



PRACTICALITY AND LEARNING OUTCOMES OF SPIRIT-BASED TEACHING MATERIALS IN 3D ANIMATION LEARNING

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ABSTRACT

Aim/Purpose	This study aimed to evaluate the practicality of SPIRIT-based teaching materials and examine changes in students' cognitive understanding following their implementation in vocational 3D animation learning. The study addresses the need for integrated instructional frameworks that support cognitive understanding and structured learning in creative-technical learning environments.
Background	Previous studies have examined flipped learning, project-based learning, collaborative instruction, and technology-enhanced learning as separate pedagogical approaches. However, limited empirical evidence exists regarding integrated instructional frameworks that systematically coordinate preparation, collaborative interaction, authentic learning activities, supervision, and formative feedback within a coherent learning sequence. The SPIRIT framework was developed to address this gap through six structured instructional stages tailored to vocational 3D animation education.
Methodology	The study employed an educational research and development approach during the implementation phase, involving one-to-one evaluation ($n = 4$), a small-group trial ($n = 8$), and full-class implementation ($n = 22$). Complete paired pre-test–posttest data from 21 students were included in the learning outcome anal-

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	ysis. Practicality data were analyzed using descriptive percentage-based evaluation, while cognitive learning outcomes were examined using normalized gain (N-Gain), paired-samples t-test, and Cohen's <i>d</i> effect size. Qualitative feedback was analyzed descriptively to support the interpretation of the quantitative findings.
Contribution	This study provides preliminary empirical evidence on the practicality and cognitive learning outcomes of implementing an integrated, multi-phase instructional framework that combines self-study preparation, retrieval-based reinforcement, collaborative learning, authentic learning activities, guided supervision, and formative feedback within a unified pedagogical sequence for vocational creative-technical education.
Findings	The practicality evaluation indicated high feasibility of implementation across the three trial stages, with scores ranging from 80.5% to 91.0%. Analysis of cognitive learning outcomes revealed a moderate N-Gain of 47.50% and a statistically significant difference between pretest and posttest scores, with posttest scores higher than pretest scores, $t(20) = 6.16, p < .001$, Cohen's $d = 1.34$. Qualitative feedback further suggested that students experienced greater clarity and understanding when working through complex animation learning activities following implementation of the SPIRIT-based materials.
Recommendations for Practitioners	Vocational educators may consider structured multi-phase instructional sequencing when designing technology-supported learning environments. The integration of preparation, collaboration, authentic learning activities, supervision, and formative feedback may support learner engagement and instructional clarity in complex digital production contexts.
Recommendations for Researchers	Future studies should examine the implementation of SPIRIT across broader institutional contexts, vocational disciplines, and longitudinal learning environments. Further research could also investigate affective outcomes, learner motivation, creative performance, and long-term competency retention.
Impact on Society	By supporting more structured approaches to complex technical learning, the SPIRIT framework may contribute to the development of digitally competent and self-regulated learners for evolving creative industries and technology-driven workplaces.
Future Research	Future research may compare SPIRIT with other integrated instructional frameworks and investigate the potential integration of adaptive learning support, gamified feedback systems, or AI-assisted instructional guidance within creative-technical education.
Keywords	SPIRIT learning model, 3D animation education, instructional sequencing, vocational higher education, instructional practicality, learning outcomes, project-based learning

INTRODUCTION

Learning 3D animation in vocational higher education presents distinctive instructional challenges due to the integration of procedural software mastery, spatial reasoning, and creative design within nonlinear production workflows (Beane, 2012; Birn, 2000; Williams, 2009). For novice learners, coordinating modeling, layout, lighting, and rendering processes often results in fragmented understand-

ing and high intrinsic cognitive load (Ma, 2018; Sweller, 2011). These conditions necessitate structured instructional sequencing to support cognitive integration and effective learning in complex creative-technical environments.

Structured instructional approaches such as flipped learning, project-based learning (PBL), collaborative learning, and technology-enhanced environments have demonstrated positive effects on learner engagement, problem-solving ability, and self-regulated learning in higher education contexts (Ariani et al., 2024; Barak, 2020; Youhasan et al., 2021). In animation and multimedia education, project-oriented learning environments have been associated with improvements in students' technical competence, confidence, and creative performance (Mou, 2020; Ramadhan et al., 2024). Likewise, immersive technologies and 3D visualization tools can enhance motivation and spatial understanding when learning complex digital production workflows (Ho et al., 2019; Radianti et al., 2020). Previous studies have also demonstrated that dynamic visualization tools such as 3D models and animations can significantly improve students' intrinsic motivation, perceived competence, engagement, and learning outcomes by facilitating conceptual understanding and reducing cognitive load during complex learning activities (Teplá et al., 2022).

Despite these advantages, existing studies generally examine these pedagogical approaches as separate instructional strategies rather than as integrated components within a coherent instructional framework. Research on flipped learning primarily focuses on pre-class preparation and student engagement, whereas project-based learning emphasizes authentic task completion and collaborative problem solving. Likewise, studies on technology-enhanced learning often prioritize visualization, immersion, and motivational aspects, while giving less attention to how instructional sequencing supports cognitive regulation during complex creative-technical activities.

Recent discussions on digital pedagogy further suggest that technology-supported learning environments may be more effective when pedagogical strategies are carefully integrated into meaningful learning processes rather than implemented merely as isolated technological or gamified features (Papadakis & Karakose, 2025). Similar findings have been reported by García-López et al. (2023), who demonstrated that gamified learning environments can support motivation, engagement, cognition, and metacognitive regulation when instructional activities are systematically organized within meaningful academic tasks. Consequently, empirical evidence remains limited on instructional frameworks that systematically integrate preparation, retrieval-based reinforcement, collaboration, guided supervision, and formative feedback into a structured learning cycle for vocational 3D animation education.

This study contributes to the growing discourse on structured digital pedagogy by empirically examining the practicality of an integrated multi-phase instructional framework and cognitive learning outcomes observed following its implementation. To address the identified gap, the SPIRIT model was developed as a structured instructional framework comprising six sequenced learning stages: self-study preparation, pre-class quizzes, interactive group work, real-world application, in-class supervision, and testing and feedback.

Unlike prior studies that examine instructional strategies in isolation, this study evaluates the practicality of SPIRIT-based teaching materials and assesses changes in students' cognitive understanding following the implementation of these complementary pedagogical components within a coherent instructional sequence for vocational 3D animation learning.

To guide the empirical investigation, the following research questions were formulated:

- RQ1:** To what extent are SPIRIT-based teaching materials practical in vocational 3D animation learning?
- RQ2:** To what extent do students demonstrate changes in cognitive understanding following the implementation of SPIRIT-based teaching materials?

LITERATURE REVIEW

INSTRUCTIONAL CHALLENGES IN 3D ANIMATION LEARNING

Learning 3D animation requires the integration of procedural software skills, spatial reasoning, conceptual design thinking, and iterative problem-solving (Beane, 2012; Birn, 2000; Williams, 2009). Unlike declarative or linear theoretical subjects, animation production follows a nonlinear workflow that involves modeling, layout, lighting, rendering, and refinement cycles, each of which demands technical precision and creative judgment (Ma, 2018; Miyai & Yamaguchi, 2016).

