Simulations of the Nem Con Folk Game: Embedding Local Wisdom into Science Education through Modeling

Dat D. Nguyen[1], Huyen N. Vu[1], Xuan T. T. Nguyen[1], Son N. N. Do[2], Anh M. Nguyen[2], and Bien V. Nguyen[3,*]

[1]Department of Physics Education, Faculty of Physics, Hanoi National University of Education, Hanoi, Vietnam
[2]HUS High School for Gifted Students VNU University of Science, Hanoi, Vietnam
[3]Center for Research and Teacher Professional Development, Hanoi National University of Education, Hanoi, Vietnam
Email: ducdat@hnue.edu.vn (D.D.N.); huyenvn2003@gmail.com (H.N.V.); thanhxuan.csp@gmail.com (X.T.T.N.); sondohsgsk38ly@gmail.com (S.N.N.D.); mianguyen.hsgs@gmail.com (A.M.N.); biennv@hnue (B.V.N.)
*Corresponding author
Manuscript received March 25, 2025; revised April 8, 2025; accepted June 11, 2025; published November 10, 2025

***Abstract*—Advancements in mobile and computer technology have made simulations a central component of many science curricula, supporting students in exploring complex scientific concepts. Complementing this, integrating culturally familiar practices, such as local wisdom, into science instruction can increase student motivation and engagement. By embedding local wisdom into simulation-based activities, students are provided with meaningful, contextualized learning experiences that support deeper understanding of scientific phenomena and foster the development of modeling competence. Integrating simulations into science education can enhance learning, but the role of local wisdom in fostering modeling competence remains understudied. This study investigates how embedding local wisdom, specifically the Nem Con folk game, into simulations impacts students' modeling competence, using the Locate, Outline, Create, Apply, and Leverage (L.O.C.A.L) model. A pre-post-follow-up design measured changes in students' modeling practices and meta-modeling knowledge after simulation-based activities. Findings show significant engagement in modeling practices but limited gains in meta-modeling knowledge.**

***Keywords*—simulation, local wisdom, science education, modeling process, modeling competence**

I. Introduction

The growing accessibility of computers and associated technologies, including smart boards and mobile devices, combined with the availability of computer simulations across a broad spectrum of science subjects, has resulted in simulations becoming a core education technology of numerous science curricula [1, 2]. Numerous studies have employed simulation-based software to support various aspects of science education, revealing that its application positively impacts learning outcomes across all levels [3–6]. In addition to key advantages such as improved conceptual understanding [7, 8], active learning and engagement [9, 10], as well as accessibility and safety [11, 12], various research studies have demonstrated that simulations can be utilized in science education to foster modeling competence [13, 14], which is increasingly recognized as essential for scientific literacy and practice in the 21st century [15].

Among the methods used to develop students' modeling competence with simulations, a commonly applied approach is having students replicate the modeling process to investigate a scientific phenomenon or a real-life issue from a scientific perspective [16]. Regarding real-life problems, integrating local wisdom (folklore, proverbs, songs, and folk games) into the teaching process, particularly in science teaching, has been shown to motivate students' learning and consequently improve their competencies [17, 18]. Therefore, when organizing science learning activities that integrate local wisdom, it is expected that students who engage in the modeling process will not only develop the ability to describe, explain, and predict phenomena but also enhance their cultural understanding [19].

Integrating local wisdom into science education not only enhances students' scientific literacy but also helps to preserve cultural heritage. Research has shown that incorporating indigenous knowledge and cultural contexts into science curricula improves learning outcomes and increases student engagement [20, 21]. This approach creates meaningful and contextual learning experiences by connecting traditional knowledge with scientific methodologies [22]. However, real-world phenomena often exceed the complexity of textbook concepts, making scientific modeling challenging for students, especially when interpreting and understanding complex systems that span multiple domains [23]. Nevertheless, students' familiarity with and curiosity about these phenomena are believed to motivate active engagement in this cognitively demanding process.

Despite its potential, there has been limited research exploring how local wisdom can be systematically embedded into the modeling process through simulations to develop students' modeling competence. This gap limits our understanding of how culturally contextualized modeling tasks may foster students' modeling competence. To address this gap, this article presents the idea of embedding local wisdom into the modeling process in the context of projectile motion. Specifically, students will engage in researching and modeling a traditional game called Nem Con.

The Nem Con folk game (Fig. 1), originating from northern Vietnam's ethnic minorities such as the Thai, Tay, Nung, and Muong, is played during traditional festivals, especially the Lunar New Year, to pray for good weather, harvests, and prosperity. It symbolizes community cohesion, spirituality, and a love of nature. Nem Con is played in an open field with a 10 to 15 Meter pole topped by a 50 to 60 Centimeter ring. The Con ball, made of fabric filled with sand or seeds, is thrown through the ring from a distance of 10 to 15 Meters. Players stand firm, holding the ball, focus on the ring, and swing their arms back before releasing the ball in a smooth arc. Hitting the ring is believed to bring good luck, prosperity, a bountiful harvest, and favorable romance. As such, Nem

doi: 10.18178/ijiet.2025.15.11.2434

Con carries profound cultural significance for the Vietnamese people, particularly in ethnic minority communities, as it embodies ancestral beliefs in fertility and cosmic harmony, reinforces communal identity through collective participation, and functions as a medium for preserving and transmitting traditional values across generations.

Fig. 1. The Nem Con folk game.

The learning process begins with students analyzing the Nem Con game to identify a problem, simplifying it through assumptions and measurable variables, and then applying kinematics and dynamics to create a theoretical model. They integrate simulation tools to visualize the model, test its outcomes through experiments, and evaluate its reliability, all while refining their modeling competence.

This study aims to investigate the integration of local wisdom into the modeling process through computer simulations, as well as its impact on students' modeling competence. Specifically, the study addresses the following research questions:

- How can local wisdom be effectively embedded into the modeling process in science classrooms through computer simulations?
- How does the lesson embedding local wisdom into the modeling process through simulations impact students' modeling competence?

By answering these questions, this study contributes to science education by developing a structured approach to embedding local wisdom into modeling, introducing a framework for local wisdom simulation development, and providing empirical evidence on its impact on students' modeling competence.

II. Literature Review

A. Simulation in Science Education

A computer simulation refers to a program consisting of a model of a system or a process, whether natural or artificial [24]. Models can be defined into two main types:

1) Conceptual models, which are representations of principles, concepts, and facts related to the system;
2) Operational models, which consist of a series of cognitive and non-cognitive processes that can be replicated and analyzed through system simulations.

In the context of discovery learning, conceptual simulations are primarily used [24].

Among the various types of computational technology studied in K-12 science classrooms, simulations have received the most extensive research attention [23]. In science education, there are two approaches to utilizing simulations: using pre-existing tools such as PHET and Crocodile, or creating custom models with software that supports simulation and modeling, such as Matlab and Coach. Besides simulations of specific phenomena, some studies, by employing the gamification approach, designed immersive virtual worlds where users can interact with objects, execute experiments, make observations, and hence engage more actively in learning about real-life phenomena [25]. On the one hand, pre-existing simulations can be used as an effective tool in group activities, homework activities, laboratory activities, or as a kind of activities database for teachers [26].

Computer simulations play an important role in science education by providing interactive and flexible learning environments that help students:

1) Enhance their comprehension of phenomena and physical laws;
2) Isolate and manipulate parameters so that students can deepen their understanding of the relationships between physical concepts, variables, and phenomena;
3) Provide diverse representations (e.g., visuals, animations, graphs, and data) to simplify complex ideas;
4) Allow learners to express and refine their mental representations and conceptual models of the physical world;
5) Allow investigation of inaccessible phenomena due to complexity, danger, cost, or time constraints [27].

