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Integrating Conventional Instruction and Simulation-Based Learning: A Three-Stage Conceptual Model for Student Engagement and Conceptual Understanding

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Abstract-Conventional instruction and simulation-based learning are frequently compared as alternative teaching approaches, yet this comparison leaves an important design question unresolved: how should explanation, simulation activity, and reflection be sequenced so that students do not merely complete a task but understand the principles underlying it? This paper addresses that question by proposing a three-stage conceptual model for higher education: Concept Introduction, Guided Simulation Exploration, and Reflection and Application. The model responds to a specific pedagogical risk in simulation-based learning which is how successful interaction or task completion may occur without conceptual understanding, particularly when students lack prerequisite knowledge or receive insufficient guidance to interpret outcomes. Using a critical narrative synthesis of 30 selected publications published between 2020 and 2026, the paper maps evidence on active instruction, simulation effectiveness, prior knowledge, instructional scaffolding, feedback, and reflection to the functions of each stage. The model's main contribution is to focus on the sequence of teaching activities rather than simply combining teaching methods, while using reflection and knowledge transfer to check whether students truly understand what they have learned. Five propositions specify expected relationships and boundary conditions, including the possibility that unguided interaction may increase activity without improving conceptual understanding. The model is a literature-informed proposition, not a validated intervention. Future studies should compare integrated, conventional-only, and simulation-only conditions and separately measure engagement, conceptual explanation, and transfer to unfamiliar problems.

Keywords: Conventional Learning; Simulation-Based Learning; Student Engagement; Conceptual Understanding; Instructional Design; Integrated Learning

1. INTRODUCTION

Higher education instructors must decide not only which teaching approach to use, but how to organise learning activities so that students can connect foundational explanations with practical investigation. Conventional instruction can make terminology and theoretical relationships explicit, while simulation-based learning allows students to manipulate variables, test predictions, and observe outcomes. Evidence supports the value of both approaches, but the evidence does not establish that simply placing them in the same lesson will reliably produce conceptual understanding. The central design problem is therefore one of sequencing and interpretation: what preparation do learners need before simulation, what guidance should accompany exploration, and what evidence demonstrates that students have understood more than the procedure?

The distinction should not be reduced to teacher-led versus technology-led learning. Conventional instruction can include discussion and problem-solving, while a simulation can remain passive or confusing if students are not given a meaningful task. Kozanitis and Nenciovici (2023) reported an average advantage for active instruction over traditional lecturing across the studies they reviewed, while Chernikova et al. (2020) found positive effects of simulation-based learning on complex-skill development. These findings establish a rationale for meaningful activity and simulation, but neither directly validates the particular three-stage sequence proposed here or guarantees gains in conceptual understanding across subjects.

Simulation effectiveness also depends on design and learner characteristics. Chernikova et al. (2024) examined the role of information salience, authenticity, and prior knowledge, while Chernikova et al. (2025) considered personalisation through adaptivity and adaptability. Taken together, this literature suggests that exposure to a simulation is not a sufficient instructional explanation: learners must notice relevant information, interpret system responses, and connect their actions with the target concepts. A remaining design need is a practical account of how foundational explanation, guided experimentation, and post-activity explanation can be coordinated as one learning sequence.

This paper addresses that need through a three-stage conceptual model: (1) Concept Introduction, which establishes a focused conceptual baseline and elicits an initial prediction; (2) Guided Simulation Exploration, which asks learners to manipulate or investigate a system while recording and interpreting evidence; and (3) Reflection and Application, which requires learners to explain outcomes, revisit misconceptions, and apply the principle to a new situation. The model does not claim that integration is inherently superior. Its distinctive claim is that the stages serve different epistemic functions and that reflection and transfer provide a check against mistaking procedural success for understanding.

The problem addressed is not a lack of evidence that active learning or simulation can be useful. Rather, findings about these approaches are often discussed separately, and evidence for one component does not automatically explain how the components should be sequenced. Without an explicit sequence, learners may enter a simulation without sufficient conceptual preparation, change several variables without interpreting the results, or finish after obtaining a

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correct output without explaining why it occurred. These risks are especially consequential when the learning objective is conceptual explanation or transfer, rather than task completion alone.

Accordingly, this paper develops a literature-informed instructional model and five propositions for subsequent testing. It contributes (i) a functional account of the three stages, (ii) a distinction between engagement as a learning-process construct and conceptual understanding as a learning outcome, and (iii) testable boundary conditions concerning prior knowledge, task complexity, and instructional guidance. The model is intended as a design and research proposition rather than a claim of demonstrated effectiveness.

Simulation-based learning offers opportunities for exploration and repeated practice (Elendu et al., 20024), but it also creates design challenges. Learners may focus on operating the tool rather than understanding the concept, make repeated attempts without interpreting the results, or become overwhelmed by complex representations (Chernikova et al., 2025). A simulation is a model of a system, not the system itself; therefore, students may need help distinguishing the features represented from those omitted. Prior knowledge also matters because learners need a sufficient conceptual foundation to interpret what the simulation displays (Chernikova et al., 2021; Riazy et al., 2021; Riazy et al., 2020; Simonsmeier et al., 2022).

The central problem is consequently not whether conventional instruction or simulation-based learning is categorically better. It is how instructors can organise these approaches so that explanation, exploration, feedback, and reflection work together toward defined learning outcomes. The literature offers evidence about active instruction and simulation design, but a practical integrated sequence can help translate these insights into a proposed teaching structure. The purpose of this paper is to develop a literature-informed conceptual approach that integrates conventional instruction and simulation-based learning to support student engagement and conceptual understanding. It has three objectives: to explain the rationale for combining structured explanation with guided simulation; to propose a three-stage instructional model; and to formulate propositions that can guide future empirical evaluation..