From a cognitive perspective, these tasks impose substantial intrinsic cognitive load, particularly for novice learners who must simultaneously navigate complex interfaces while making aesthetic and technical decisions (Sweller, 2011). Without structured instructional sequencing, learners often struggle to integrate isolated technical operations into coherent scene production, resulting in fragmented understanding and inconsistent performance (Kolb, 2015).

Previous research has shown that dynamic visualization environments, including 3D models and animations, can support students' conceptual understanding and intrinsic motivation by reducing abstraction and facilitating cognitive scaffolding during complex learning tasks (Teplá et al., 2022). Empirical and theoretical studies in creative-technical education suggest that structured instructional frameworks, such as project-based and design-based learning, support learner engagement, self-regulated learning, and higher-order problem-solving skills (Barak, 2020; Mou, 2020). However, animation instruction frequently adopts discrete pedagogical strategies without integrating cognitive preparation, collaborative interaction, authentic production, and systematic feedback into a coherent instructional sequence. This fragmentation highlights the need for integrated instructional models tailored to the complexity of animation learning.

EVIDENCE ON MULTI-PHASE AND STRUCTURED LEARNING MODELS

Although flipped learning enhances learner readiness and classroom engagement, most implementations focus on separating pre-class preparation from in-class activities and do not systematically integrate collaborative production, guided supervision, and iterative feedback into a unified instructional sequence. Similarly, project-based learning effectively promotes authentic problem solving and practical competence. However, many studies emphasize project completion outcomes rather than examining how structured sequencing supports cognitive regulation throughout complex production workflows. These limitations suggest that the effectiveness of multi-phase learning depends not only on the presence of active learning activities but also on the systematic coordination of pedagogical components within the learning process. Nevertheless, several studies have also noted that the effectiveness of flipped learning depends heavily on students' completion of pre-class activities and their ability to engage in self-regulated learning (Ariani et al., 2024).

Higher-education research increasingly emphasizes multi-phase instructional approaches such as flipped learning, project-based learning (PBL), collaborative learning, and formative assessment cycles. These approaches aim to shift students from passive knowledge reception to active engagement and self-regulated learning. Flipped classroom models distinguish between pre-class preparation and in-class application. Empirical studies consistently report that pre-class instructional exposure improves learner readiness and engagement during face-to-face interaction (Ariani et al., 2024; Sunway et al., 2024). Students report higher behavioral, emotional, and cognitive engagement when pre-class exposure supports in-class interaction. While design-oriented studies have further refined flipped classroom implementation frameworks (Mukhtar et al., 2026), empirical classroom research primarily highlights improved participation and learning performance.

Interactive engagement approaches have been shown to produce significantly higher learning gains compared with traditional instruction (Hake, 1998). Such findings reinforce the importance of active instructional structures in promoting measurable cognitive improvement. Project-based learning

aligns closely with creative-technical disciplines by emphasizing authentic task engagement, problem-solving, and knowledge application (Barak, 2020). Despite these benefits, project-based learning may require substantial instructional support and can create unequal participation among group members during complex collaborative tasks (Barak, 2020). Empirical evidence in multimedia and animation-related domains indicates that PBL enhances students' practical capacity, motivation, and self-regulated learning attitudes. For example, in a 3D design course, students demonstrated increased confidence, practical skills, and self-regulated learning behaviors following project-based implementation. Similarly, hybrid project-based learning models in animation and multimedia education have demonstrated statistically significant improvements in learning outcomes (Ramadhan et al., 2024).

Formative assessment and constructivist learning environments further contribute to students' academic self-efficacy and reflective engagement. Research comparing constructivist and traditional instructional settings shows that constructivist learning environments are associated with higher perceptions of academic self-efficacy. In addition, integrating problem-based learning with peer- and self-assessment practices promotes lifelong learning skills, reflective thinking, and collaborative dialogue. These findings suggest that structured feedback and dialogical assessment practices are integral components of effective multi-phase instructional models. Although these pedagogical strategies individually demonstrate strong theoretical and empirical support, most studies examine flipped learning, PBL, constructivist environments, or formative assessment as discrete approaches. Empirical validation of instructional frameworks that systematically integrate preparation, active engagement, collaborative production, guided supervision, and structured formative evaluation within a single coherent sequence remains limited, particularly in creative-technical disciplines such as 3D animation.

TECHNOLOGY-ENHANCED 3D LEARNING AND COGNITIVE STRUCTURING

Technological advancements, including immersive virtual reality (VR), 3D animation, and simulation-based environments, have demonstrated measurable benefits for learner motivation, spatial reasoning, and skill acquisition across multiple educational domains. In 3D animation education specifically, immersive VR environments have been shown to enhance students' motivation and engagement when learning complex software tools (Ho et al., 2019). Systematic reviews of immersive VR applications in higher education further report improvements in cognitive, psychomotor, and affective outcomes across diverse disciplines (Radianti et al., 2020). However, such reviews also indicate that many VR implementations prioritize technological immersion without sufficiently grounding instructional design in established learning theories. This limitation suggests that technological sophistication alone does not guarantee meaningful learning gains without pedagogical orchestration.

Meta-analytic evidence comparing dynamic and static visualization indicates that 3D models and animations positively influence intrinsic motivation and domain-specific knowledge acquisition (Teplá et al., 2022). In medical and engineering education, integrating 3D visualization with structured pedagogical strategies such as problem-based learning has yielded substantial improvements in theoretical understanding and practical performance (Li et al., 2025). Similarly, hybrid 3D video instructional systems have been shown to improve procedural comprehension while reducing perceived cognitive load compared with conventional instructional methods (Xue et al., 2024).

Nevertheless, Cognitive Load Theory emphasizes that multimedia-rich environments may increase extraneous cognitive load if not supported by structured instructional sequencing (Sweller, 2011). While dynamic visualization can scaffold understanding of complex spatial relationships, unstructured exposure to immersive tools may overwhelm novice learners. Therefore, the effectiveness of technology-enhanced 3D instruction depends not merely on visualization fidelity but on pedagogical frameworks that regulate learner engagement across preparation, guided interaction, application, supervision, and evaluation phases.

THEORETICAL FOUNDATIONS AND CONCEPTUAL RATIONALE OF THE SPIRIT MODEL

The SPIRIT model is conceptualized as an integrated instructional sequencing framework representing six systematically structured stages: *Self-study preparation*, *Pre-class quizzes*, *Interactive group work*, *Real-world application*, *In-class supervision*, and *Test and feedback*. The acronym serves as a mnemonic that reflects the model's integrative and cyclical nature rather than implying religious or spiritual connotations. Conceptually, the model synthesizes complementary pedagogical theories within a unified sequence. It is grounded in constructivist and self-determination perspectives, which emphasize active knowledge construction, autonomy, and guided engagement (Ryan & Deci, 2017). Each stage operationalizes a distinct theoretical principle:

- **Self-study preparation** aligns with Self-Regulated Learning theory, promoting learner autonomy and preparatory engagement.
- **Pre-class quizzes** operationalize retrieval-based reinforcement mechanisms (Ka et al., 2025).
- **Interactive group work** reflects Collaborative Learning and Social Constructivism, emphasizing peer-supported problem solving (Meier, 2022).
- **Real-world application** embodies Project-Based and Experiential Learning principles, simulating authentic production workflows (Ramadhan et al., 2024).
- **In-class supervision** draws on Guided Discovery and Scaffolding theory, ensuring targeted instructional support (Alt, 2015).
- **Test and feedback** operationalize Formative Assessment theory, facilitating iterative evaluation and performance refinement (Alt & Raichel, 2022).