On the other hand, engaging in the modeling cycle is a powerful approach to enhancing students' modeling competence [16]. Previous studies on having students create simulations typically focus on topics such as ki nematics and Newtonian mechanics [27, 28]. However, these studies have not been linked to specific contexts, particularly the cultural contexts of the country. Moreover, students are often unaware of the mathematical models behind the simulation and are not connected to specific modeling processes. Among simulation-building software, a study conducted in a Dutch secondary school revealed that Coach software has been widely used across many European countries, offering flexible authoring tools that facilitate inquiry-based learning and incorporate more realistic contexts into science lessons [29].

Given the benefits of both pre-existing simulations and custom-built models in enhancing students' understanding of scientific concepts and fostering modeling competence, this research aims to develop simulations embedded in specific cultural contexts, serving as direct learning materials and enabling students to utilize Coach software to model and construct conceptual representations of projectile motion.

B. Embedding Local Wisdom into Science Education

Many Asian countries, such as Indonesia, have conducted numerous studies on integrating local wisdom into STEM education to enhance practicality and connect learning with local culture and contexts [30, 31]. While less common, this approach has also appeared in some studies from the United States and Europe. For example, Smith and Cardenas [32] incorporated traditional Mexican beliefs, such as the notion that applying cow manure to one's head can stimulate hair growth, into a college-level chemistry course at a university

near the U.S.-Mexico border. Similarly, Smith *et al*. [33] engaged Dutch Caribbean students in a science curriculum that integrated local folktales.

Embedding local wisdom into science education can bring several benefits, including enhancing cultural relevance [21, 34], student scientific literacy [35], and student competence [18]. Hence, developing a curriculum that integrates local wisdom is necessary, not only for preserving cultural identity but also for improving science learning outcomes [36, 37]. Research shows that the effective embedding of local wisdom requires the implementation of suitable pedagogical strategies, which facilitate the alignment of indigenous knowledge with modern scientific concepts [38].

However, teachers often face difficulties when trying to integrate local wisdom into their lesson plans and assessments due to limited understanding and a lack of appropriate teaching resources [39, 40]. One of the key challenges lies in the development of instructional materials that simultaneously align with formal science curricula and reflect local wisdom. This includes the creation of lesson plans, student activity sheets, and assessment tools that incorporate elements of indigenous wisdom in a scientifically meaningful way [18].

Among various approaches, incorporating local wisdom into digital tools has been identified as a promising method to enhance accessibility and student engagement. Nevertheless, the effectiveness of this approach depends on the careful design of digital tools to ensure an optimal balance between culturally relevant content and ease of use [41]. Furthermore, research has shown that embedding culturally relevant contexts in science education can significantly increase student engagement by leveraging their cultural interests to support and enhance their learning process [42].

C. Modeling Competence in Science Education

1) Modeling process

The modeling process in physics education is the systematic approach of creating, manipulating, and analyzing models to represent and understand physical systems and phenomena. Several steps are identified, such as constructing, validating, applying, evaluating, and revising scientific models during the process [15]. Since the 2000 s, there has been a growing body of research on the modeling process in science education. Schwarz *et al*. [43] claimed that the practice of modeling includes four elements: constructing, using, comparing and evaluating, and revising. Another process is the Hannafin and Peck model, which consists of three main stages: analyzing, designing, developing, and implementing, and has been widely applied in research on teaching with simulations (e.g. [44]). However, the Hannafin and Peck model is a product-oriented development model, while our research focuses on the modeling process as an approach to foster students' competence. The development model used in this study is Buuren's model of the ICT-supported physical-mathematical modeling process (Fig. 2) [45].

This process is commonly referred to as a cycle because testing, validation, and evaluation of the model require revisiting the real-world context. The reason behind the selection of this model is its alignment with the steps of scientific inquiry. By participating in the modeling process, students have the opportunity to develop scientific literacy as well as scientific modeling competence.

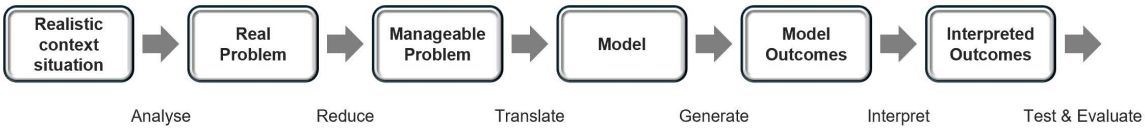

Fig. 2. The model of the ICT-supported physical-mathematical modeling process used by Van Buuren (2019) [45].

2) Modeling competence

Modeling can be seen as a competence, as it encompasses not only knowledge and skills but also a combination of cognitive, motivational, moral, and social foundations that individuals or communities possess or can develop, all of which contribute to effective mastery [46]. Regarding learners' active participation in modeling-based instruction, Nicolaou and Constantinou [47] introduced a framework for modeling competence, which consists of two main components: modeling practices and modeling meta-knowledge. The core modeling practices in which learners participate include model construction (PRA01), model use (PRA02), model comparison (PRA03), model revision (PRA04), and model validation (PRA05). Meanwhile, modeling meta-knowledge is shaped by metacognitive knowledge about the modeling process and meta-modeling knowledge, which represents an epistemological understanding of the nature and purpose of models. The understanding of models in science learning can be divided into five themes: Models as Multiple Representations (MR), Models as Exact Replicas (ER), Models as Explanatory Tools (ET), Uses of Scientific Models (USM), and Changing Nature of Models (CNM) [48]. The MR scale assesses students' willingness to engage with multiple representations at the same time and their awareness of the necessity of such diversity. The ER scale measures students' perceptions of how accurately a model reflects reality. The ET scale evaluates the ways in which a model aids students in grasping a concept, such as by offering visual support, fostering the formation of a mental model, or serving as a tangible representation. The USM scale examines students' comprehension of the broader applications of models in science, extending beyond their roles in description and explanation. Lastly, the CNM scale pertains to the durability and lasting nature of models [48].

III. Materials and Methods

A. Embedding Local Wisdom into the Modeling Process in Science Education

This study adapts the Locate, Outline, Create, Apply, and Leverage (L.O.C.A.L) model (Fig. 3) from Le *et al*. (2025) [49] to incorporate local wisdom into science

teaching via scientific modeling. This model consists of five main phases: Locate, Outling, Create, Apply, and Leverage:

- **Locate** phase involves identifying and categorizing local wisdoms based on their educational relevance.
- **Outline** phase focuses on conducting an in-depth analysis of the scientific principles embedded in local wisdom and selecting appropriate modeling methods, including mathematical, physical, digital, and interactive simulations.
- **Create** phase entails the development of simulations, lesson plans, and instructional materials to enhance learning.
- **Apply** phase involves implementing these materials in real classrooms, gathering feedback to refine and optimize the approach.
- **Leverage** phase evaluates the model's effectiveness and provides guidelines for broader implementation, ensuring its sustainability and impact on education.

Fig. 3. The L.O.C.A.L model: embedding local wisdom into the modeling process in science education by Le *et al*. (2025) [49].

In **phase 1 (Locate)**, we identified Nem Con, a traditional folk game in Vietnam, as an engaging context to capture students' interest while establishing a strong connection between projectile motion concepts and real-world applications. The game is chosen due to its due to its inherent relevance to projectile motion and its roots in Vietnamese ethnic tradition. By embedding Nem Con into the lesson, students were encouraged to have familiar experiences, bridging abstract physics concepts with their lived cultural practices. This aligns with the L.O.C.A.L model, which aims to integrate local wisdom into science education.

In **phase 2 (Outline)**, we apply the modeling process (based on Buuren's model) to outline the modeling framework.