2. RESEARCH METHODOLOGY

3.1 Research Design

This study uses a conceptual paper design informed by a critical narrative synthesis. It is not an empirical study, systematic review, or meta-analysis; no participant data or new effect estimates are reported. The purpose of the synthesis is analytical rather than exhaustive: to identify recurring instructional functions and tensions in the selected literature, then use those patterns to construct a coherent sequence and derive propositions that can be tested empirically. The 30 cited publications, dated 2020–2026, were considered for their relevance to one or more of five analytic domains: (1) conventional instruction and active learning; (2) simulation-based learning and learning outcomes; (3) prior knowledge, task complexity, and instructional scaffolding; (4) feedback and reflection; and (5) conceptual understanding, engagement, or transfer. Sources were retained in the conceptual synthesis when they addressed a higher-education or transferable instructional context and provided a clear conceptual, empirical, review-based, or design-related contribution to at least one domain. Sources were not treated as equivalent evidence: meta-analyses informed broad patterns, individual empirical studies informed context-specific considerations, and conceptual or practice-oriented publications informed design possibilities. Studies were not used to claim that the proposed three-stage model had already been tested.

The synthesis was organised around four questions: what foundational explanation should precede simulation; what learner actions make simulation exploration purposeful; how should learners interpret errors and feedback; and what activities can demonstrate conceptual understanding beyond task completion? For each domain, the paper compared the instructional function described in the sources, the risk or limitation identified, and the design implication for the proposed model. The three stages were then constructed by assigning these functions to a sequence: preparation, guided evidence-generating exploration, and explanation with transfer. This is a purposive narrative synthesis, not a reproducible database search. The manuscript does not claim exhaustive coverage or a PRISMA screening process; a future systematic review would need a documented search string, database-specific search dates, independent screening, and a study-selection flow diagram.

3.2 Development of the Conceptual Model

Before presenting the proposed conceptual model, it is important to establish an understanding of conventional instruction and its role in the teaching and learning process. Conventional instruction refers to a structured approach in which instructors introduce learning content, explain theoretical concepts, demonstrate procedures, and guide students through the acquisition of foundational knowledge. This approach provides an organised learning environment in which students can develop an initial understanding of a subject before engaging in more complex learning activities. Within the proposed conceptual model, conventional instruction represents the first stage, Concept Introduction, in which instructors explain key concepts, establish foundational knowledge, and encourage students to make initial predictions about the learning topic. This stage prepares students for the second stage, Guided Simulation Exploration, where they interact with simulation-based applications to investigate concepts, test predictions, observe outcomes, and receive immediate feedback.

The learning process then progresses to the third stage, Reflection and Application, in which students interpret their observations, reflect on their learning experiences, clarify misconceptions, and apply their acquired knowledge to

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relevant problems or new situations. Dietrich and Evans (2022) discussed the relationship between traditional lecturing and active learning, suggesting that conventional instruction and active learning should not necessarily be viewed as mutually exclusive approaches. Instead, conventional instruction can serve as a foundation for subsequent learning activities that require students to apply, investigate, and evaluate the knowledge they have acquired. Therefore, integrating conventional instruction with simulation-based learning across these three stages may provide a structured learning experience that supports student engagement and the development of conceptual understanding.

3.2.1 Conventional Instruction as Conceptual Preparation

Conventional instruction serves as the conceptual preparation stage in the proposed model because it helps students establish the foundational knowledge required for meaningful participation in simulation-based activities. During this stage, instructors introduce essential terminology, explain key principles, provide examples, and demonstrate relevant procedures through lectures, presentations, discussions, or instructional materials. For example, before students use network simulation software to design and configure a computer network, the instructor may first explain network topology, IP addressing, and the principles of data transmission. This preparation enables students to approach the simulation with an initial understanding of the concepts they are expected to explore. Nevertheless, conventional instruction alone may not provide sufficient opportunities for students to test their understanding or examine the consequences of their decisions. Research comparing active learning with traditional lecturing indicates that opportunities for active participation can contribute to improved learning achievement (Kozanitis & Nenciovici, 2023). Therefore, in the proposed conceptual model, conventional instruction is not intended to be replaced by simulation-based learning; rather, it establishes the theoretical foundation upon which guided simulation exploration and subsequent reflection can be developed.

3.2.2 Simulation As a Space for Guided Exploration

Simulation-based learning allows learners to investigate a model or scenario by changing conditions, testing predictions, observing outcomes, and repeating tasks. This can be useful when the target concept involves relationships that are difficult to observe directly or when repeated practice in a real environment is impractical. Chernikova et al. (2020) found an overall positive effect of simulation-based learning on complex skill development across the empirical studies included in their meta-analysis. The result supports the potential of simulation as a learning approach, but it should not be generalised to every type of simulation, discipline, or learning outcome.

The quality of the learning activity matters. Students need to know which variables to change, what to observe, and how to relate results to the principles introduced earlier. A guided task might ask students to predict an outcome before changing a parameter, record what happens, and explain whether the observation matches their prediction. This process can turn interaction into evidence-based reasoning. By contrast, unstructured exploration may lead students to make many changes without identifying which change produced a particular result.

Chernikova et al. (2024) highlight the relevance of prior knowledge and simulation design features, including the salience of information and the authenticity of scenarios. For instructional practice, this suggests that the most realistic simulation is not necessarily the most educationally useful. The representation should make relevant relationships visible and manageable for the learners' level of expertise. A simplified model may be preferable when it helps students focus on the principle being taught, provided its limitations are made explicit.