The theoretical alignment of these elements is illustrated in Figure 1.

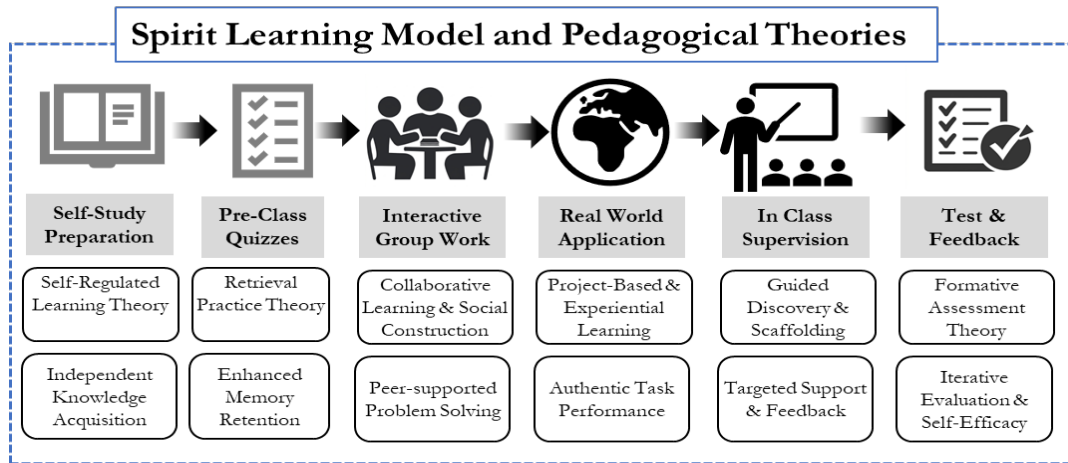


Figure 1. The SPIRIT learning model and its pedagogical theories

Although each SPIRIT stage draws upon established pedagogical theories, the framework is not intended as a simple aggregation of existing instructional strategies. Flipped learning, project-based learning, collaborative learning, and formative assessment are typically implemented as separate or partially connected approaches, each emphasizing a particular aspect of the learning process. In contrast, SPIRIT was designed as a deliberately sequenced instructional framework that coordinates learner preparation, retrieval reinforcement, collaborative production, guided supervision, and iterative feedback within a single pedagogical cycle. The emphasis, therefore, lies not in introducing new instructional components but in structuring their interaction specifically aligned with the cognitive and procedural demands of vocational 3D animation learning. As shown in Table 1, SPIRIT does

not introduce entirely new pedagogical elements. Rather, it differs from related instructional approaches by organizing self-study preparation, retrieval reinforcement, collaborative interaction, authentic application, supervision, and formative evaluation into an explicitly sequenced instructional cycle. While flipped learning, project-based learning, and collaborative learning primarily emphasize specific aspects of the learning process, SPIRIT integrates these complementary approaches into a unified instructional framework that accommodates the cognitive and procedural complexity of vocational 3D animation learning.

Despite their documented benefits, previous studies have also reported important limitations. In flipped learning environments, researchers have identified challenges in adapting when students fail to complete preparatory activities before class, leading to uneven readiness and participation (Ariani et al., 2024; Guilbert et al., 2025). Project-based learning has similarly been associated with increased instructional workload and unequal contribution among group members, particularly during complex collaborative tasks (Barak, 2020; Ramadhan et al., 2024). Studies of collaborative learning have further documented that positive learning outcomes are not always achieved when interaction structures, role distribution, and facilitation mechanisms are insufficiently organized, leading to unequal participation or social loafing (Meier, 2022). Collectively, these findings suggest that the challenge lies not merely in selecting active learning strategies but in coordinating them within a coherent instructional sequence that balances learner autonomy, collaboration, supervision, and formative feedback.

Table 1. Comparison of SPIRIT and related instructional approaches across key learning stages

Learning stage	Flipped learning	Project-based learning (PBL)	Collaborative learning	Spirit*
Self-study preparation	Strong emphasis on pre-class independent learning through digital resources and preparatory activities (Ariani et al., 2024; Sunway et al., 2024)	Learners independently identify knowledge needs and gather resources to support project completion (Barak, 2020)	Preparation may occur individually or collectively, depending on group goals and task design (Meier, 2022)	Explicitly structured self-study phase designed to support readiness and self-regulated learning
Pre-class quizzes	Frequently used to assess preparation and strengthen learning readiness before classroom interaction (Ariani et al., 2024; Mukhtar et al., 2026)	Not typically emphasized; assessment is generally embedded within project activities and reflection processes (Barak, 2020; Ramadhan et al., 2024)	Rarely implemented as a formal instructional component (Meier, 2022)	Integrated as a dedicated retrieval and readiness stage before collaborative work
Interactive group work	Collaborative activities are commonly conducted during face-to-face sessions following pre-class preparation (Sunway et al., 2024)	Core pedagogical component involving collaborative inquiry and problem solving (Barak, 2020; Ramadhan et al., 2024)	Central mechanism emphasizing peer interaction, shared responsibility, and knowledge construction (Meier, 2022)	Structured collaborative stage integrated within the overall learning sequence

Learning stage	Flipped learning	Project-based learning (PBL)	Collaborative learning	Spirit*
Real-world application	Application activities generally occur during in-class problem solving and higher-order learning tasks (Ariani et al., 2024)	Authentic project production and real-world problem solving constitute the primary learning mechanism (Barak, 2020; Ramadhan et al., 2024)	Context-dependent and varies according to collaborative task design (Meier, 2022)	Explicit stage focused on authentic production workflows in vocational 3D animation learning
In-class supervision	Instructors typically act as facilitators who guide classroom interaction and monitor participation (Sunway et al., 2024)	Facilitators provide guidance throughout project development and implementation (Barak, 2020)	Instructors support group processes and collaborative engagement when required (Meier, 2022)	Dedicated supervision stage providing targeted scaffolding and instructional support
Test and feedback	Feedback is commonly provided through quizzes, discussions, and instructor evaluations (Ariani et al., 2024)	Assessment often includes reflection, peer review, and project evaluation (Ramadhan et al., 2024)	Feedback is largely peer-mediated and supported by facilitator input (Meier, 2022)	Explicit evaluation and feedback stage supporting iterative improvement and performance refinement

**This study*

Beyond integrating multiple pedagogical functions, SPIRIT introduces a specific implementation logic. The implementation logic of SPIRIT is grounded in the premise that learners first establish foundational understanding through self-study preparation and retrieval activities before engaging in collaborative production tasks. Guided supervision and formative feedback are subsequently integrated into the production process to support continuous refinement rather than relying solely on end-stage evaluation. This sequencing is intended to reduce cognitive fragmentation and provide progressive instructional support throughout complex 3D animation workflows. Pedagogically, SPIRIT assumes that effective learning in creative-technical domains emerges when cognitive preparation, collaborative production, guided supervision, and formative evaluation operate as interdependent rather than isolated instructional processes. Accordingly, learning is viewed as a progressive and interconnected process in which each instructional stage provides the foundation for subsequent stages within a coherent instructional sequence.