Firstly, starting with identifying a realistic context situation, which in this case is the Nem Con game, students analyze the game's mechanism to identify a real problem. A meaningful problem can be to redesign the game with possible heights and horizontal distances of the pole relative to the thrower's position in order to be suitable for the thrower's physical characteristics, such as height, arm length, and throwing velocity so that the Con ball possibly passes through the ring.

We then reduce the real problem into a more manageable problem by making suitable assumptions and focusing on variables that can be measured and calculated.

Here is an example of a manageable problem: Nem Con is a traditional Vietnamese game in which a player stands on the ground, holds the Con ball in one hand, and performs a circular throwing motion with the shoulder as the pivot point. The objective is to propel the ball through the target ring in a single throw. The height from the ground to the player's shoulder is h, and the distance from the shoulder to the ball (arm length) is r. Let v_0 be the average initial throwing velocity, and α be the angle between the initial velocity and the horizontal direction, constrained within $0° < \alpha < 90°$. Determine the possible heights and horizontal distances of the pole relative to the thrower's position so that the Con ball possibly passes through the ring.

After that, We apply the physics concepts about kinematics and dynamics, especially projectile motions, to translate the problem into a theoretical model of the game, clearly defining how each variable interacts, with a particular focus on how the angle and initial velocity affect the outcome. This step necessitates both experience and proficiency in the subsequent stages of the modeling process.

At this stage, we begin with a basic mathematical model of projectile motion, assuming no air resistance.

We then generated model outcomes by inputting data collected from real-world conditions.

The interpreted outcome can initially describe, explain, and predict what happens in the game without any verifications.

Finally, we carry out video tracking experiments (Fig. 4) to test and evaluate the reliability of the theoretical model in describing, explaining, and predicting the outcomes.

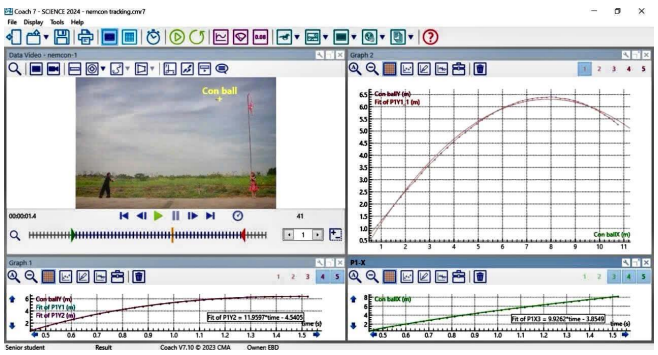

Fig. 4. Video tracking experiments with Coach 7.

However, the first mathematical model did not accurately describe the phenomenon. Therefore, we developed a second model that incorporates air resistance, modeled as a linear function of velocity.

Although this problem is relatively complex, it can be effectively addressed using computational modeling techniques, particularly through numerical methods such as Runge-Kutta second-order method (RK2) and Runge-Kutta fourth-order method (RK4). These methods allow for a more accurate model of the con ball's motion under realistic conditions.

This Outline phase serves as the foundation for the following steps, both in creating the simulation and in enabling students, under the guidance of the teacher during classroom activities, to fully recreate it.

B. Simulations of the Nem Con Folk Game

In **phase 3 (Create)**, after finalizing the mathematical model, we proceeded to develop two simulations using specific tools: a custom-coded simulation built with Python and Pygame, and a student-created simulation developed with Coach 7 software.

The first simulation (Simulation 01) is a pre-programmed Nem Con folk game simulation, integrated as an interactive tool to introduce key concepts and engage students in scientific exploration. This simulation provides a dynamic, visual representation of the traditional Vietnamese game, allowing students to manipulate key parameters such as

throwing angle, velocity, rope length, and arm length (Fig. 5). The simulation is capable of handling complex calculations, and once packaged, can be shared and used immediately without requiring additional software installation. Moreover, students can interact with the simulation without needing to understand the underlying mathematical model, making it an accessible and effective learning tool.

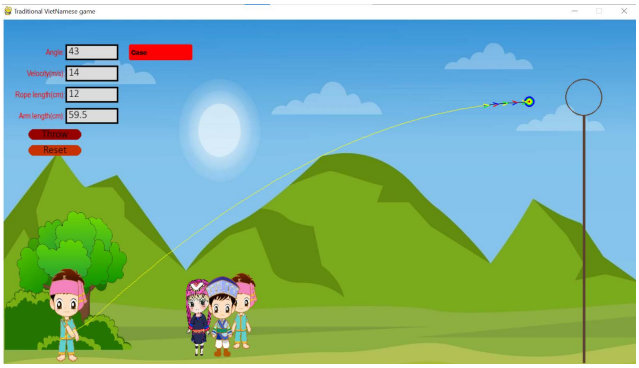

Fig. 5. Pre-programmed Nem Con folk game simulation (Simulation 01).

The development process of this simulation applies a computational modeling approach using Python, integrating numerical processing techniques, computer graphics, and educational technology to support the visualization of physics concepts within the context of Vietnamese folk games.

First, the dynamics model of projectile motion is established based on second-order differential equations, solved using numerical integration methods to ensure high accuracy in calculating the object's position over time. The simulation algorithm accommodates various scenarios with an optional friction setting (enabled or disabled) to simulate real-world conditions.

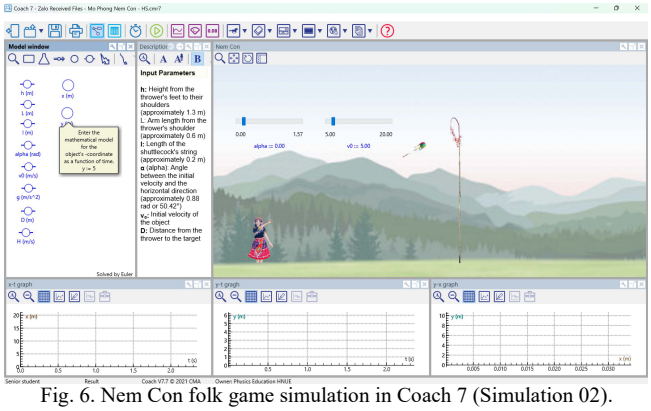

Fig. 6. Nem Con folk game simulation in Coach 7 (Simulation 02).

Key parameters in the model include gravitational acceleration, the mass of the Con Ball, the coefficient of drag, and a frame update frequency of 40 FPS to ensure smooth display performance.

The user interface is developed using the Pygame library, combined with pygame_widgets to create interactive components such as input boxes, buttons, and dropdown lists. Essential physical parameters such as initial velocity, launch angle, and lengths can be adjusted through the interface.

After completing the simulation algorithm and interface, PyInstaller is used to package the program into a standalone executable file, ensuring easy deployment on systems without a pre-installed Python environment.

The second simulation (Simulation 02) was developed using Coach 7, software that enables students to actively construct their own simulations by connecting variables and constants based on fundamental mathematical relationships (e.g., instantaneous velocity as the rate of change of position over an infinitesimally small-time interval). This hands-on approach helps students gain deeper insights into the phenomenon and develop a clearer understanding of the mathematical model behind it. Furthermore, the simulation allows students to modify the mathematical model and apply it to new situations by themselves (Fig. 6).

C. The Developed Lesson: Investigating Projectile Motion in the Nem Con Folk Game

In **phase 3 (Create),** we also developed an intervention consisting of a three-period lesson. The detailed teaching process for the lessons is presented in Table 1 below.

