International Journal of Research and Review
[Indexed, Peer-Reviewed Journal]
Volume 12; Issue: 8; August 2025
Website: www.ijrrjournal.com
Research Paper E-ISSN: 2349-9788; P-ISSN: 2454-2237

Practicality of the 5C Learning Model (Connecting, Confrontation, Collaboration, Clarification, Confirmation) Based on Virtual Laboratory in the Implementation of Physical Chemistry Lectures

Nita Suleman[1], Astin Lukum[2], Masrid Pikoli[3], Akram La Kilo[4], Mursalin[5], Elya Nusantasri[6], Frida Maryati Yusuf[7], Masra Latjompoh[8]

[1,2,3,4,5,6,7,8]State University of Gorontalo, Indonesia

Corresponding Author: Nita Suleman

DOI: https://doi.org/10.52403/ijrr.20250822

ABSTRACT

This study aims to assess the practicality of the 5C learning model based on virtual laboratories in the context of real classroom implementation. The assessment was conducted through limited and extensive trials involving students of the Chemistry Study Program at Gorontalo State University who were enrolled in the Physical Chemistry II course. The research employed a research and development approach using the ADDIE development model, focusing on the implementation and evaluation stages. Instruments included observation sheets for learning syntax implementation, student response questionnaires, and a reflective interview with lecturers. The results showed that the 5C learning model was considered highly practical by lecturers and students. The five analyzed aspects of practicality, namely ease of syntax, material suitability, virtual interaction, student comfort, and lecturer readiness, all scored above 80%, with the highest score of 90% in the virtual interaction aspect. The practicality of the 5C model was reflected in its consistently and efficiently implemented syntax, complemented by a virtual laboratory that operated effectively and supported active student engagement. These findings suggest that the 5C learning model based on virtual laboratories demonstrates high practicality and is suitable for broad implementation as an alternative to a modern, efficient, and technology-based approach to chemistry learning.

Keywords: practicality, 5C learning, virtual laboratory, learning syntax

INTRODUCTION

Learning physical Chemistry, especially the topic of reaction kinetics, requires students to understand mathematical procedures and develop strong conceptual connections between the components of content. However, classroom observations indicate that many students struggle to articulate the interrelationships among reaction variables, analyze experimental data, and contextualize their understanding within relevant chemical phenomena. This condition indicates a weak relational understanding, which refers to the ability to integrate procedural knowledge with conceptual meaning across various learning contexts (Yuksekgonul et al., 2022). Most of the learning process still adopts traditional approaches and emphasizes formula memorization, which fails to support students in achieving meaningful and lasting learning experiences.

Limited facilities in many higher education institutions often result in students experiencing only demonstrative experiments. Consequently, they miss out on direct involvement in the scientific process, essential for developing scientific reasoning skills and relational understanding. In this context, the development of a learning model that emphasizes active engagement, concept visualization, and meaning exploration has become an urgent necessity, particularly for teaching abstract and complex chemistry topics. Therefore, a learning model is required that is theoretically valid but also practical and relevant in the digital era.

The 5C learning model (Connecting, Confrontation, Collaboration, Clarification, and Confirmation) was developed systematically, integrating constructivist theory with digital learning technology through virtual laboratories. Students are encouraged to activate prior knowledge through contextual phenomena at the Connecting stage. Confrontation introduces cognitive dissonance by presenting experiments or data that contradict student predictions. Collaboration then fosters conceptual discussion within groups, Clarification strengthens understanding through collective reflection, and Confirmation emphasizes deepening meaning and applying concepts across various contexts.

The virtual laboratory integrated into this model is not only a substitute for physical practical facilities but also a constructive medium for presenting real-time experimental data, interactive visualizations, and adjustable variable controls tailored to specific learning scenarios. Previous researchs (Alnaser & Forawi, 2024; Dyrberg et al., 2017) proved that virtual laboratories can significantly increase student participation, conceptual understanding, and learning motivation. Conversely, findings by Demelash et al. (2024) revealed that misconceptions in chemistry learning occur due to low student involvement in constructing meaning, rather than from the inherent complexity of the material.

The success of a learning model in addressing 21st-century curriculum demands and learner needs is measured not only by its theoretical validity and effectiveness in achieving learning outcomes, but also by the extent to which it is practical and applicable in real classroom settings, ensuring the sustainability of learning innovation (Phinla et al., 2024). Therefore, this study aims to test the practicality of the 5C learning model based on virtual laboratories by examining the extent to which this model can be applied consistently, is easy to use, is accepted by students and lecturers, and can facilitate contextual and meaningful learning experiences. The syntax of the 5C learning model is presented in Table 1 below.