PRACTICALITY AND LEARNING OUTCOMES AS EVALUATION DIMENSIONS

In instructional design research, educational innovations are commonly evaluated through two complementary dimensions: practicality and learning outcomes. Practicality refers to the degree to which teaching materials are usable, feasible, and acceptable within authentic classroom contexts, including clarity of instructions, ease of implementation, and compatibility with existing learning environments (Ariani et al., 2024; Mukhtar et al., 2026). It addresses whether instructors and learners can realistically adopt instructional materials without excessive cognitive or logistical burden.

Learning outcomes may refer to observable changes in learners' knowledge, skills, or attitudes following the implementation of instruction. In the present study, however, learning outcomes were operationalized as changes in students' cognitive understanding, measured by pretest–posttest scores (Nurhastuti et al., 2025). While practical materials are more likely to be adopted in educational settings,

practicality alone does not guarantee significant improvements in learning. Empirical evidence indicates that instructional feasibility and measurable effectiveness may not always align; therefore, both dimensions must be examined concurrently (Fatmawaty et al., 2023).

This dual evaluation framework is particularly critical in complex creative-technical domains such as 3D animation learning. Teaching materials may appear operationally efficient yet fail to support higher-order integration of procedural and conceptual skills. Conversely, theoretically powerful instructional models may prove difficult to implement consistently in classroom settings. Evaluating both practicality and learning outcomes ensures that instructional materials not only function smoothly in practice but also support cognitive understanding and meaningful learning experiences in complex creative-technical contexts. This dual-perspective evaluation is particularly relevant when introducing structured instructional innovations into technology-intensive learning environments. Accordingly, the present study adopts this dual evaluative perspective to examine whether SPIRIT-based teaching materials are both implementable in vocational higher education contexts and associated with positive learning outcomes.

RESEARCH GAP AND CONCEPTUAL FRAMEWORK

The literature consistently demonstrates that 3D animation learning is cognitively demanding, multi-phase instructional strategies enhance learner engagement, and visualization technologies improve spatial understanding and support learning in complex production tasks. Despite the growing body of research on technology-enhanced learning and multi-phase instructional strategies, several important limitations remain evident. Existing studies on 3D animation and visualization-based learning frequently emphasize technological immersion and visual fidelity without sufficiently addressing how instructional sequencing supports cognitive organization and procedural understanding (Radianti et al., 2020; Sweller, 2011).

Likewise, flipped learning, project-based learning, and formative assessment are commonly investigated as independent pedagogical strategies rather than as coordinated components within an integrated instructional framework (Ariani et al., 2024; Barak, 2020). Furthermore, many evaluation studies focus primarily on learning outcomes while paying limited attention to the practical feasibility of implementing instructional innovations in authentic classroom environments.

Building upon the limitations identified in previous studies, a more specific empirical gap remains. Although existing research has demonstrated the potential benefits of flipped learning, project-based learning, collaborative learning, and technology-enhanced instruction, limited evidence is available on the classroom implementation of an integrated instructional framework that combines these pedagogical approaches in vocational 3D animation education.

Furthermore, few studies have simultaneously examined both the practicality of implementation and the learning outcomes associated with such an integrated approach. Previous implementation studies of the SPIRIT model in 3D animation learning have also indicated that integrating self-study preparation, collaborative interaction, guided supervision, and iterative feedback may support more structured and contextualized learning experiences in practice-based higher education environments (Abdillah, 2026).

Based on the identified instructional challenges and theoretical foundations discussed in the literature, this study conceptualizes the SPIRIT model as an integrated instructional framework for vocational 3D animation learning. The framework combines six complementary instructional stages designed to support cognitive organization, collaborative interaction, authentic production activities, guided supervision, and formative feedback within a coherent learning sequence. Figure 2 illustrates the conceptual relationship between instructional challenges, theoretical foundations, integrated pedagogical principles, and the anticipated learning outcomes of the SPIRIT model.

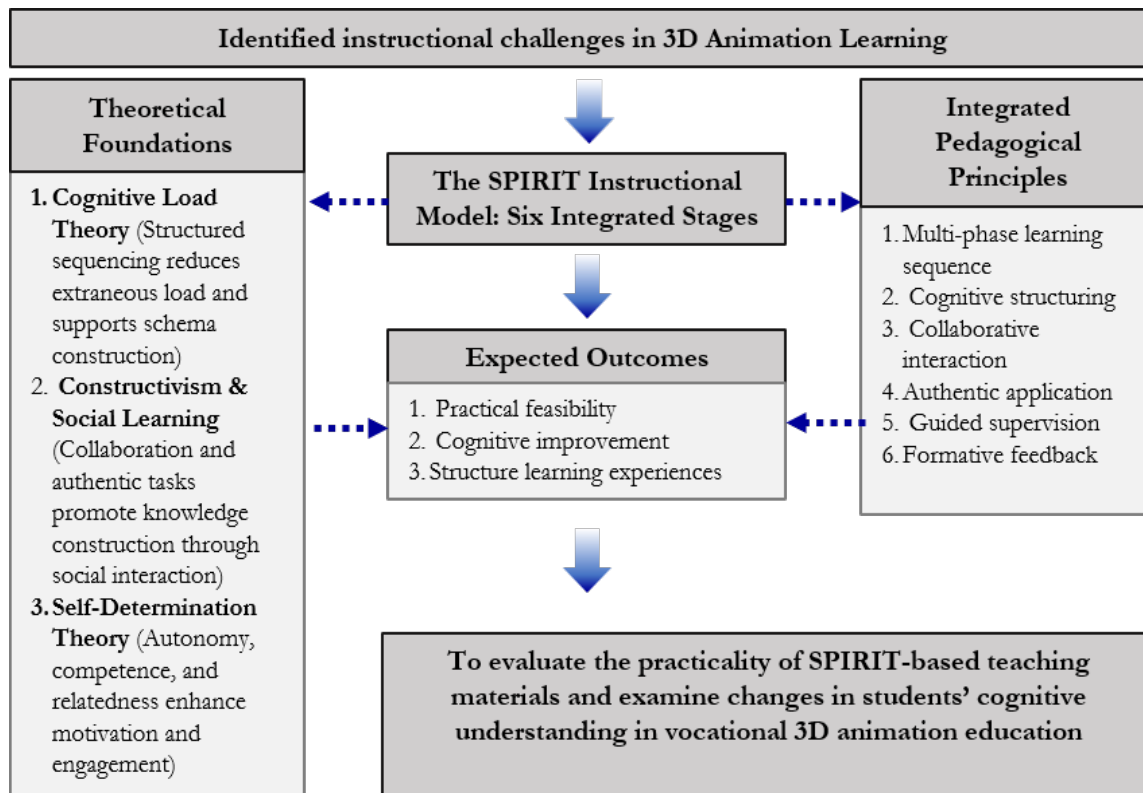


Figure 2. Conceptual framework of the SPIRIT instructional model for vocational 3D animation learning

As illustrated in Figure 2, the SPIRIT framework operationalizes multiple pedagogical principles into a structured instructional sequence intended to address the cognitive and procedural complexity of learning 3D animation. The model integrates theoretical perspectives from Cognitive Load Theory, Constructivism, and Self-Determination Theory to support practical feasibility, cognitive learning, and structured learning experiences in vocational education contexts. The SPIRIT model addresses these limitations by operationalizing six complementary instructional stages within structured teaching materials tailored for vocational 3D animation learning. Rather than functioning as a standalone technological innovation, SPIRIT integrates multi-phase learning principles, cognitive structuring mechanisms, collaborative interaction, and formative guidance into an implementable pedagogical sequence. This study, therefore, evaluates the practicality of SPIRIT-based teaching materials and examines changes in students' cognitive understanding following their implementation, thereby providing empirical evidence to inform the development of integrated instructional approaches for creative and technical education.