Table 1. Teaching process: embedding the Nem Con folk game into the modeling process using simulations to study projectile motion

Activity 1: Defining the learning problem
Objectives: Use simulation 01 to represent understanding of objects and phenomena. [PRA02] **Educational Technology:** Simulation 01; **Content:** Students watch a video of projectile motion (e.g., throwing a ball) to spark curiosity and interest in physics. Students use a ready-to-use simulation to experiment with different variables (angle, velocity, etc.) to explore projectile motion. Through guided experimentation, students analyze and identify the real problem (understanding projectile motion) and begin to break it down into manageable parts. Students then recognize the real problem and structure the manageable problem scientifically.
Activity 2: Creating the first model
Objectives: Build Model 01 with the function of representing, explaining, and predicting; Use Model 01 and Simulation 02 to represent understanding of objects and phenomena. [PRA01, PRA02] **Educational Technology:** video tracking, Simulation 02; **Content:** Students complete the task to build Model 01, solving the model to find the motion equation of the Con ball to put in Simulation 02. Model outcomes: students gather data from Simulation 02. Interpreting outcomes: from graph x(t), y(t) in Simulation 02, students describe, explain, and predict the Con's ball movement.
Activity 3: Testing and evaluating the model
Objectives: Test Model 01 by comparing the outcomes with real-world data; and finding ways to improve it. [PRA01, PRA03] **Educational Technology:** video tracking (COACH 7), Simulation 02; **Content:** Students compare Model 01 (underlying Simulation 02) with actual data gathered from video tracking (COACH 7); calculate the deviation, and evaluate the reliability of Model 01.
Activity 4: Revising the model
Objectives: Revise Model 01, build Model 02; test and evaluate Model 02; and choose the most suitable model for the problem. [PRA03, PRA04] **Educational Technology:** video tracking (COACH 7), Simulation 02; **Content:** List and define the factors influencing Model 01. After revising Model 01, students then build Model 02, test, and evaluate its reliability. Students choose the most suitable model between the two models.
Activity 5: Applying
Objectives: Verify the reliability of a model through real-world observations and apply it to a new situation [PRA05]; Use the model to make prediction. [PRA02] **Educational Technology:** **Content:** Student test the prediction function of the model in similar phenomena and new situations assigned as homework.

D. Procedure and Sample

Phase 4 (Apply) followed a pre-post-follow-up research design to examine the development of students' modeling

competence.

To ensure transparency in reporting, this study followed key elements of the SPIRIT 2013 checklist [50].

The participants were 31 tenth-grade students (16 females, 15 males) from a high school in Hanoi, Vietnam. These students were enrolled in a physics course and had not received prior formal instruction on scientific modeling. Their selection was based on accessibility and willingness to participate in the study.

The limited sample size in this study was attributed to several challenges. As this is a pioneering study exploring the integration of local wisdom into scientific modeling through the L.O.C.A.L framework, the research received ethical approval to involve only a small number of students (30–40). Additionally, the participant group was restricted to Grade 10 students who were studying the topic of projectile motion at the time of data collection, making it difficult to conduct the study at other points during the school year. Participation also required students to have access to a personal laptop to engage in computer-based modeling and simulation tasks, further narrowing the eligible pool.

The instructional intervention was designed to integrate modeling tasks into a physics lesson, incorporating structured learning activities and problem-solving exercises. Data collection included a modeling competence survey administered before (PRE), immediately after (POS), and three months following the intervention (POL) to assess both immediate and long-term effects. Additionally, students' behavioral engagement was documented through structured observations during learning tasks.

E. Data Collection

To mitigate the potential impact of the small sample size on the reliability and generalizability of the findings regarding the development of students' modeling competence, the study employed a mixed-methods approach. Qualitative data were collected to provide contextual depth and to support the interpretation of quantitative results, and comparisons with findings from prior studies were used to triangulate the results and enhance the study's overall credibility.

The quantitative data were obtained through a Modeling Competence 5-point Likert Survey administered at three time points: before instruction (PRE), immediately after instruction (POS), and in a follow-up assessment (POL). Based on the framework of Nicolaou and Constantinou [47], the survey assessed students' modeling practices (PRA), metacognitive knowledge about the modeling process (PRO), and meta-modeling knowledge (MR, ER, ET, USM, CNM).

In this context, meta-modeling knowledge refers to students' understanding of the nature of models, their function in scientific inquiry, and the factors that influence model development and revision. This knowledge is measured using the Students' Understanding of Models in Science (SUMS) instrument [48], a 27-item, paper-based survey in which students rate their responses on a five-point Likert scale: strongly disagree (1), disagree (2), not sure (3), agree (4), and strongly agree (5). The instrument was selected due to its strong reliability and validity in assessing students' meta-modeling knowledge of scientific models. The SUMS instrument demonstrated high internal consistency, with Cronbach's alpha values ranging from 0.71 to 0.84 across its five scales, MR ($\alpha = 0.81$), ER ($\alpha = 0.84$), ET ($\alpha = 0.71$), USM ($\alpha = 0.72$), and CNM ($\alpha = 0.73$) [48]. Additionally, factor analysis using varimax rotation confirmed a clear five-factor structure, supporting the construct validity of the instrument. Given its prior implementation with 228 students (Grade 8–11) from two non-selective, co-educational high schools in Australia, the SUMS instrument provides a rigorous measure for evaluating students' understanding of scientific models in our educational context (Grade 10 students).

Additionally, students' engagement in modeling practices and their comprehension of models were evaluated based on their self-efficacy in carrying out modeling practices or articulating the modeling process.

In addition to self-reported data, observational data were collected through learning activity sheets, which systematically recorded students' behavioral expressions during instructional activities.

F. Data Analysis

Descriptive statistical analysis was conducted to summarize students' survey responses, including mean scores and standard deviations across different time points. Normality tests were performed to determine the appropriate statistical tests for further analysis. Given the sample size and distribution characteristics, non-parametric statistical methods were applied where necessary.

To assess changes over time, the Friedman test was used to analyze within-subject differences across PRE, POS, and POL phases. Where significant differences were detected, post-hoc pairwise comparisons were conducted using the Wilcoxon Signed-Rank test. Effect sizes were also calculated to determine the magnitude of the observed changes.

For qualitative data, observational records were analyzed to identify trends in students' engagement with modeling practices. The categorization of behaviors into three levels provided additional insights into students' participation and competency development. These observational findings were compared with quantitative results to triangulate the data and enhance the validity of the study.

By employing a combination of self-reported survey data and direct observations, this study ensured a comprehensive analysis of students' modeling competence, allowing for both statistical validation and contextual interpretation of their learning behaviors.

IV. Result and Discussion

A. Modeling Competence Survey

After filtering out responses that were incomplete or not taken seriously (e.g., selecting the same answer for all questions), only 21 responses were used for analysis. The quantitative analysis aimed to evaluate the effectiveness of the lesson on students' modeling competence by comparing their survey results before the intervention, immediately after, and in the long term.

To assess students' modeling competence, descriptive statistics (Table 2) were calculated for modeling practice (PRA), metacognitive knowledge about the modeling process (PRO), and meta-modeling knowledge (MR, ER, ET, USM, CNM) at three different time points.

The mean scores for PRA increased from PRE ($M = 3.09$,

SD = 0.73) to POS (M = 3.52, SD = 0.79) and remained stable at POL (M = 3.51, SD = 0.59), suggesting a sustained improvement in students' modeling practices. Similarly, PRO showed an increase from PRE (M = 2.90, SD = 1.09) to POS (M = 3.52, SD = 1.12) but declined slightly at POL (M = 3.14, SD = 0.91). The meta-modeling knowledge components (MR, ER, ET, USM, CNM) generally followed a pattern of improvement from PRE to POS and were maintained or slightly decreased at POL.

After the descriptive analysis, additional statistical methods were applied to examine the significance of changes in students' modeling competence over time. Due to the small sample size (N = 21), normality was assessed using the Shapiro-Wilk test. The results indicated that several variables violated normality assumptions ($p < 0.05$), leading to the use of non-parametric tests for further analysis.