3.2.3 Feedback, Guidance, and Error Interpretation

Feedback helps learners compare their current understanding with the intended learning outcome. In a simulation, feedback may be provided by the system, the instructor, peers, or a combination of these sources. A system response can show that a decision has changed an outcome, but the learner may still need an explanation of why the change occurred. Instructors can prompt students to interpret the response, identify misconceptions, and consider alternative explanations.

Guidance is especially important when the simulation is unfamiliar or cognitively demanding. Examples, prompts, staged tasks, and questions can reduce the risk that students focus on interface operation rather than the target concept. Guidance should not necessarily remove all challenge; rather, it should help students direct their attention to relevant features and gradually take greater responsibility for interpretation. The simulation literature synthesised by Chernikova et al. (2020) explicitly considers scaffolding as a factor in learning complex skills, supporting the inclusion of guidance as a core design consideration.

Errors can become useful learning opportunities when students are able to recognise them, understand their consequences, and revise their reasoning. Simply allowing repeated attempts is insufficient. Students should be asked to explain what went wrong, which evidence supports their explanation, and what they would change in a subsequent attempt. These activities prepare the transition from simulation exploration to reflective understanding.

3.2.4 Reflection and Conceptual Understanding

Conceptual understanding involves explaining principles and relationships, interpreting evidence, and applying knowledge beyond the exact example encountered during instruction. Correctly operating a simulation is not, by itself, proof of conceptual understanding. A student may discover a successful sequence through trial and error without being able to explain why it works or whether it would work under different conditions.

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Reflection provides an opportunity to make the reasoning behind an activity explicit. Students can compare their predictions with observed outcomes, explain discrepancies, connect results to theoretical principles, and identify limitations in the model. An instructor can then ask students to apply the principle to a new scenario or solve a related problem without relying on the simulation. Such tasks help distinguish tool-use proficiency from understanding of the underlying concept. The proposed integrated approach therefore includes reflection as a required stage rather than an optional end-of-lesson discussion. It is the point at which learners are asked to translate activity into an explanation and consider how the knowledge might transfer to another context.

3.3 Proposed Integrated Conceptual Model

The proposed model consists of three connected stages: Concept Introduction, Guided Simulation Exploration, and Reflection and Application. The stages are intended to form a coherent learning sequence and are not presented as a universally optimal sequence; instructors may adapt the duration, order, or level of support according to learning objectives, students' prior knowledge, and the nature of the subject. The following section discusses on the stages involved in the conceptual model.

3.3.1 Stage 1: Concept Introduction

The instructor introduces the central concept, explains relevant terminology, presents a concise example, and clarifies the learning objectives. Students may answer diagnostic questions or make an initial prediction about how a system will behave. This stage establishes a conceptual reference point for the simulation activity. Suggested instructor actions include: explaining the principle to be investigated; showing a simple diagram or worked example; identifying the variables or decisions that matter; and explaining the simulation task. Suggested student actions include recording an initial prediction, identifying relevant concepts, and stating what evidence would support or challenge the prediction. The output of this stage is a shared understanding of the task and a preliminary expectation that can be revisited after the simulation. It is important that the explanation remain focused. A lengthy lecture may reduce the time available for exploration, while insufficient preparation may leave learners unable to interpret the simulation.

3.3.2 Stage 2: Guided Simulation Exploration

Students interact with the simulation to investigate the concept introduced in Stage 1. They follow a task sequence that encourages prediction, action, observation, and explanation. Depending on the subject, students may change parameters, compare scenarios, test configurations, or make decisions in a simulated environment. A simple activity cycle is proposed: (a) predict the likely outcome; (b) perform a controlled change; (c) observe and record the result; (d) compare the result with the prediction; and (e) explain the difference. Students should, where feasible, change one important variable at a time so they can reason about the relationship between action and outcome. For more complex tasks, the instructor may provide a worksheet or prompts to keep attention on the learning objective. The instructor acts as a facilitator who monitors progress, asks diagnostic questions, and provides targeted guidance. Rather than immediately giving the answer, the instructor can ask what the student expected, what changed, and what evidence supports the student's interpretation. The amount of support should be adjusted to learners' needs. Beginners may benefit from step-by-step guidance, while more experienced learners may be ready for less structured tasks. The output of this stage is a record of observations and decisions that students can use to justify an explanation. Interaction is treated as a means to investigate the concept, not as an outcome in itself.

3.3.3 Stage 3: Reflection and Application

Students review their predictions, actions, and observations and connect them to the theoretical concepts introduced in Stage 1. They explain why an outcome occurred, identify any misconception that changed, and discuss limitations of the simulation. The instructor can facilitate a short discussion or ask students to submit a written explanation. To examine transfer, students should also apply the concept to a new example, a changed set of conditions, or a problem that cannot be solved simply by repeating the same simulation steps. This helps assess whether students understand the underlying relationship rather than merely remembering a procedure. Reflection can be individual or collaborative, depending on the learning objective. The output of this stage is a reasoned explanation, an application to a related problem, and an indication of any remaining misunderstanding. Assessment may include a concept question, an explanation of cause and effect, a short problem-solving task, or a comparison of predictions and outcomes.