RESEARCH OBJECTIVE

This study aimed to evaluate the practicality of SPIRIT-based teaching materials and examine cognitive learning outcomes following their implementation in vocational 3D animation learning. Specifically, the study sought to:

1. Assess the practicality of the SPIRIT-based materials in terms of clarity, usability, attractiveness, relevance, and feasibility during classroom implementation.
2. Examine changes in students' cognitive understanding following implementation of the SPIRIT-based materials.

Through this dual evaluation, the study aimed to provide empirical evidence on the feasibility and learning outcomes of an integrated, multi-phase learning framework for creative-technical education.

METHODOLOGICAL DESIGN

RESEARCH DESIGN

This study represents the implementation and evaluation phase of a previously developed instructional model, conducted within the framework of educational research and development (Gall et al., 2007; van den Akker et al., 2013). The earlier developmental stages, including needs analysis, model design, expert validation, and initial revision, had been completed before this investigation. Accordingly, the present study focused on examining the practicality and learning outcomes of SPIRIT-based teaching materials in authentic classroom settings.

A sequential trial design was employed to ensure systematic evaluation. The implementation consisted of three progressive stages: (1) one-to-one evaluation, (2) small-group trial, and (3) full classroom implementation. Each stage served a distinct evaluative purpose: assessment of clarity and readability, operational feasibility testing, and field-level evaluation of practicality and learning outcomes.

The study was conducted at Politeknik Negeri Lhokseumawe, Department of Information and Computer Technology, within the Multimedia Engineering Technology program during the even semester of the 2024/2025 academic year. This setting was selected for its emphasis on digital production tools, project-based learning, and creative-technical competencies, which align with the objectives of SPIRIT-based instruction.

PARTICIPANTS

Participants were students enrolled in the 3D Animation Production course in the Multimedia Engineering Technology program.

- The one-to-one evaluation involved 4 respondents, comprising three students and one lecturer, selected to assess readability, clarity of instructions, and workflow logic of the SPIRIT-based teaching materials.
- The small-group trial included 8 students and was conducted over several class meetings to evaluate operational feasibility and implementation consistency before full-scale classroom application.
- The full classroom implementation involved 22 students, constituting the regular class cohort for the practicality evaluation and implementation of the SPIRIT-based materials. Complete paired pretest–posttest data from 21 students were included in the learning outcome analysis.

Participants were selected using purposive sampling based on course enrolment. All students had completed prerequisite introductory multimedia courses and possessed comparable baseline familiarity with basic 3D animation tools. Purposive sampling was employed because the participants had previously completed introductory multimedia coursework and represented the intended users of the SPIRIT-based instructional materials.

The sample size reflects the intact cohort of students enrolled in the course during the implementation semester. This approach is consistent with classroom-based educational R&D studies that emphasize formative implementation evaluation within authentic instructional settings rather than population generalization. Consequently, the findings should be interpreted as context-specific evidence derived from a single vocational 3D animation cohort and should not be generalized to broader educational populations without further investigation.

INSTRUCTIONAL IMPLEMENTATION PROCEDURES

The implementation followed the six instructional stages of the SPIRIT model:

1. Self-study preparation
2. Pre-class quizzes
3. Interactive group work
4. Real-world application (project-based task)
5. In-class supervision
6. Test and feedback

One-to-one evaluation

The one-to-one evaluation involved four respondents, comprising three students and one lecturer, who reviewed the SPIRIT teaching materials individually. This stage focused on assessing readability, instruction clarity, workflow logic, and ease of navigation. Feedback was used to perform minor revisions before group implementation.

Small-group trial

The revised materials were implemented in small groups over several class meetings. Data collected included practicality responses and classroom observation notes. This stage evaluated operational feasibility and instructional consistency before full-scale application.

Full classroom implementation

The complete SPIRIT sequence was applied in a regular class environment. Students completed:

- A pretest assessing prior knowledge
- All six SPIRIT learning stages
- A posttest measuring cognitive improvement
- A practicality response questionnaire

Classroom observations were conducted to verify the consistency of implementation across sessions. The overall procedural flow of the study is illustrated in Figure 3.

INSTRUMENTS

Learning outcomes and practicality were examined using multiple instruments:

1. Cognitive Test (Pretest–Posttest)

A structured test measured students' understanding of layout design, camera operation, scene setup, and foundational 3D production concepts. Test items were developed based on Course Learning Outcomes (CLO) and the Semester Learning Plan (SLP), and aligned with Bloom's revised taxonomy (Bloom et al., 1956; Wilson, 2016).

2. Practicality Questionnaire

A structured questionnaire measured clarity, usability, attractiveness, relevance, and feasibility of the SPIRIT materials. Responses were recorded using a five-point Likert scale.

3. Observation Sheets

Observation instruments were used to document adherence to the six SPIRIT stages and ensure procedural consistency during classroom sessions.