Table 2. Descriptive statistics for modeling competence variables

Variable	Phase	*N*	Min	Max	Mean	SD
PRA	PRE	21	2.0	5.0	3.09	0.73
	POS	21	1.8	5.0	3.52	0.79
	POL	21	2.2	4.6	3.51	0.58
PRO	PRE	21	1.0	5.0	2.9	1.09
	POS	21	1.0	5.0	3.52	1.12
	POL	21	2.0	5.0	3.14	0.91
MR	PRE	21	2.75	4.38	3.71	0.39
	POS	21	3.0	5.0	3.89	0.52
	POL	21	3.0	4.63	3.66	0.44
ER	PRE	21	2.25	4.88	3.18	0.62
	POS	21	2.0	5.0	3.4	0.64
	POL	21	2.75	4.13	3.49	0.41
ET	PRE	21	2.8	4.8	3.93	0.59
	POS	21	2.8	5.0	3.87	0.55
	POL	21	2.8	4.6	3.87	0.4
USM	PRE	21	1.33	5.0	3.7	0.96
	POS	21	2.33	5.0	3.81	0.65
	POL	21	2.67	4.67	3.84	0.4
CNM	PRE	21	2.33	5.0	3.54	0.73
	POS	21	2.67	5.0	3.83	0.62
	POL	21	2.0	5.0	3.71	0.72

To compare students' modeling competence over time, the Friedman test was conducted across the three time points. The results revealed a statistically significant difference for PRA (χ^2 = 7.658, df = 2, p = 0.022), indicating that students' modeling practices changed over time, while other dimensions of modeling competence, including metacognitive knowledge and meta-modeling knowledge, did not show significant changes ($p > 0.05$).

Given the significant result for modeling practices (PRA), the Wilcoxon Signed-Rank test was performed for pairwise comparisons. The results showed a significant increase in PRA from PRE to POS (Z = -2.451, p = 0.014) and from PRE to POL (Z = -2.693, p = 0.007), suggesting that students' modeling practices improved and that the effect was sustained over time (Table 3). However, there was no statistically significant difference between POS and POL (Z = −0.787, p = 0.431), indicating that the improvement in PRA was maintained over the long term.

To assess the strength of this effect, the effect size (r) was calculated for PRA, yielding r = 0.535 (PRE to POS) and r = 0.587 (PRE to POL), both indicating a large effect.

Table 3. Wilcoxon Signed-Rank test results for modeling practice

Comparison	*Z*	*p* value	Effect Size (*r*)
PRE to POS	−2.451	0.014	0.535
PRE to POL	−2.693	0.007	0.587
POS to POL	−0.787	0.431	0.172

These findings suggest that the developed lesson had a substantial and lasting impact on students' ability to engage in modeling practices, while their conceptual understanding and perception of modeling remained relatively stable.

B. Recording Student Behavioral Expressions through Learning Activity Sheets

To complement the statistical findings and address potential limitations of self-reported survey data, we conducted direct observations of students' behaviors throughout the experimental process. Behavioral expressions related to modeling competence were systematically recorded using learning activity sheets. These recorded behaviors were categorized into three levels:

- Level III: Behaviors that were widely observed across most students.
- Level II: Behaviors that were observed in some students.
- Level I: Behaviors that did not manifest, even when conditions were provided to facilitate them.

The recorded data (see Table 4) indicate that the majority of student behaviors were classified as either Level III (widely observed) or Level II (partially observed), with no behaviors falling into Level I.

Table 4. Matrix of recorded expressions of students' modeling competency in the lesson investigating projectile motion through the Nem Con folk game

	Task	PRA01	PRA02	PRA03	PRA04	PRA05
Modeling Practice	T1		III			
	T2		III			
	T3		III			
	T4	II				
	T5	III				
	T6	II				
	T7	II				
	T8	III				
	T9		III			
	T10		III			
	T11		III			
	T12			III		
	T13			III		
	T14	III				
	T15				II	
Maximum Recorded Level		III	III	III	II	

It is evident that Practices 1 and 2 had the highest engagement, as students had multiple opportunities to apply them across various learning tasks, with a high frequency of participation at Level III.

In PRA01, tasks T4, T6, and T7 showed student behaviors at Level II; while some students completed these tasks, others did not participate. In contrast, Level III was observed in T5, T8, and T14, where most students successfully constructed models for the given problems, including identifying variables and processes. Although some students made errors, they still demonstrated key aspects of PRA01, such as the ability to build models, and were thus recognized as exhibiting competency. Since T4, T6, and T7 were preparatory steps for T5 and T8, respectively, some students skipped them and moved directly to T5 and T8, which explains why T4, T6, and T7 were only marked at Level II. T14 was also recorded at Level III, as most students demonstrated the ability to build the second model. The majority of students' engagement in these key tasks explains the significant rise in Practice 01 (model construction) from PRE to POS, with only a slight decline observed in the POL

phase.

In PRA02, all students in the class completed Tasks T1, T2, T3, T9, T10, and T11 in the worksheet (level III). These learning tasks supported students' use of models more fluently, which is further interpreted the results shown in Table 5. Moreover, students used the models to demonstrate their understanding of the Con ball's movement: "When the Con ball goes up, gravity causes it to decelerate, and when it goes down, gravity makes it accelerate" (S001). Explaining the motion of objects in this way helps students grasp the fundamentals of physics represented by the model.

Although appearing in only two learning tasks, PRA03 still demonstrated a high level of student participation (level III). In T12, most students showed this competency by comparing the deviation between the first model and real-life observations, thereby recognizing the model's reliability. Students also identified several factors that influence the motion of the Con ball in order to propose ways to improve the model, such as: "wind, air resistance, throwing force, throwing angle, and the thrower's height" (S015). Additionally, students were able to choose the factors that should be considered in order to refine the model.

Practice 4 was observed in just one activity and was demonstrated by only a few students (Level II). In T15, only 45.83% of students were able to compare the deviation between the two models and consequently select the one with higher reliability.

Notably, Practice 5 did not appear due to the scope of the lesson, where students were only required to investigate motion in a single scenario. However, it still shares similarities with other practices in terms of developing, comparing, and evaluating models. The key difference lies in students' ability to apply it in new situations. Therefore, students still had a basis to assess their ability to perform this practice.

These qualitative observations align with the quantitative data for each practice (Table 5). Practices 1, 2, and 3 showed significant development and sustained improvement over time, whereas Practice 4 exhibited little noticeable change. Practice 5 showed some development but was less sustainable compared to the other practices.

Table 5. Mean scores of students' modeling practices across time

	PRA01 (N = 21) M (SD)	PRA02 (N = 21) M (SD)	PRA03 (N = 21) M (SD)	PRA04 (N = 21) M (SD)	PRA05 (N = 21) M (SD)
PRE	2.76 (0.23)	3.14 (0.24)	3.14 (0.26)	3.57 (0.20)	2.81 (0.16)
POS	3.57 (0.24)	3.57 (0.21)	3.67 (0.20)	3.38 (0.18)	3.43 (0.24)
POL	3.52 (0.15)	3.62 (0.16)	3.61 (0.21)	3.67 (0.20)	3.14 (0.17)

These behavioral observations provide additional support for the quantitative findings by confirming that students actively engaged in core modeling practices during the lesson. The presence of some Level II behaviors suggests that while most students demonstrated the expected competencies, others may have required additional instructional support. This highlights the need for further refinements in instructional design to ensure broader participation and deeper engagement with all aspects of modeling competence.

By integrating both self-reported survey data and direct observations, this study provides a more comprehensive understanding of students' modeling competence development. While statistical analysis confirmed significant improvements in modeling practices, the observational data reinforce the robustness of these findings by capturing real-time engagement patterns.