3.4 Model Overview

The proposed conceptual model integrates conventional instruction and simulation-based learning through three sequential but interconnected stages: Concept Introduction, Guided Simulation Exploration, and Reflection and Application. The model is designed to explain how structured knowledge delivery, active learning experiences, and reflective activities can work together to support student engagement and conceptual understanding. Rather than treating each stage as an isolated activity, the model emphasises a continuous learning process in which students acquire knowledge, investigate concepts, interpret outcomes, and apply what they have learned. This approach is informed by research highlighting the importance of instructional support, relevant information, and personalisation in simulation-based learning (Chernikova et al., 2020, 2024, 2025). Figure 1 shows the proposed model:

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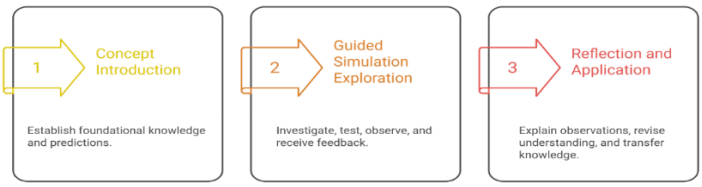


Figure 1: Proposed model

Within the proposed model, student engagement is an expected process outcome, whereas conceptual understanding is the intended learning outcome. Engagement refers to the extent to which students participate in learning activities, invest mental effort in understanding concepts, and demonstrate interest or involvement in the learning process. It may be supported throughout all three stages: students participate in discussions during concept introduction, actively investigate problems during simulation exploration, and engage in explanation and evaluation during reflection. Conceptual understanding, in contrast, concerns students' ability to explain underlying principles, recognise relationships between concepts, justify their decisions, and apply knowledge to unfamiliar situations. Although engagement may contribute to conceptual understanding, the two constructs should not be treated as equivalent. A student may be highly engaged in a simulation but still misunderstand the principles being demonstrated. Therefore, the model proposes that engagement should be supported through meaningful learning activities, while conceptual understanding should be assessed separately through suitable assessments, such as explanation-based questions, pre-tests and post-tests, and knowledge-transfer tasks. The relationship between engagement and conceptual understanding remains a proposition to be examined empirically.

Feedback and instructional guidance operate across all three stages rather than being restricted to simulation exploration. During concept introduction, instructors can check students' prerequisite knowledge, clarify misconceptions, and help them formulate predictions. During simulation exploration, feedback can help students identify errors, understand system responses, and revise their decisions. During reflection and application, instructors can provide explanations that help learners connect observations with theoretical principles and apply those principles to new problems. The level of support may be adjusted according to students' prior knowledge and progress, consistent with research examining scaffolding and personalisation in simulation-based learning (Chernikova et al., 2020, 2025). Contextual factors may also influence the effectiveness of the proposed sequence. Students with limited prior knowledge may require more explicit explanations and step-by-step guidance, whereas experienced learners may benefit from more independent exploration. Similarly, highly complex tasks may require additional scaffolding, while poorly designed simulations may obscure important relationships or distract learners from the intended concepts. The model therefore recognises that learning outcomes depend not only on the sequence of instructional stages but also on how these stages are implemented and supported.

In summary, the proposed model presents a structured pathway from foundational knowledge to guided exploration and reflective application. Conventional instruction prepares students to engage with the concepts, simulation provides opportunities to investigate and test their understanding, and reflection helps them explain outcomes and transfer knowledge. Student engagement is expected to be supported throughout this process, while conceptual understanding remains the primary intended learning outcome. Feedback, instructional guidance, prior knowledge, task complexity, and simulation design are incorporated as factors that may influence the effectiveness of the sequence. As the model is conceptual rather than empirically validated, future research is needed to determine whether this integrated approach produces better learning outcomes than conventional instruction or simulation-based learning used independently.

3.5 Literature Review

3.5.1 Conventional Instruction and Active Learning

Conventional instruction remains an important component of teaching and learning because it enables instructors to organise learning content systematically, introduce essential terminology, explain foundational principles, and demonstrate procedures in a logical sequence. This structured approach can help students establish the prerequisite knowledge needed before engaging with more complex learning activities. Dietrich and Evans (2022) discussed the relationship between traditional lecturing and active learning, highlighting the importance of considering how these approaches can complement rather than necessarily replace one another. Similarly, Tripon (2020) explored the use of video tools to support personalised learning and thinking skills, suggesting a potential role for instructional resources beyond conventional delivery alone. Nevertheless, conventional instruction may provide limited opportunities for students to test their understanding independently if lessons rely predominantly on listening and information reception. Therefore, instructors should complement explanations with activities that encourage students to interpret information, ask questions, and apply theoretical concepts to practical situations.

Student participation and engagement are particularly important when the learning objectives involve conceptual understanding, problem-solving, and the application of knowledge. Atmojo et al. (2026) examined interactive multimedia based on Lumi Education in relation to student learning outcomes, while Shahbazi and Villa López (2024) investigated a point-based gaming framework intended to enhance student engagement and deep learning in engineering education. These studies provide examples of how interactive and innovative learning strategies can extend learning beyond teacher-

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led explanations. More broadly, a meta-analysis by Kozanitis and Nenciovici (2023), covering 104 studies and 15,896 students in humanities and social sciences, found that active instruction was associated with higher assessment performance than traditional lecturing, with an average effect size of 0.489 standard deviations. However, the reported effects varied according to factors such as subject area, class size, and course level. These findings support the importance of meaningful student participation, although they should not be interpreted as proof that every active-learning strategy or simulation will produce the same benefits across all educational settings.

As stated before, simulation-based learning is an instructional approach that falls within the broader category of active learning, in which students actively participate in the learning process rather than relying solely on listening to lectures or receiving information passively. It involves the use of simulations, interactive models, or computer-based applications to represent real-world situations, systems, or abstract concepts in a controlled learning environment. Through these simulations, students can explore different scenarios, manipulate variables, test hypotheses, observe outcomes, and receive feedback that helps them understand the relationships between concepts and their practical applications. Unlike conventional instruction, which primarily focuses on introducing and explaining foundational knowledge, simulation-based learning emphasises experiential exploration, experimentation, and active knowledge construction. However, simulation-based learning does not necessarily replace conventional instruction; instead, it can complement instructor explanations by providing opportunities for students to apply and investigate the concepts they have learned. Chernikova et al. (2020) demonstrated the potential of simulation-based learning to support learning outcomes in higher education, highlighting its value as an instructional approach.