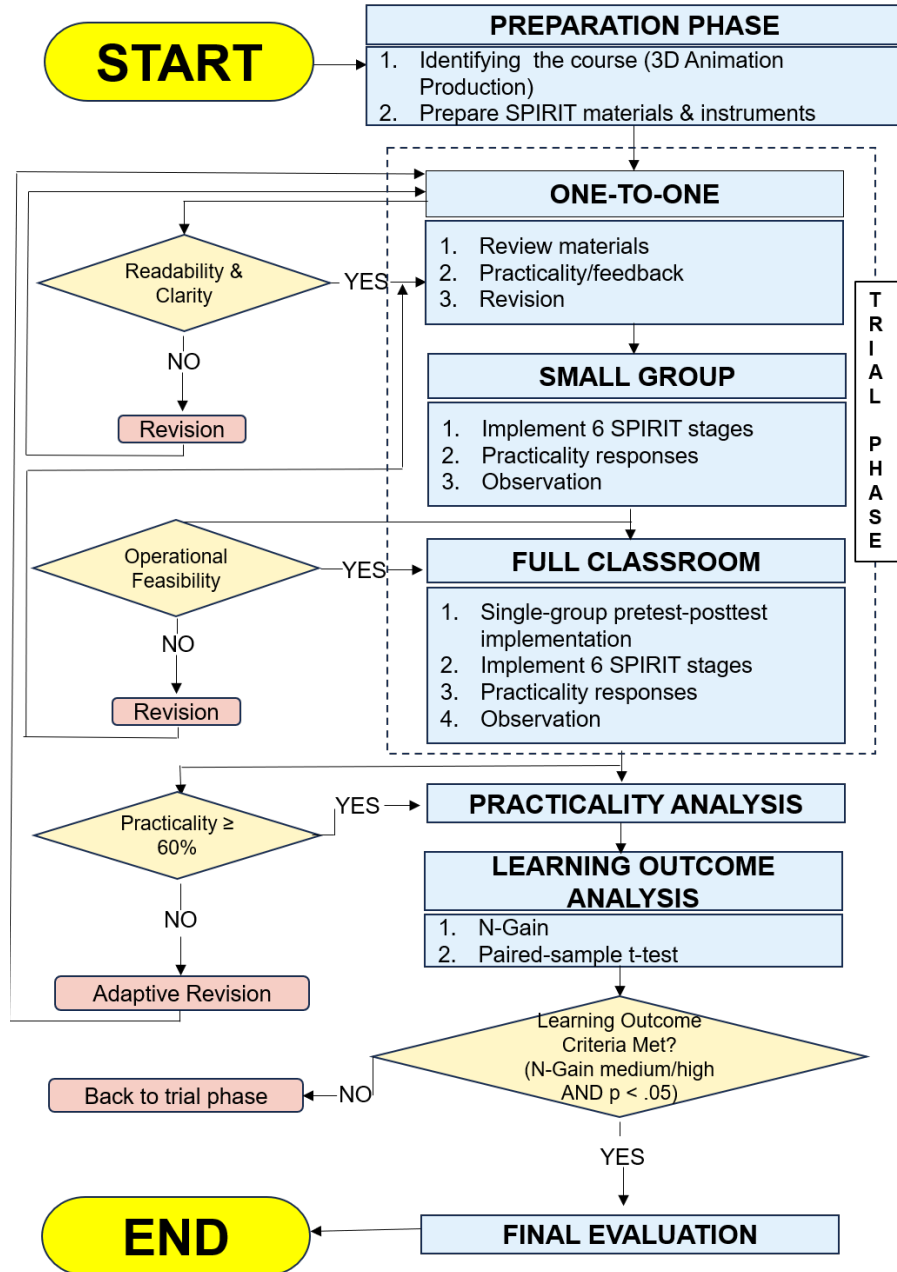


Figure 3. Flowchart of the implementation procedures for practicality and learning outcomes testing of the SPIRIT-based teaching materials

VALIDITY AND RELIABILITY

The SPIRIT instructional model and its supporting teaching materials underwent expert validation during the developmental phase of this study, before classroom implementation. The validation involved three expert reviewers representing instructional design and curriculum development, educational media and technology, and learning materials and academic language. All validators held doctoral qualifications and had more than 10 years of professional experience in their respective fields.

Validation covered content validity (alignment of materials with learning objectives and theoretical principles), construct validity (internal coherence between learning activities and pedagogical structure), and syntax validity (logical sequence and flow of instructional implementation). Results yielded mean scores ranging from 4.14 to 4.58 on a five-point scale, with validity percentages between 82.86% and 91.56%, corresponding to Valid and Highly Valid classifications across all instructional products. These findings confirmed the conceptual, pedagogical, and structural quality of the SPIRIT-based teaching materials before classroom implementation.

Regarding the measurement instruments used in this study, the cognitive test items were developed in alignment with Course Learning Outcomes (CLO) and Bloom's revised taxonomy, and reviewed for content relevance during the instructional development phase. However, empirical reliability coefficients (e.g., Cronbach's alpha or KR-20) were not calculated for the cognitive test or the practicality questionnaire in the present study. This is acknowledged as a limitation that may affect the precision of score interpretation.

Classroom observation sheets were used to document implementation consistency across sessions; they were structured around the six SPIRIT stages, but were administered by a single observer, and inter-rater agreement was not assessed. These reliability limitations are further acknowledged in the Limitations section of this study and should be considered when interpreting the findings.

DATA ANALYSIS

Practicality

Practicality responses were analyzed descriptively using a percentage-based evaluation commonly applied in instructional R&D studies. The calculation followed practicality evaluation procedures adapted from Sugiyono (2020) and van den Akker et al. (2013). Practicality was computed using the following formula:

$$P = \frac{\sum X}{N \times K \times S_{\max}} \times 100\% \quad (1)$$

where P represents the practicality percentage, $\sum X$ is the total score obtained, N is the number of respondents, K is the number of items, and $S_{\max}$ is the maximum score per item. The resulting percentages were interpreted based on Fajriati and Putra's (2023) practicality criteria.

Learning outcome analysis

Learning outcomes following the implementation of the SPIRIT-based teaching materials were examined through two complementary measures:

1. Normalized Gain (N-Gain) to measure the improvement from pretest to posttest, following Hake (1998), with categories of high (≥ 0.70), medium (0.30–0.69), and low (< 0.30) learning gain.

$$N - Gain = \frac{Posttest\ Score - Pretest\ Score}{Ideal\ Score - Pretest\ Score} \quad (2)$$

2. A paired-samples t-test was conducted to determine whether differences between pretest and posttest scores were statistically significant ($p < 0.05$). Statistical analysis was performed using SPSS software. Before conducting parametric testing, data normality was examined using the Shapiro–Wilk test to ensure the suitability of the paired-samples t-test.

Qualitative analysis

Qualitative data from open-ended questionnaire responses and classroom observations were analyzed descriptively. The analysis focused on identifying recurring patterns in instructional clarity, workflow challenges, learner engagement, and the consistency of SPIRIT implementation.

ETHICAL CONSIDERATIONS

This study involving human participants was conducted in accordance with applicable institutional ethical standards and research regulations. The ethical status of the study was determined and documented by the Institute for Research and Community Service (LPPM), Universitas Negeri Medan, through Research Ethics Status Certificate No. 3751/UN33.8/1L/2026. In accordance with the applicable regulations of Universitas Negeri Medan, the study does not require further ethical review. Formal institutional research permission was also obtained from the Postgraduate Program of Universitas Negeri Medan through Letter No. 0104/UN33.19.1/PG/2025 and from the Department of Information and Computer Technology, Politeknik Negeri Lhokseumawe through Letter No. 1428/PL20.6.6/KP.01.00/2025. All participating students were informed of the study's objectives, procedures, and voluntary nature before participation. Informed consent was obtained from all participants. Participants' identities and responses were treated confidentially and used solely for academic research purposes.

RESULTS

PRACTICALITY

The practicality evaluation results across the one-to-one, small-group, and full classroom implementation stages are presented in Table 2 and visualized in Figure 4. Overall, the SPIRIT-based teaching materials received high practicality ratings across all stages, with mean scores of 91.0% for the one-to-one evaluation, 80.5% for the small-group trial, and 83.9% for the full classroom implementation. These findings indicate that the instructional materials were operationally feasible and well accepted within vocational 3D animation learning environments.

Table 2. Practicality scores of the SPIRIT learning materials across trial stages

No.	Indicators	One-to-one	Small groups	Full classroom
1	The textbook provides a clear description of 3D Animation material and the learning sequence.	90.0%	82.5%	85.5%
2	The textbook clearly explains the learning outcomes.	90.0%	90.0%	83.6%
3	The textbook provides indicators of learning achievement for each chapter.	95.0%	82.5%	82.7%
4	The textbook includes images and illustrations that support conceptual understanding.	90.0%	70.0%	84.5%
5	The textbook includes practice exercises for independent evaluation.	90.0%	87.5%	87.3%
6	Tables in the textbook are clearly presented and easy to read.	90.0%	75.0%	83.6%
7	The textbook's use of technical terminology is easy to understand.	90.0%	72.5%	82.7%
8	The sequence of material presentation is systematic and logical.	85.0%	90.0%	83.6%
9	The font type and text size in the textbook are comfortable to read.	100.0%	82.5%	85.5%
10	The textbook's visual design is attractive and supports readability.	90.0%	72.5%	80.0%
Mean		91.0%	80.5%	83.9%

As illustrated in Figure 4, several indicators consistently achieved high practicality scores across implementation stages. Indicators related to the clarity of learning materials and instructional organization, such as the explanation of learning outcomes (Indicator 2), the provision of practice exercises (Indicator 5), and the systematic sequence of material presentation (Indicator 8), obtained particularly strong evaluations. Likewise, visual readability aspects, including font type and text size (Indicator 9), received the highest score during the one-to-one evaluation stage (100.0%), suggesting that the textbook design effectively supported learner readability and accessibility.