C. Discussion

The findings have shown that integrating simulations into the modeling process can facilitate the development of students' modeling practices in science classrooms. A deeper analysis of the data from the learning tasks reveals that all of the tasks supported by simulations are at engagement level III, while tasks at engagement level II do not involve simulation. This suggests that using simulations can enhance students' engagement in the modeling process, thereby fostering their modeling practices.

The intervention did not lead to significant changes in students' understanding of scientific models. This finding reinforces the perspective presented in the study of Juliane Grünkorn *et al*. [51] which suggests that while students' conceptions of scientific models and their applications in science can be explained within a theoretical framework, shifting these understandings remains challenging. This difficulty arises from deeply rooted misconceptions that are resistant to change [52]. Conceptual change is rarely a sudden shift; instead, it typically develops gradually as learners accumulate information and experiences, which they use to determine when it is more effective to apply one type of explanation over another [53]. Therefore, it is understandable why the intervention in this study, due to its short duration, could not immediately have a significant impact on students' modeling meta-knowledge. To foster this higher-order dimension of modeling competence, potential instructional improvements include the cognitive conflict strategy [54], which involves using cognitive conflict to reduce misconceptions; misconception-driven feedback [55], which provides feedback specifically aimed at correcting misconceptions; and empirically supported refutational methods [56], which use evidence-based refutations to address and correct misconceptions. However, it is also important to note that conceptual change does not necessarily have to occur, even when all stages, whether standard or refined, are followed. In fact, the literature provides evidence showing that conceptual change often fails to take place [52].

Although the intervention did not result in significant differences in students' understanding of scientific models, the collected data can be compared with findings from Australian students in Treagust's study [48], as both studies utilized the SUMS instrument. A comparison of Vietnamese and Australian students' understanding of scientific models revealed both similarities and notable differences (Table 6).

No significant differences were observed in students' recognition of models as Multiple Representations (MR) or their conceptual nature (CNM), suggesting that both groups generally acknowledge the role of models in science learning. However, these findings differ from those of Grosslight *et al*. [57], who reported that only a small number of mixed-ability 7th-grade students and advanced 11th-grade students showed any indication of understanding the concept of multiple models.

However, significant differences emerged in other aspects. Vietnamese students scored significantly lower on models as Exact Replicas (ER), $t(247) = -2.79$, $p = 0.009$, $d = -0.64$,

which is a positive finding as it indicates a better understanding that scientific models are not precise copies of reality but rather abstract representations. Nonetheless, mean scores above 3 suggest that some students still perceive scientific models as exact replicas of reality, consistent with findings from previous studies [58, 59].

Table 6. Comparison of Vietnamese and Australian students' understanding of scientific models

Factor	Vietnam (N = 21) M (SD)	Australia (N = 228) M (SD)	t	p	Cohen's d
MR	3.71 (0.39)	3.52 (0.63)	2	0.05	0.42
ER	3.18 (0.62)	3.58 (0.71)	-2.8	**0.01**	-0.64
ET	3.93 (0.59)	3.58 (0.71)	2.55	**0.02**	0.56
USM	3.70 (0.96)	3.41 (0.73)	1.35	0.19	0.34
CNM	3.54 (0.73)	3.73 (0.74)	-1.1	0.27	-0.26

Additionally, Vietnamese students scored significantly higher in recognizing the evolving nature of models (ET), $t(247) = 2.55$, $p = 0.017$, $d = 0.56$, suggesting a stronger appreciation for the dynamic nature of scientific knowledge. While Vietnamese students had a slightly higher mean score in the Use of Scientific Models (USM), this difference was not statistically significant.

These findings indicate that while both groups have a solid foundational understanding of scientific models, Vietnamese students may demonstrate a more sophisticated grasp of their abstract and evolving nature. Given that neither group received explicit instruction on scientific models, future research should investigate how curriculum design and instructional approaches influence students' conceptualization of models. Furthermore, studies could explore the impact of cultural and educational contexts on students' understanding of models and assess the effectiveness of interventions designed to enhance model-based learning in science classrooms.

V. Conclusion

The study demonstrates the effectiveness of embedding local wisdom into the modeling process in science education, particularly by utilizing the Nem Con folk game as a context for teaching projectile motion. The findings yield both theoretical and practical contributions.

Theoretically, the study advances the conceptual understanding of how cultural contexts can be integrated into scientific modeling processes. It proposes a structured approach to embedding local wisdom into the modeling process through the use of simulations. Secondly, the research introduces a framework for developing simulations that align with scientific modeling practices, bridging the gap between abstract science concepts and real-world phenomena.

Practically, by integrating a traditional Vietnamese folk game into a science lesson, this study illustrates how local wisdom can serve as a meaningful context for the scientific modeling process. The study evaluates the effects of this integration on students' modeling competence, providing empirical evidence on how cultural-contextualized learning approaches influence students' practices in constructing, using, comparing, revising, and validating scientific models. The results contribute to ongoing discussions on the role of simulations in fostering modeling competence and provide insights into designing culturally relevant science curricula that enhance both conceptual understanding and engagement.

Ethical Statement

The authors stated that the study was conducted in accordance with ethical standards for research involving human participants, under the ethical approval provided by the Ethics Committee for Scientific Research of Hanoi National University of Education (Approval No. 981/GCN-ĐHSPHN) before data collection. All participants were informed about the purpose and procedures of the study and participated voluntarily. Informed consent was obtained from their parents or legal guardians, and assent was obtained from the students themselves. All data were anonymized to protect participants' identities, and confidentiality was strictly maintained throughout the research process.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Dat Duc Nguyen conceptualized the study, designed the research framework, and led the writing of the manuscript. Huyen Ngoc Vu contributed to the research by refining the study design, analyzing the data, and drafting key sections. Xuan Thi-Thanh Nguyen assisted in data collection and conducted a literature review to support the theoretical foundation. Authors Son Nhu Nam Do and Anh Minh Nguyen were responsible for analyzing the scientific model of the Nem Con folk game and creating the simulations used in the research using Python. Bien Van Nguyen supervised the study, provided critical revisions to the manuscript, and served as the corresponding author. All authors contributed to the discussion, reviewed the manuscript, and approved the final version for submission.

References

[1] N. Rutten, W. R. V. Joolingen, and J. T. V. D. Veen, "The learning effects of computer simulations in science education," *Comput. Educ.*, vol. 58, no. 1, pp. 136–153, 2012. doi: 10.1016/j.compedu.2011.07.017

[2] H. K. Lu and P. C. Lin, "A study of the impact of collaborative problem-solving strategies on students' performance of simulation-based learning—A case of network basic concepts course," *Int. J. Inf. Educ. Technol.*, vol. 7, no. 5, pp. 361–366, 2017. doi: 10.18178/ijiet.2017.7.5.895

[3] H. Pol, E. Harskamp, and C. Suhre, "Solving physics problems with the help of computer-assisted instruction," *Int. J. Sci. Educ.*, vol. 27, no. 3, pp. 451–469, 2005. doi: 10.1080/0950069042000266164

[4] H. J. Pol, E. G. Harskamp, C. J. M. Suhre, and M. J. Goedhart, "The effect of hints and model answers in a student-controlled problem-solving program for secondary physics education," *J. Sci. Educ. Technol.*, vol. 17, no. 4, pp. 410–425, 2008. doi: 10.1007/s10956-008-9110-x

[5] L. Stern, L. Stern, N. Barnea, and S. Shauli, "The effect of a computerized simulation on middle school students' understanding of the Kinetic molecular theory," *J. Sci. Educ. Technol.*, vol. 17, no. 4, pp. 305–315, 2008.