Integrating conventional instruction with simulation-based learning may therefore offer a balanced approach that combines structured knowledge acquisition with experiential exploration. Conventional instruction can introduce key concepts and explain the theoretical principles, while simulations allow students to experiment with different scenarios, observe outcomes, and evaluate their decisions. For example, in a computer networking course, an instructor could first explain network topology, IP addressing, and data transmission before asking students to configure a simulated network and investigate connectivity problems. This sequence provides opportunities to connect theoretical explanations with practical experiences. However, the effectiveness of this integration depends on the alignment between instructional activities, learning objectives, and assessment methods. Students should be encouraged to explain their decisions, reflect on the results, and apply the concepts to new situations rather than simply complete simulation tasks. Accordingly, this study conceptualises conventional instruction as the foundation for introducing knowledge and simulation-based learning as a complementary approach that promotes active exploration, student engagement, and deeper conceptual understanding (Dietrich & Evans, 2022; Kozanitis & Nenciovici, 2023).

3.5.2 Simulation-Based Learning and Learning Outcomes

Compared with conventional learning methods, simulation-based learning (SBL) enables learners to interact with representations of real-world systems or situations, experiment with different decisions, observe consequences, and practise responses in a controlled learning environment. This approach promotes active participation by allowing students to explore scenarios that may be difficult, costly, or impractical to reproduce in actual settings. Simulation-based activities can also support learner engagement and motivation by providing opportunities for experiential learning and immediate feedback (Drumhiller et al., 2021; Ma et al., 2025). Their value is particularly evident in learning contexts involving complex procedures, decision-making, problem-solving, and the application of theoretical knowledge to practical situations (Choi & Um, 2022; Drumhiller et al., 2021; Roy et al., 2025). For example, nursing students can practise communication and clinical decision-making through simulated patient scenarios, while students in technical disciplines can investigate system behaviour by modifying parameters and observing the resulting changes. These experiences enable learners to connect theoretical concepts with practical applications while developing their ability to respond to different situations.

The effectiveness of SBL is also supported by research examining its contribution to skill development and learner confidence. Chernikova et al. (2020), in a meta-analysis synthesising 145 empirical studies in higher education, reported a large positive overall effect of simulation-based learning on complex-skill development ($g = 0.85$). Their analysis also considered instructional scaffolding and learner characteristics, highlighting the importance of designing appropriate learning support rather than assuming that simulation alone guarantees successful outcomes. Furthermore, studies involving nursing and healthcare education have examined outcomes such as communication skills, satisfaction, self-confidence, and confidence in simulation-based practice (Binsuwaidan et al., 2025; Choi & Um, 2022; Jallad, 2025; Turatsinze et al., 2020). These findings provide a rationale for using simulations to support practical skill development and learner confidence. Nevertheless, improvements in complex skills or self-confidence should not automatically be interpreted as equivalent improvements in conceptual understanding. To achieve deeper learning, simulation activities should be accompanied by guided reflection, explanatory feedback, and opportunities for students to articulate the principles underlying their decisions and apply their understanding to unfamiliar situations.

3.5.3 Simulation Design, Prior Knowledge, and Guidance

The presence of a simulation alone does not guarantee meaningful learning, as its educational effectiveness depends on several interconnected factors, including simulation design, learner characteristics, active participation, and opportunities for collaboration. Team dynamics and collaboration can influence how learners communicate, exchange ideas, and solve problems collectively, while appropriate simulation design and fidelity help ensure that learning activities align with the

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intended educational objectives (Pham & Duong, 2025). Active participation is equally important because learners need opportunities to make decisions, test assumptions, and evaluate outcomes rather than passively observe simulated events (Cook & Cook, 2023; Nightingale, 2019; Skjaeret-Maroni et al., 2026). Furthermore, learners must be able to identify relevant information, interpret system responses, and connect their actions with the underlying concepts (Nightingale, 2019; Ronda-Carracao et al., 2021). These considerations indicate that effective simulation-based learning requires more than realistic scenarios or sophisticated technology; it requires purposeful instructional design that encourages learners to think critically and understand the relationships between their decisions and the resulting outcomes.

The importance of instructional design is further supported by Chernikova et al. (2024), who synthesised 214 empirical studies to examine the effectiveness of simulation-based learning in relation to information salience, authenticity, and prior knowledge. Their analysis highlights the relevance of making important information noticeable and meaningful to learners. A simulation may appear realistic but still provide limited educational value if learners cannot distinguish essential information from irrelevant details or understand how particular actions influence outcomes. Consequently, the quality of a simulation should be evaluated not only by its visual realism but also by how effectively it communicates the concepts that learners are expected to understand. Barlow et al. (2024) also examined evidence-based standards for healthcare simulation design, reinforcing the importance of systematic design and alignment with educational purposes. Depending on the learning objectives, a simplified simulation may be more appropriate than a highly realistic environment if it makes important relationships easier to identify and understand. Instructors can strengthen this process through task prompts, worked examples, staged challenges, and guiding questions that direct attention towards relevant concepts. Such support can help learners move beyond operating the simulation interface towards interpreting results, explaining underlying principles, and applying their knowledge to new situations.