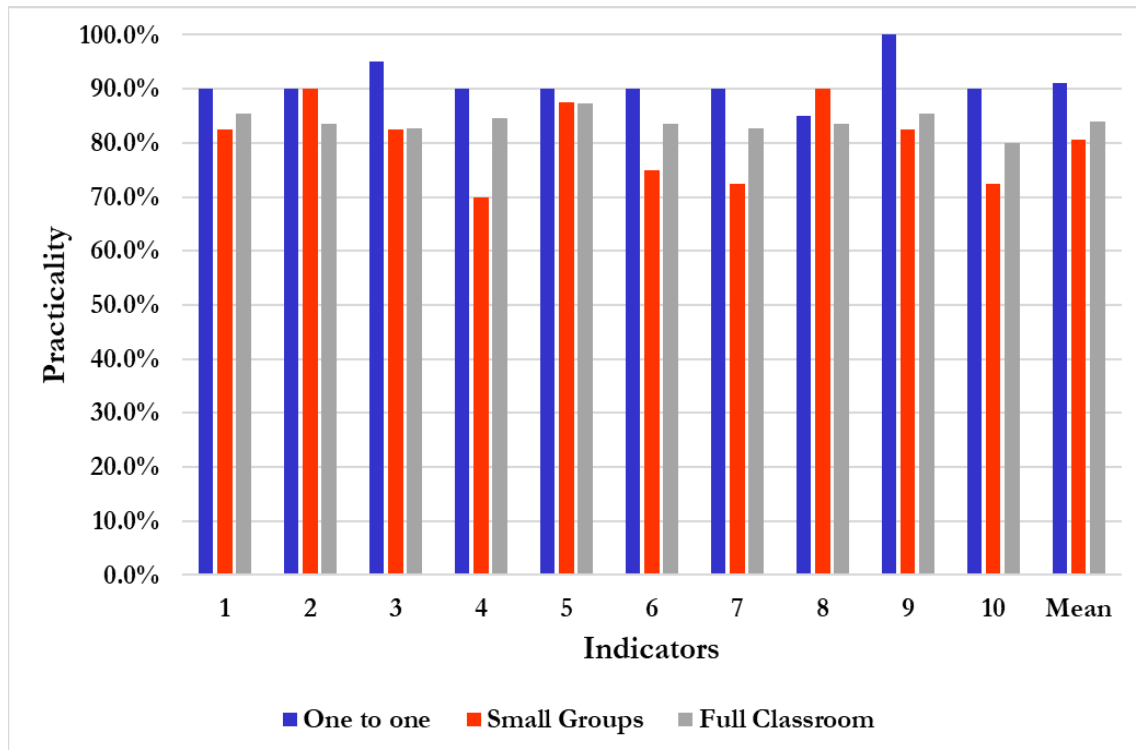


Figure 4. Comparison of practicality percentages across one-to-one, small-group, and full classroom implementation stages

Some indicators showed lower scores during the small-group implementation stage, particularly those related to illustrations and visual presentation, such as supporting images and conceptual illustrations (Indicator 4), readability of tables (Indicator 6), clarity of technical terminology (Indicator 7), and visual design attractiveness (Indicator 10). However, these indicators showed higher scores during the full-classroom implementation stage, suggesting improved instructional clarity and usability following revisions made after the small-group trial.

Table 3 presents a summary of qualitative feedback gathered from students regarding their experience with the SPIRIT-based teaching materials. Four recurring themes were identified from the open-ended responses, reflecting students' perceptions of the materials' clarity, visual support, technical depth, and the role of instructor guidance during implementation.

As shown in Table 3, students generally responded positively to the structured sequencing and visual scaffolding provided by the SPIRIT-based materials. However, feedback also highlighted areas for further development, particularly the need for more technical examples and continued instructor support during complex procedural tasks. These qualitative findings complement the quantitative practicality scores and provide contextual insight into students' experience of the instructional materials.

Table 3. Summary of student feedback on the practicality of the SPIRIT learning model

Theme	Representative student comments
Structured sequencing reduces confusion	“The step-by-step sequence helps me understand the workflow and reduces confusion during complex tasks.”
Visual scaffolding supports comprehension	“The illustrations and diagrams really help me grasp the concepts better, especially as a beginner.”
Need for additional technical examples	“More examples are needed for rigging, camera movement, and navigating Blender’s interface.”
In-class guidance remains essential	“Even with clear materials, I still need the lecturer’s guidance for difficult technical operations.”

LEARNING OUTCOMES

Table 4 presents the normalized gain (N-Gain) results for the SPIRIT learning model. The analysis yielded a mean score of 47.50%, categorized as a moderate level of learning gain according to Hake’s (1998) classification. The distribution of scores ranged from 0% to 100%, with a median of 50% and a standard deviation of 27.71. This suggests a moderate positive change in students’ cognitive understanding following implementation of the SPIRIT-based materials. Before conducting the paired-samples t-test, the normality of the pretest–posttest difference scores was examined using the Shapiro–Wilk test. The Shapiro–Wilk test yielded $W = .908, p = .050$ ($n = 21$).

Table 4. N-Gain descriptive statistics

Statistic	Value
N (Students)	21
Mean	47.50%
Median	50.00%
Minimum	0.00%
Maximum	100.00%
Standard Deviation	27.71
Category	Moderate Learning Gain

Table 5 presents the results of the paired-samples t-test conducted to examine changes in cognitive learning outcomes following implementation of the SPIRIT-based materials. The posttest mean score (74.52) was significantly higher than the pretest mean score (47.62), with a mean difference of 26.91 points ($t(20) = 6.16, p < .001$, Cohen’s $d = 1.34$).

Table 5. Paired-samples t-test

Pair	N	Mean (pre)	Mean (post)	Mean difference	SD difference	<i>T</i>	<i>Df</i>	<i>P</i>	Cohen’s <i>d</i>	Interpretation
Posttest–pretest	21	47.62	74.52	26.91	20.03	6.16	20	< .001	1.34	Significant, large effect

DISCUSSION

The discussion addresses two research questions concerning the practicality and cognitive learning outcomes of implementing SPIRIT-based teaching materials. The findings suggest that students showed positive changes in cognitive understanding following implementation of the SPIRIT instructional sequence.

The highest mean practicality score was observed during the one-to-one evaluation (91.0%), followed by the full-classroom implementation (83.9%) and small-group trial (80.5%). Practicality remained consistently high during the small-group and full-classroom stages, suggesting that the instructional framework could be implemented consistently across increasingly complex learning settings. Similar trends have been reported in instructional development studies emphasizing iterative validation and staged implementation procedures in technology-supported vocational learning environments (Fajriati & Putra, 2023; Ramadhan et al., 2024). The relatively small fluctuations across implementation stages suggest that the SPIRIT model maintained structural consistency and usability even within more complex classroom interactions. These findings are also consistent with earlier descriptive implementation research on the SPIRIT model, which reported that integrating self-study preparation, collaborative interaction, guided supervision, and iterative feedback was associated with more systematic and contextualized animation learning processes (Abdillah, 2026).