[6] H. C. Liu and I. H. Su, "Learning residential electrical wiring through computer simulation: The impact of computer-based learning environments on student achievement and cognitive load," *Br. J. Educ. Technol.*, vol. 42, no. 4, pp. 598–607, 2011. doi: 10.1111/j.1467-8535.2009.01047.x

[7] S. Pang, G. Lv, Y. Zhang, and Y. Yang, "Enhancing students' science learning using virtual simulation technologies: A systematic review," *Asia Pacific J. Educ.*, pp. 1–21, 2025. doi: 10.1080/02188791.2024.2441676

[8] M. Shane Tutwiler and T. Grotzer, "Why immersive, interactive simulation belongs in the pedagogical toolkit of 'next generation'

science: Facilitating student understanding of complex causal dynamics," *STEM Educ. Concepts, Methodol. Tools, Appl*., vol. 3–3, pp. 1578–1597, 2014. doi: 10.4018/978-1-4666-7363-2.ch083

[9] E. S. Quellmalz, M. D. Silberglitt, B. C. Buckley, M. T. Loveland, and D. G. Brenner, "Simulations for supporting and assessing science literacy," *Learn. Perform. Assess*., pp. 760–799, 2019. doi: 10.4018/978-1-7998-0420-8.ch036

[10] H. Diab, W. Daher, B. Rayan, N. Issa, and A. Rayan, "Transforming science education in elementary schools: The power of PhET simulations in enhancing student learning," *Multimodal Technol. Interact*., vol. 8, no. 11, 2024. doi: 10.3390/mti8110105

[11] S. Wang, X. Mao, and Q. Zhu, "Simulation technology in the development of mechanics digital instructional resources: A case study," in *ACM Int. Conf. Proceeding Ser*., 2023, pp. 156–161. doi: 10.1145/3637907.3637968

[12] H. C. Lin, G. J. Hwang, K. R. Chou, and C. K. Tsai, "Fostering complex professional skills with interactive simulation technology: A virtual reality-based flipped learning approach," *Br. J. Educ. Technol*., vol. 54, no. 2, pp. 622–641, 2023. doi: 10.1111/bjet.13268

[13] N. Tsankov, "Development of the modeling competence of students in the pedagogical majors in the conditions of a simulation training in computer-based distance learning," *Perspekt. Nauk. i Obraz.*, vol. 53, no. 5, pp. 238–246, 2021. doi: 10.32744/PSE.2021.5.16

[14] A. Guajardo-Cuellar, "Molecular dynamics simulations as a competence developer for materials science," in *Proc. Int. Conf. Comput. Autom. Knowl. Manag. ICCAKM 2020*, 2020, pp. 328–331. doi: 10.1109/ICCAKM46823.2020.9051522

[15] M. H. Chiu and J. W. Lin, "Modeling competence in science education," *Discip. Interdiscip. Sci. Educ. Res.*, vol. 1, no. 1, pp. 1–11, 2019. doi: 10.1186/s43031-019-0012-y

[16] B. T. Tran and Q. T. Nguyen, "How to develop modelling competence for Vietnamese students," *J. Phys. Conf. Ser*., vol. 2727, no. 1, 2024. doi: 10.1088/1742-6596/2727/1/012027

[17] Y. Fauzana, Ratnawulan, and Usmeldi, "The effectiveness of physics learning materials using problem-based learning model integrated with local wisdom," *J. Phys. Conf. Ser*., vol. 1185, no. 1, 2019. doi: 10.1088/1742-6596/1185/1/012087

[18] Usmeldi and R. Amini, "The effect of integrated science learning based on local wisdom to increase the students competency," *J. Phys. Conf. Ser*., vol. 1470, no. 1, 2020. doi: 10.1088/1742-6596/1470/1/012028

[19] E. Etkina, A. Warren, and M. Gentile, "The role of models in physics instruction," *Phys. Teach*., vol. 44, no. 1, pp. 34–39, 2006. doi: 10.1119/1.2150757

[20] N. N. S. P. Verawati and W. Wahyudi, "Raising the issue of local wisdom in science learning and its impact on increasing students' scientific literacy," *Int. J. Ethnoscience Technol. Educ.*, vol. 1, no. 1, p. 42, 2024. doi: 10.33394/ijete.v1i1.10881

[21] A. Anwari, M. S. Nahdi, and E. Sulistyowati, "Biological science learning model based on Turgo's local wisdom on managing biodiversity," *AIP Conf. Proc.*, vol. 1708, no. 1, 030001, 2016. doi: 10.1063/1.4941146

[22] Y. F. Kasi, A. Widodo, A. Samsudin, *et al*., "Integrating local science and school science: The benefits for preserving local wisdom and promoting students' learning," *Paedagogia*, vol. 27, no. 1, p. 24, 2016. doi: 10.20961/paedagogia.v27i1.83925

[23] A. Oliveira, R. Feyzi Behnagh, L. Ni, A. A. Mohsinah, K. J. Burgess, and L. Guo, "Emerging technologies as pedagogical tools for teaching and learning science: A literature review," *Hum. Behav. Emerg. Technol.*, vol. 1, no. 2, pp. 149–160, 2019. doi: 10.1002/hbe2.141

[24] T. De Jong and W. R. Van Joolingen, "Scientific discovery learning with computer simulations of conceptual domains," *Rev. Educ. Res.*, vol. 68, no. 2, pp. 179–201, 1998. doi: 10.3102/00346543068002179

[25] A. I. Zourmpakis, M. Kalogiannakis, and S. Papadakis, "Adaptive gamification in science education: An analysis of the impact of implementation and adapted game elements on students' motivation," *Computers*, vol. 12, no. 7, 2023. doi: 10.3390/computers12070143

[26] C. E. Wieman, W. K. Adams, P. Loeblein, and K. K. Perkins, "Teaching physics using PhET simulations," *Phys. Teach.*, vol. 48, no. 4, pp. 225–227, 2010. doi: 10.1119/1.3361987

[27] A. Jimoyiannis and V. Komis, "Computer simulations in physics teaching and learning: A case study on students' understanding of trajectory motion," *Comput. Educ.*, vol. 36, no. 2, pp. 183–204, 2001. doi: 10.1016/S0360-1315(00)00059-2

[28] G. Andaloro, L. Bellomonte, and R. M. Sperandeo-Mineo, "A computer-based learning environment in the field of newtonian mechanics," *Int. J. Sci. Educ.*, vol. 19, no. 6, pp. 661–680, 1997. doi: 10.1080/0950069970190604

[29] A. Heck, E. Kedzierska, and T. Ellermeijer, "Design and implementation of an integrated computer working environment for doing mathematics and science," *J. Comput. Math. Sci. Teach*, vol. 28, no. 2, pp. 147–161, 2009.

[30] M. Henie *et al*. "Local wisdom-based conservation ethics of Tabaru traditional community on Halmahera island, Indonesia," *Int. J. Conserv. Sci.* vol. 10, no. 3, pp. 533–542, 2019.

[31] M. T. Chaer, E. Y. Rochmah, and S. Sukatin, "Education based on local wisdom," *Journal Islam. Educ.*, vol. 6, no. 2, p. 145, 2021. doi: 10.52615/jie.v6i2.216

[32] C. K. Smith and A. Cardenas, "Introducing multicultural science into the chemistry curriculum in the Mexican-American border region," *J. Coll. Sci. Teach*. vol. 41, no. 4, pp. 30–35, 2012.