Recent research also highlights the potential of personalisation in improving simulation-based learning. Chernikova et al. (2025) synthesised 217 empirical studies in higher education and examined adaptivity and adaptability as approaches to personalising instructional support and task progression. Their findings suggest that system-led adaptivity may be particularly beneficial for scaffolding, whereas learner-controlled adaptability may be more advantageous for task progression. These findings indicate that simulation activities should accommodate differences in learners' prior knowledge, abilities, and learning needs rather than provide identical levels of support to everyone. For example, beginners may benefit from step-by-step instructions, worked examples, and immediate guidance, while more experienced learners may benefit from open-ended challenges and greater control over their learning activities. Consideration of simulation quality and assessment is also important when determining whether the learning experience supports the intended outcomes (Jin et al., 2020). In the proposed integrated learning approach, conventional instruction can establish foundational knowledge before students engage in simulation activities with adjustable levels of guidance. As learners develop greater understanding and confidence, the support can gradually be reduced to encourage independent exploration, reflection, and problem-solving. This approach positions simulation as a structured learning environment in which instructional support, active participation, and appropriate task progression work together to promote deeper conceptual understanding.

3.5.4 Feedback, Reflection, and Conceptual Understanding

Simulation activities provide learners with opportunities to explore concepts, make decisions, test different approaches, and observe the consequences of their actions in a controlled environment. However, achieving a successful outcome does not necessarily indicate that learners have developed a deep conceptual understanding. Students may obtain the correct result through repeated attempts, guessing, or trial and error without understanding the principles that explain the outcome. This distinction highlights the importance of instructional scaffolding in simulation-based learning. Chernikova et al. (2020) emphasised the role of instructional support in developing complex skills through simulations, while Chernikova et al. (2024) examined the importance of salient information in determining learning effectiveness. These findings suggest that simulation activities should be designed to help learners distinguish relevant information from less important details, recognise relationships between variables, and understand how their decisions influence the simulated system. For example, students using a network simulation may successfully establish a connection between two devices by changing configuration settings repeatedly, yet remain unable to explain why a particular IP address or subnet configuration is appropriate. Providing guiding questions, hints, and conceptual explanations can help students connect their actions with the underlying principles rather than focus solely on completing the task. Therefore, simulation-based learning should emphasise not only task completion but also the reasoning processes through which learners interpret and explain their experiences.

Reflection plays an important role in transforming practical experiences into meaningful conceptual learning because it encourages students to examine the relationship between their expectations, decisions, and observed outcomes. During a simulation, learners may develop initial predictions based on their existing knowledge, but the actual results may differ from what they anticipate. Structured reflection provides an opportunity to investigate these discrepancies, identify misconceptions, and reconsider the assumptions that influenced their decisions. Instructors can facilitate this process by asking questions such as “What did you expect to happen?”, “Why did the outcome differ from your prediction?” and “What would happen if the conditions changed?” Such questions encourage students to move beyond describing events towards explaining the principles responsible for them. Prior knowledge is particularly relevant because learners interpret new information through their existing understanding of a subject (Simonsmeier et al., 2022). Students with insufficient prerequisite knowledge may find it difficult to recognise important patterns or connect simulation

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outcomes with theoretical concepts. Consequently, reflection activities should be supported by appropriate explanations, examples, and opportunities to revisit relevant concepts. Learners should also be encouraged to apply their explanations to a new scenario to determine whether they can transfer their understanding beyond the original simulation. This process can help distinguish genuine conceptual understanding from the ability to reproduce a successful sequence of actions.

Feedback complements reflection by providing learners with information that helps them evaluate their decisions, understand errors, and improve their subsequent attempts. However, feedback is most valuable when it explains the reasons behind an outcome rather than simply indicating whether a response is correct or incorrect. For example, when a student makes an incorrect prediction in a simulation, explanatory feedback can identify the relevant concept, clarify the relationship between variables, and suggest how the student's reasoning could be revised. Students can then test the revised explanation by changing the relevant parameters and comparing the new outcome with their original prediction. This iterative process creates opportunities for learners to refine their understanding through experimentation, explanation, and evaluation. Chernikova et al. (2025) further examined personalisation in simulation-based learning, highlighting the relevance of adapting instructional support and task progression to learners' needs. Accordingly, beginners may require detailed feedback, step-by-step guidance, and worked examples, whereas more experienced learners may benefit from less direct assistance and more challenging tasks. Integrating conventional instruction, guided simulation, structured reflection, and explanatory feedback can therefore establish a coherent learning process in which each component serves a complementary purpose. Conventional instruction introduces foundational knowledge, simulation provides opportunities for practical exploration, reflection encourages learners to explain their experiences, and feedback supports the revision of their reasoning. This integrated approach provides a conceptual basis for promoting student engagement and deeper conceptual understanding, while enabling learners to apply acquired knowledge to unfamiliar situations.

3.5.5 Rationale for Integrating Conventional and Simulation-Based Learning

The reviewed literature suggests that conventional instruction and simulation-based learning can serve complementary functions in promoting student engagement and conceptual understanding. Conventional instruction provides a structured foundation for introducing essential terminology, explaining theoretical principles, and establishing the prerequisite knowledge required for subsequent learning activities. However, conceptual understanding may remain limited when students are not provided with sufficient opportunities to actively process, test, and apply the information presented. Integrating simulation-based activities into conventional instruction may address this limitation by allowing learners to explore theoretical concepts through practical experiences. Guided simulations provide opportunities for students to test predictions, make decisions, and examine the consequences of their actions in controlled environments (Fincham et al., 2022). Furthermore, interactions with simulations can help students observe relationships between variables and investigate concepts that may be difficult to understand through verbal explanations or static learning materials alone (Magkouta et al., 2024). Reflection activities can subsequently encourage learners to evaluate their experiences, explain observed outcomes, identify misconceptions, and connect practical findings with theoretical knowledge (Love, 2021; Walsh & Sethares, 2022). Collectively, these instructional components offer a potential approach to supporting learning through structured explanation, active exploration, and reflective application.

