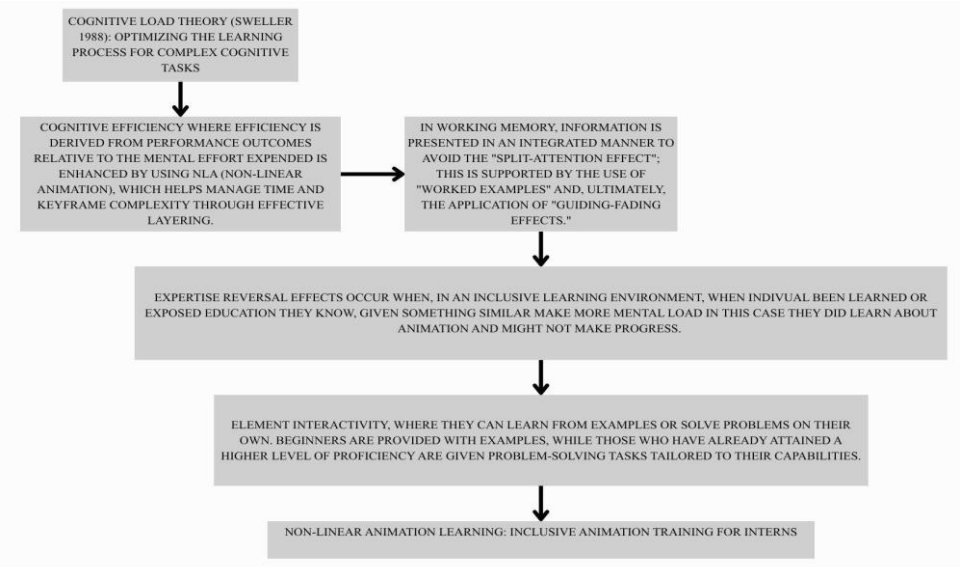


Figure 5. Work Flow Inclusive Training NLA Interns at Mari Nganimasi

The findings provide a qualitative account of how learner heterogeneity, procedural complexity, and differentiated instructional assistance intersected during Blender NLA adoption within a single internship cohort. The study's five participants and single-studio setting limited the transferability of its observations, while the sequential introduction of conventional keyframe editing and NLA prevented the independent isolation of software-related effects from accumulated practice and instructional exposure. The absence of standardized cognitive load measurements, comparable task-completion metrics, and systematically recorded individual guidance exposure also restricted the extent to which the expertise reversal effect could be empirically established. Peer observation during open preview sessions and differences in participants' motivation may have influenced procedural adaptation, although these potential contributions were not independently assessed. Future investigations could incorporate validated cognitive load instruments, structured records of instructional assistance, and comparable animation tasks across different expertise levels to examine whether perceived mental effort and performance change in response to differentiated scaffolding (Krieglstein et al., 2023). The principal contribution of the present case study lies in identifying observable instructional differences and developing an empirically grounded basis for further examination of expertise-sensitive Blender NLA training, rather than demonstrating a generalizable causal relationship between nonlinear animation adoption, reduced cognitive load, and improved learning performance.

CONCLUSION

Operational challenges associated with Blender's Nonlinear Animation (NLA) adoption in heterogeneous 3D animation learning environments reflect the interaction between procedural complexity, prior technical experience, and differences in instructional support requirements, although the expertise reversal effect could not be conclusively established. Qualitative observations involving five interns at Mari Nganimasi revealed that conventional keyframe editing conducted on August 25, 2026, presented difficulties involving animation timing, spacing, movement continuity, and repeated manual corrections. During the subsequent NLA assignment on September 3, 2026, all five participants successfully completed modified walk-cycle animations comprising at least 300 frames within the designated three-hour period. Participants perceived the NLA multi-track workflow as more convenient and less mentally demanding because reusable animation actions reduced their reliance on direct modifications to existing keyframe sequences. Two interns nevertheless experienced initial difficulties with unfamiliar NLA functions, indicating that differences in procedural knowledge remained relevant despite successful task completion. These findings suggest that nonlinear animation workflows can support more manageable revision procedures while requiring instructional assistance responsive to learners' existing competencies and technical readiness. The absence of standardized cognitive load measurements and equivalent comparative tasks limits causal interpretations concerning workflow efficiency, working memory demands, and the occurrence of expertise reversal.

Integrating cognitive load considerations, expertise-sensitive instructional guidance, and inclusive animation training provides a practical foundation for understanding how differentiated learning arrangements can support the adoption of complex digital animation workflows. The implementation of sequential tutorials, worked examples, guidance fading, and individualized feedback provided instructional support during participants' transition from conventional keyframe manipulation to nonlinear animation procedures. Differentiated learning activities subsequently accommodated variations in procedural readiness by assigning more complex storyboard-based animation projects to participants demonstrating rapid technical progress while retaining foundational walk-cycle exercises for those requiring further consolidation. These instructional arrangements illustrate the practical relevance of replacing uniform technical instruction with flexible scaffolding that responds to demonstrated proficiency without compromising shared learning objectives. For animation educators and industry mentors, the findings provide a basis for adjusting procedural explanations, technical demonstrations, and task complexity according to learners' developing competencies. The limited sample of five interns, single-studio setting, sequential task differences, and reliance on qualitative feedback restrict the transferability of the findings and prevent definitive conclusions regarding cognitive efficiency improvements. Future research should incorporate larger and more diverse participant groups, comparable animation tasks, validated cognitive load instruments, and systematic assessments of instructional guidance to determine whether adaptive scaffolding produces measurable reductions in cognitive burden and identifiable expertise reversal effects.

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