[33] T. Smith, L. Avraamidou, and J. D. Adams, "Culturally relevant/responsive and sustaining pedagogies in science education: theoretical perspectives and curriculum implications," *Cult. Stud. Sci. Educ.*, vol. 17, no. 3, pp. 637–660, 2022. doi: 10.1007/s11422-021-10082-4

[34] C. Dahsah and C. Pruekpramool, "Using community resources as funds of knowledge to promote science learning in Thailand," *Sci. Educ. Res. Pract. Asia Challenges Oppor.*, pp. 553–568, 2016. doi: 10.1007/978-981-10-0847-4_30

[35] A. Harjono, N. N. S. P. Verawati, Wahyudi, S. Gummah, and S. Prayogi, "Integrating ethnoscience in inquiry-creative learning: A new breakthrough in enhancing critical thinking," *Int. J. Eval. Res. Educ.*, vol. 14, no. 1, pp. 636–647, 2025. doi: 10.11591/ijere.v14i1.29259

[36] S. Suciati, "Integrating local wisdom in science learning: an opportunities and challenges," *AIP Conf. Proc*., vol. 2619, no. 1, 100018, 2023. doi: 10.1063/5.0125371

[37] D. Nasrudin, F. S. Irwansyah, H. Sugilar, M. A. Ramdhani, and H. Aulawi, "Packaging science and local wisdom in digital devices for primary school students: Challenges and obstacles," *J. Phys. Conf. Ser*., vol. 1318, no. 1, 2019. doi: 10.1088/1742-6596/1318/1/012033

[38] G. Zinyeka, G. O. M. Onwu, and M. Braun, "A truth-based epistemological framework for supporting teachers in integrating indigenous knowledge into science teaching," *African J. Res. Math. Sci. Technol. Educ.*, vol. 20, no. 3, pp. 256–266, 2016. doi: 10.1080/18117295.2016.1239963

[39] A. A. Jingga and I. Sujadi, "Teachers' belief toward science and local wisdom's integration in mathematics instruction," *J. Phys. Conf. Ser.*, vol. 1465, no. 1, 2020. doi: 10.1088/1742-6596/1465/1/012056

[40] I. B. A. Arjaya, I. W. Suastra, I. W. Redhana, and A. A. I. A. R. Sudiatmika, "Global trends in local wisdom integration in education: A comprehensive bibliometric mapping analysis from 2020 to 2024," *Int. J. Learn. Teach. Educ. Res.*, vol. 23, no. 7, pp. 120–140, 2024. doi: 10.26803/ijlter.23.7.7

[41] J. H. S. Brar and W. Setioko, "ChatGPT and local wisdom: An exploratory study of ai-assisted ethnoscience lesson plan," in *Proc. 2024 Int. Semin. Appl. Technol. Inf. Commun. Smart Emerg. Technol. a Better Life, iSemantic 2024*, 2024, pp. 294–299. doi: 10.1109/iSemantic63362.2024.10762585

[42] J. P. Gomes, M. S. Lima, and F. F. D. Filho, "Integrating local knowledge on cactus pear from Brazilian northeastern communities for culturally responsive chemistry teaching," *J. Chem. Educ.*, vol. 101, no. 8, pp. 3578–3583, 2024. doi: 10.1021/acs.jchemed.4c00463

[43] C. V. Schwarz *et al*., "Developing a learning progression for scientific modeling: Making scientific modeling accessible and meaningful for learners," *J. Res. Sci. Teach*., vol. 46, no. 6, pp. 632–654, 2009. doi: 10.1002/tea.20311

[44] E. P. Azrai, M. Japar, R. Situmorang, R. D. Wulaningsih, and M. B. Rifqi, "The development of Virtual Food Simulation (VIFO) media as a realization of 21st Century learning demands," *Int. J. Inf. Educ. Technol.*, vol. 14, no. 4, pp. 564–572, 2024. doi: 10.18178/ijiet.2024.14.4.2078

[45] O. van Buuren and A. Heck, "Learning to use formulas and variables for constructing computer models in lower secondary physics education," *Math. Phys. Educ.*, 2019, pp. 175–194. doi: 10.1007/978-3-030-04627-9_8

[46] C. P. Constantinou, C. T. Nicolaou, and M. Papaevripidou, "A framework for modeling-based learning, teaching, and assessment," *Towards a Competence-Based View on Models and Modeling in Science Education*, vol. 12, pp. 39–58, 2019. doi: 10.1007/978-3-030-30255-9_3

[47] C. T. Nicolaou and C. P. Constantinou, "Assessment of the modeling competence: A systematic review and synthesis of empirical research," *Educ. Res. Rev.*, vol. 13, pp. 52–73, 2014. doi: 10.1016/j.edurev.2014.10.001

[48] D. F. Treagust, G. Chittleborough, and T. L. Mamiala, "Students' understanding of the role of scientific models in learning science," *Int. J. Sci. Educ.*, vol. 24, no. 4, pp. 357–368, 2002. doi: 10.1080/09500690110066485

[49] T. V. A. Le, V. B. Nguyen, V. H. Nguyen, and D. D. Nguyen, "Designing STEM experiential activities integrated with simulations based on Vietnamese proverbs and folk verses" *Tạp chí Giáo dục (Journal of Education)*, 2025, pp. 47–52.

[50] A. W. Chan, *et al*., "Spirit 2013 statement: Defining standard protocol items for clinical trials," *Chinese J. Evidence-Based Med*., vol. 13, no. 12, pp. 1501–1507, 2013. doi: 10.7507/1672-2531.20130256

[51] J. Grünkorn, A. U. zu Belzen, and D. Krüger, "Assessing students' understandings of biological models and their use in science to evaluate a theoretical framework," *Int. J. Sci. Educ*., vol. 36, no. 10, pp. 1651–1684, 2014. doi: 10.1080/09500693.2013.873155

[52] E. L. Zirbel, "Framework for conceptual change," *Astron. Educ. Rev.*, vol. 3, no. 1, pp. 62–76, 2009. doi: 10.3847/aer2004007

[53] P. J. Fensham, R. F. Gunstone, and R. T. White, "The content of science : A constructivist approach to its teaching and learning," Routledge, 1994, p. 278.

[54] A. Akmam, R. Anshari, H. Amir, N. Jalinus, and A. Amran, "Influence of learning strategy of cognitive conflict on student misconception in computational physics course," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 335, no. 1, 2018. doi: 10.1088/1757-899X/335/1/012074

[55] L. Gusukuma, A. C. Bart, D. Kafura, and J. Ernst, "Misconception-driven feedback: Results from an experimental study," in *ICER 2018-Proc. 2018 ACM Conf. Int. Comput. Educ. Res*., 2018, pp. 160–168. doi: 10.1145/3230977.3231002

[56] C. Basterfield, S. O. Lilienfeld, R. L. Cautin, and D. Jordan, "Mental illness misconceptions among undergraduates: Prevalence, correlates, and instructional implications," *Scholarsh. Teach. Learn. Psycho*l., vol. 9, no. 2, pp. 115–132, 2023. doi: 10.1037/stl0000221

[57] L. Grosslight, C. Unger, E. Jay, and C. L. Smith, "Understanding models and their use in science: Conceptions of middle and high school students and experts," *J. Res. Sci. Teach*., vol. 28, no. 9, pp. 799–822, 1991. doi: 10.1002/tea.3660280907

[58] A. M. Ingham and J. K. Gilbert, "The use of analogue models by students of chemistry at higher education level," *Int. J. Sci. Educ*., vol. 13, no. 2, pp. 193–202, 1991. doi: 10.1080/0950069910130206

[59] A. G. Harrison and D. F. Treagust, "Secondary students' mental models of atoms and molecules: Implications for teaching chemistry," *Sci. Educ.*, vol. 80, no. 5, pp. 509–534, 1996.

Copyright © 2025 by the authors. This is an open access article distributed under the Creative Commons Attribution License which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited (CC BY 4.0).