Existing empirical evidence provides further justification for investigating the integration of conventional instruction and simulation-based learning. Kozanitis and Nenciovici (2023), through a meta-analysis comparing active learning with traditional lecturing, demonstrated the broader educational benefits associated with meaningful student participation. Similarly, Chernikova et al. (2020) reported positive effects of simulation-based learning on complex-skill development, highlighting the importance of instructional support in facilitating learning outcomes. Subsequent research by Chernikova et al. (2024) examined how the salience of relevant information, authenticity, and prior knowledge relate to simulation effectiveness, suggesting that learning outcomes depend not only on the presence of a simulation but also on how learners interact with and interpret the information presented. More recently, Chernikova et al. (2025) investigated personalisation through adaptivity and adaptability, providing additional insights into how instructional scaffolding and task progression can be adjusted to learners' needs. Together, these findings indicate that simulation-based learning is influenced by multiple instructional and learner-related factors, including the quality of guidance, the clarity of information, prior knowledge, and opportunities for active participation. Nevertheless, the effectiveness of individual instructional strategies does not automatically establish the superiority of a particular integrated learning sequence. Therefore, further investigation is necessary to determine how conventional instruction and simulation-based activities can be systematically organised to support both engagement and conceptual understanding.

Based on this synthesis, the present paper proposes a three-stage instructional model consisting of concept introduction, guided simulation exploration, and reflection and application. The first stage, concept introduction, focuses on establishing foundational knowledge through structured explanations, demonstrations, and discussions of essential principles. This stage is intended to prepare students with the conceptual understanding needed to engage meaningfully with subsequent simulation activities. The second stage, guided simulation exploration, provides opportunities for students to apply theoretical knowledge, manipulate variables, test predictions, and observe the consequences of their decisions. Instructional scaffolding, including guiding questions, worked examples, and appropriate feedback, can be incorporated to ensure that students focus on the intended learning objectives rather than merely completing procedural tasks. The third stage, reflection and application, encourages students to analyse their experiences, explain the relationships between actions and outcomes, identify misconceptions, and transfer acquired knowledge to unfamiliar

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situations. This proposed sequence is informed by the literature on simulation-based learning, instructional support, and reflective practice (Chernikova et al., 2020, 2024, 2025; Walsh & Sethares, 2022). However, the sequence represents a conceptual instructional proposal rather than an empirically validated model. Its effectiveness must therefore be examined through systematic research before conclusions can be drawn about its educational benefits.

Despite the growing body of research on active learning and simulation-based education, several research gaps remain relevant to the proposed model. First, although existing studies have investigated conventional instruction, simulation effectiveness, instructional scaffolding, and personalisation, the reviewed sources do not directly establish the effectiveness of the specific three-stage sequence proposed in this paper. Second, student engagement and conceptual understanding are related but distinct educational outcomes that require separate evaluation. Students may demonstrate high levels of participation, motivation, or satisfaction during simulation activities without necessarily developing an accurate understanding of the underlying concepts. Likewise, successful task completion may reflect procedural familiarity rather than the ability to explain principles or apply knowledge in unfamiliar situations. Consequently, future studies should distinguish behavioural, cognitive, and emotional dimensions of engagement from measures of conceptual understanding. Third, the influence of learner characteristics and instructional design requires further investigation. Prior knowledge, the complexity of simulation tasks, the level of guidance, and the availability of explanatory feedback may influence how students respond to integrated learning activities (Chernikova et al., 2024, 2025). These factors should be considered when evaluating whether the proposed approach benefits learners with different educational backgrounds and levels of experience.

To address these gaps, future empirical research should compare the proposed integrated instructional model with conventional instruction and simulation-only approaches. A quasi-experimental research design could be employed to investigate differences in student engagement and conceptual understanding across instructional conditions. Student engagement could be evaluated using validated questionnaires and classroom observation, while conceptual understanding could be assessed through pre-tests, post-tests, explanation-based questions, and transfer tasks requiring students to apply learned principles to new situations. Such an approach would allow researchers to distinguish improvements in factual knowledge, procedural performance, and deeper conceptual understanding. In addition, qualitative data collected through student reflections, interviews, or learning journals could provide insights into how learners interpret simulation outcomes and connect them with theoretical concepts. Future studies should also document simulation characteristics, instructional scaffolding, task complexity, and learners' prior knowledge to support meaningful comparisons. Accordingly, the contribution of the present paper is to develop a literature-informed conceptual model and formulate five research propositions concerning the relationships among integrated instruction, simulation interactivity, visualisation, explanatory feedback, student engagement, and conceptual understanding. These propositions provide a foundation for future empirical testing rather than established causal conclusions. By specifying an instructional sequence and identifying measurable educational outcomes, the proposed model aims to contribute to the development and evaluation of more systematic approaches to integrating conventional instruction with simulation-based learning.

3. RESULTS AND DISCUSSION

The synthesis yields a model and five propositions rather than empirical results. The propositions are designed to move beyond the general claim that interaction or feedback is beneficial. They specify the instructional mechanism, the outcome that should be measured, and conditions under which the expected relationship may weaken or fail. In particular, the model distinguishes visible activity and successful simulation performance from evidence of conceptual explanation and transfer.