The practicality levels observed in this study are also comparable to those reported in multimedia-based and hybrid project-oriented instructional developments, which generally demonstrate high practicality following iterative revisions and implementation refinement (Mou, 2020; Ramadhan et al., 2024). Similar findings have been documented in technology-enhanced animation and mixed-reality learning environments, where structured instructional sequencing and visual scaffolding have been associated with improvements in learner comprehension, usability, and engagement (Ho et al., 2019; Piankarnka et al., 2023; Teplá et al., 2022). However, unlike many prior studies that investigate flipped learning, project-based learning, visualization technologies, or gamified interaction independently, the present study evaluated these pedagogical functions as interconnected components within a unified instructional sequence. This distinction is important because vocational animation learning requires students to coordinate conceptual understanding, software-based activities, and collaborative production.

The findings further reinforce recent international discussions emphasizing that the effectiveness of technology-supported learning environments depends not merely on technological sophistication or engagement-oriented features, but on how pedagogical components are systematically integrated into the learning process (Papadakis & Karakose, 2025). Papadakis and Karakose (2025) argue that technology-enhanced and gamified learning environments do not always lead to meaningful improvements in learning when implemented as isolated motivational features without coherent pedagogical integration. In the present study, the observed practicality ratings and positive learning changes may reflect more than the use of digital visualization or collaborative project activities. They may also be associated with the coordinated sequencing of preparation, retrieval, reinforcement, collaborative interaction, guided supervision, and formative feedback within a coherent instructional cycle. These findings suggest that the deliberate orchestration of complementary instructional components may play a more substantial role in supporting meaningful learning than the isolated implementation of individual technological or motivational elements.

Qualitative feedback further substantiates the quantitative findings. Students reported that the step-by-step sequencing reduced confusion during complex animation workflows and supported clearer understanding of the learning process. This observation is consistent with Cognitive Load Theory, which suggests that structured instructional guidance may help learners manage intrinsic cognitive load during complex, multi-step procedural tasks (Sweller, 2011). In creative-technical disciplines such as 3D animation, learners are required to simultaneously process software operations, engage in spatial reasoning, and make aesthetic decisions. Accordingly, structured sequencing may help reduce

learners' cognitive burden and support more coherent integration of technical procedures. However, this interpretation remains speculative because cognitive load was not measured directly in the present study.

At the same time, students' requests for additional technical examples and continued guidance from the lecturer indicate that structured instructional materials alone may not fully support all dimensions of complex vocational learning. These findings are consistent with constructivist perspectives emphasizing the importance of instructor scaffolding, guided interaction, and contextual support during authentic problem-solving activities (Alt, 2015). The need for continued instructional guidance suggests that even highly structured learning materials remain most effective when combined with responsive facilitation and adaptive instructional support.

With respect to the second research question, the findings suggest positive changes in students' cognitive understanding following implementation of the SPIRIT-based teaching materials. The moderate N-Gain score (47.50%) suggests a moderate level of learning gain, while the statistically significant pretest–posttest difference ($p < .001$) indicates that students achieved higher scores after implementation. The Shapiro–Wilk test yielded $W = .908$, $p = .050$ ($n=21$). The result should be considered when interpreting the paired-samples t-test, together with the limitations of the single-group design. Although the large effect size (Cohen's $d = 1.34$) suggests a substantial magnitude of observed improvement, the findings should be interpreted with caution, given the results of the Shapiro–Wilk test, the single-group design, and the absence of a comparison group (Becker, 2000; Cohen, 1988). Consequently, the results provide preliminary, context-specific evidence regarding cognitive learning gains associated with SPIRIT-based materials, rather than definitive evidence of instructional effectiveness.

The variability observed in individual learning gains may also reflect differences in learners' readiness for self-directed and technology-supported learning. Previous research has shown that students' responses to digitally mediated instructional environments are influenced by contextual and individual characteristics, including motivation, prior experience, and adaptive learning preferences (Alt & Raichel, 2022; Kolb, 2015; Papadakis & Karakose, 2025). In this regard, the SPIRIT framework appears to accommodate learner diversity by integrating multiple complementary instructional processes, including self-study preparation, collaborative interaction, authentic production activities, guided supervision, and iterative feedback. This balanced sequencing is consistent with Self-Determination Theory. The preparatory stage may support learner autonomy, guided supervision and feedback may strengthen perceptions of competence, and collaborative group activities may foster relatedness (Maryono et al., 2025; Ramadhan et al., 2024; Setyaedhi, 2023). The SPIRIT model operationalizes these motivational dimensions within a coherent instructional structure, which may help explain the observed practicality and positive cognitive learning outcomes within vocational animation learning environments. Overall, the findings suggest that integrated pedagogical orchestration warrants further investigation as an approach to vocational creative-technical education, particularly through comparative or experimental research designs.

Alternative explanations should also be considered when interpreting these findings. Improvements in posttest performance may have been influenced not only by the instructional materials but also by factors such as increased familiarity with the learning tasks, normal progression throughout the course, instructor guidance, or students' growing experience with 3D animation software. Therefore, while the findings are encouraging, they should be interpreted as preliminary evidence that warrants further investigation using comparative or experimental research designs.

CONCLUSION

This study aimed to evaluate the practicality of SPIRIT-based teaching materials and examine changes in students' cognitive understanding following their implementation in vocational 3D animation learning. The findings indicate that the SPIRIT-based instructional materials were practical and

were associated with positive cognitive learning outcomes within an authentic vocational classroom setting. Regarding the first research question, the practicality evaluation across the one-to-one, small-group, and full-classroom implementation stages consistently indicated high practicality. These findings suggest that the SPIRIT learning sequence was operationally feasible, understandable, and well accepted by the participating respondents. The structured integration of self-study preparation, collaborative interaction, guided supervision, and formative feedback was associated with instructional clarity and learning organization as reflected in the practicality evaluation and qualitative feedback.

Regarding the second research question, the learning outcome analysis revealed a statistically significant pretest–posttest difference in students’ cognitive understanding following implementation of the SPIRIT-based materials. The moderate N-Gain score and significant pretest–posttest difference indicate positive cognitive learning gains within this specific vocational context. Overall, the findings provide preliminary evidence that the structured orchestration of complementary pedagogical processes may support positive learning outcomes in vocational 3D animation learning. This study, therefore, provides preliminary empirical evidence regarding the feasibility and potential learning benefits of integrated multi-phase instructional approaches in creative-technical and vocational learning environments.

LIMITATIONS

Although the findings indicate positive learning outcomes following the implementation of the SPIRIT-based teaching materials, several limitations should be acknowledged. First, the study employed a single-group pretest–posttest design without a comparison group. Consequently, the observed learning improvements cannot be attributed solely to the SPIRIT-based materials, as alternative explanations such as maturation, testing effects, instructor influence, and normal course progression may also have contributed to the results. Second, the study was conducted within a single institutional context involving a relatively small group of vocational higher-education students. While the findings provide useful context-specific evidence, the limited sample size constrains broader generalizability to other educational contexts or creative-technical disciplines. Third, classroom observations were conducted by a single observer, and inter-rater agreement was not assessed. These factors should be considered as methodological limitations of the study. Fourth, empirical reliability coefficients for the cognitive test and the practicality questionnaire, such as Cronbach’s alpha or KR-20, were not calculated in the present study. The absence of reliable evidence for these instruments may affect the precision of score interpretation and should be considered when evaluating the findings.

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