a. P1 (Sequencing mechanism): Compared with conventional instruction alone or simulation activity without conceptual preparation, a sequence that links focused explanation to a guided investigation is expected to improve students' ability to explain the relationship between a manipulated variable and an observed outcome, provided the explanation and simulation are aligned to the same learning objective.
b. P2 (Interaction versus understanding): Simulation interaction is expected to relate more strongly to conceptual understanding when learners are required to predict, control or record changes, and explain evidence than when interaction is measured only as time-on-task or number of actions. High interaction without explanatory prompts may increase behavioural engagement without producing equivalent gains in conceptual understanding.
c. P3 (Explanatory feedback and revision): Feedback is expected to contribute to conceptual understanding when it helps learners diagnose why a prediction or action failed and then gives them an opportunity to revise and retest their explanation. Correct/incorrect signals without opportunities for interpretation and revision are expected to have a weaker relationship with transfer performance.
d. P4 (Reflection as a transfer mechanism): The relationship between guided simulation exploration and performance on an unfamiliar problem is expected to be stronger when the lesson includes structured reflection that requires students to explain the observed mechanism and apply it under changed conditions, rather than merely summarising the activity or reporting task completion.
e. P5 (Boundary conditions): The benefits of the integrated sequence are expected to vary with prior knowledge, task complexity, and the clarity of relevant information. Learners with limited prerequisite knowledge or tasks with high

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complexity may require more explicit scaffolding; excessive guidance for experienced learners may constrain independent reasoning. These interactions should be tested rather than assumed.

These propositions offer a more discriminating evaluation agenda than a general comparison of teaching methods. Researchers should measure engagement separately from conceptual understanding and distinguish immediate performance from transfer. A suitable study could compare three conditions conventional explanation, simulation-based learning, and the integrated three-stage sequence while matching instructional time, learning objectives, and assessment difficulty as closely as possible. Pre-tests can estimate prior knowledge; post-tests can assess conceptual explanation; and transfer tasks can test application to an unfamiliar scenario. Process data, observation, and learner interviews can help explain why similar performance scores may arise from different reasoning processes.

The model's theoretical contribution is a shift from method selection to instructional-function sequencing. Conventional explanation establishes a conceptual reference point; guided simulation generates evidence through controlled exploration; and reflection requires learners to convert that evidence into an explanation that can travel beyond the original task. The stages are therefore not simply three activities placed in order. Each addresses a different potential break in the learning process: insufficient preparation, unproductive trial-and-error, and failure to transfer an observed result into a general principle. This functional account makes the model open to falsification: if reflection and transfer tasks do not improve explanatory or transfer outcomes, the proposed role of Stage 3 would need revision.

The model also challenges the assumption that more interactivity necessarily means deeper learning. A learner can be behaviourally active and still construct an incorrect explanation, while a simpler simulation may support learning if it makes the target relationship visible. Thus, the relevant design criterion is not technological sophistication but whether the activity produces interpretable evidence that students can connect to a concept. This argument is consistent with research on active instruction and simulation design, but the specific sequence and proposed mechanisms remain to be tested.

Implementation presents practical constraints: simulation access, instructor preparation, time for reflection, accessibility, and alignment between the simulation and assessment. The model should not be applied mechanically. If a learning objective concerns basic terminology, simulation may add little value; if it concerns dynamic relationships, a guided simulation may be appropriate. In either case, assessment should require students to explain the result or apply the principle to a changed scenario rather than rely solely on successful operation of the tool.

For future empirical evaluation, researchers should pre-register hypotheses where feasible, report the instructional materials and guidance provided, use validated engagement measures where appropriate, and assess conceptual understanding with explanation-based and transfer items. A quasi-experimental design may be practical in intact classes, but baseline differences should be measured and addressed. A mixed-methods follow-up can examine learners' predictions, errors, and revisions. Design-based research is another option when the purpose is to refine the prompts and reflection activities iteratively; its reports should document each design cycle and the evidence used to revise the model.

Several limitations must be acknowledged. The paper uses a purposively selected narrative corpus rather than a systematic or exhaustive review, so relevant publications may have been missed and selection bias cannot be ruled out. The cited studies span disciplines, learner groups, simulation types, and outcomes; evidence on complex-skill development cannot be assumed to establish conceptual understanding in every context. Finally, the proposed sequence and propositions have not been empirically validated. They should therefore be interpreted as a theoretically motivated design proposal, not evidence that integrated instruction is superior.

A focused research programme should begin with a pilot study to check the clarity and feasibility of the three stages, followed by a comparative study involving conventional-only, simulation-only, and integrated conditions. The primary outcomes should include conceptual explanation and transfer, with engagement treated as a separate process measure. Researchers should report prior knowledge, task complexity, simulation features, guidance intensity, instructional time, attrition, and implementation fidelity. Subsequent replication across disciplines would establish the contexts in which the model is useful and identify cases where a different sequence is preferable.

4. CONCLUSION

This paper has proposed a three-stage conceptual model Concept Introduction, Guided Simulation Exploration, and Reflection and Application for organising conventional instruction and simulation-based learning. The model's central contribution is not the assertion that both methods are useful, but the proposition that each should perform a distinct instructional function and that learners should be required to interpret and transfer what they observe. The sequence addresses three risks: entering a simulation without a conceptual reference point, engaging in trial-and-error without interpreting evidence, and completing a task without being able to explain the underlying principle. The model also separates student engagement from conceptual understanding. Engagement may indicate participation or mental investment, but it cannot by itself demonstrate accurate understanding. The propositions therefore predict not only possible benefits but also boundary conditions: interaction may fail to support understanding when it is unguided; feedback may have limited value when learners cannot interpret or revise their reasoning; and the sequence may need different levels of scaffolding according to prior knowledge and task complexity. These claims make the model testable and allow evidence to challenge or refine it. The next step is a staged validation programme: first assess the usability and fidelity of the lesson sequence; then compare the three instructional conditions using baseline measures, explanation-

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based post-tests, and transfer tasks; and finally replicate the study across subject areas and learner groups. Qualitative analysis of students' predictions, explanations, and revisions should be used to investigate the mechanism behind any observed differences. Until such evidence is available, the model should be used as a design hypothesis to guide evaluation, not as a proven prescription.

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