Table 1. Syntax of the 5C Learning Model: *Connection*, *Conflict*, Collaboration, *Clarification* and *Confirmation*

Stages of the 5C learning model	Activities of Lecturers and Students in the 5C learning model syntax		Relational Understanding Indicators
	Lecturer Activities	**Student Activities**	
Connecting (Initial Schema Activation)	a. Distribute Student Activity Sheets (LKM) and communicate learning objectives. b. Explore students' prior knowledge by presenting contextual problems and connecting them to previously taught	a. Convey what they know, experience, or think about the topic. b. Observe and respond to images, videos, or texts provided by the teacher c. Discuss the initial topic with a deskmate or small group. d. Note down or describe what they know before studying further e. Explain their guesses about the	Identifying the prerequisites needed Recognizing new question forms

	concepts. c. Help build context and attract students' attention by presenting phenomena related to the concepts to be learned. d. Ask students to relate the material to be learned to their experiences.	content of a lesson or the solution to a problem f. Examine the relationship between the presented phenomena and previous experiences.	
Confrontation (Creating Cognitive Conflict)	a. Present facts that contradict students' initial conceptions b. Present examples of questions that challenge students' prior knowledge	a. Pay attention to and respond to facts that contradict their knowledge or reveal inconsistencies with previous understanding. b. Complete the practice questions in the LKM and note any issues.	Providing logical arguments Recognizing new question forms
Collaboration (Conducting practical work using a virtual laboratory)	a. Organize students into study groups b. Motivate and facilitate each group in completing the practicum using a virtual laboratory and the use of the Crocodile Chemistry application. c. Monitor student involvement in group discussions, d. Provide student activities in group work and provide guidance if students experience difficulties. e. Facilitate students in group discussions and share information and knowledge with group members.	a. Develop a plan together to solve problems in the LKM b. Conduct experiments using the Crocodile Chemistry application c. Discuss, exchange opinions, and share information.	Demonstrating the ability to perform procedures Carrying out the procedure step by step
Clarification (Clarification of ideas, class discussion and presentation)	a. Direct students to take turns in presenting the results obtained in each group. b. Manage discussion dynamics so that all students are involved.	a. Each group presents the results of the experiment and the discussion. b. Explain the group's conclusions. c. Provide logical reasons, concrete examples, and connect related concepts. d. Ask questions to other groups. e. Respond to arguments with data, experiences, or related concepts. f. Try to explain other groups' ideas in their own words.	Demonstrating the ability to perform procedures
Phase 5 Confirmation (Reinforcement and reflection)	a. Provide reinforcement for answers arising during class discussions or presentations. b. Asks students to reflect on their	a. Pay attention to the lecturer's affirmation during the discussions. b. Reflect by summarizing the studied material individually. c. Develop a plan to deepen understanding or solve new problems.	Obtaining accurate results Identifying errors in procedures

	understanding before and after the discussion and experiment, to encourage conceptual change through individual and group summaries/report.	d. Submit group work reports. e. Solve new problems in different contexts.	

RESEARCH METHOD

This study employs a research and development (R&D) approach using the ADDIE (Analysis, Design, Development, Implementation, Evaluation) development model. The study was conducted at Gorontalo State University in two groups enrolled in the Physical Chemistry II course. A limited trial was carried out in one Chemistry Education Study Program class consisting of 25 students. Meanwhile, an extensive trial was conducted across three classes: two Chemistry undergraduate programs (Classes A and B) and one from the Chemistry Education program (Class A), with a total of 99 students. According to the Physical Chemistry II lecture schedule, this activity lasted for two semesters, namely the even semester of 2022/2023 and the odd semester of 2023/2024.

The research design adopted a field test-based development research, prioritizing the assessment of model implementation in an authentic learning environment. Data collection was carried out using three integrated techniques. First, structured observations were carried out to assess the implementation of the 5C learning model syntax. Two external observers evaluated each of the five stages using an observation sheet to ensure objectivity. The results were then analyzed based on the percentage of implementation at each stage. Second, a student response questionnaire using a 5-point Likert scale was distributed to measure perceptions related to the ease of following the syntax, the relevance of the material, the interactivity of the virtual laboratory, the availability of study guides, the overall learning experience, and lecturer readiness. These quantitative data were analyzed to determine the average score for each indicator. Third, semi-structured reflective interviews were conducted with the lecturer and selected student representatives to explore their experiences during implementation, challenges, and suggestions for improvement. The interview results were thematically analyzed and triangulated with observation and questionnaire data.

Data analysis employed a combination of quantitative and qualitative descriptive approaches. Observation and questionnaire data were analyzed by calculating percentages and average scores, which were then classified according to Akker's (1999) practicality criteria: scores > 80% (very practical), 60–80% (quite practical), and < 60% (less practical).

RESULT AND DISCUSSION

This study focuses on five aspects of practicality: the ease of following the syntax, the suitability of the material, the quality of virtual interaction, student comfort, and lecturer readiness.

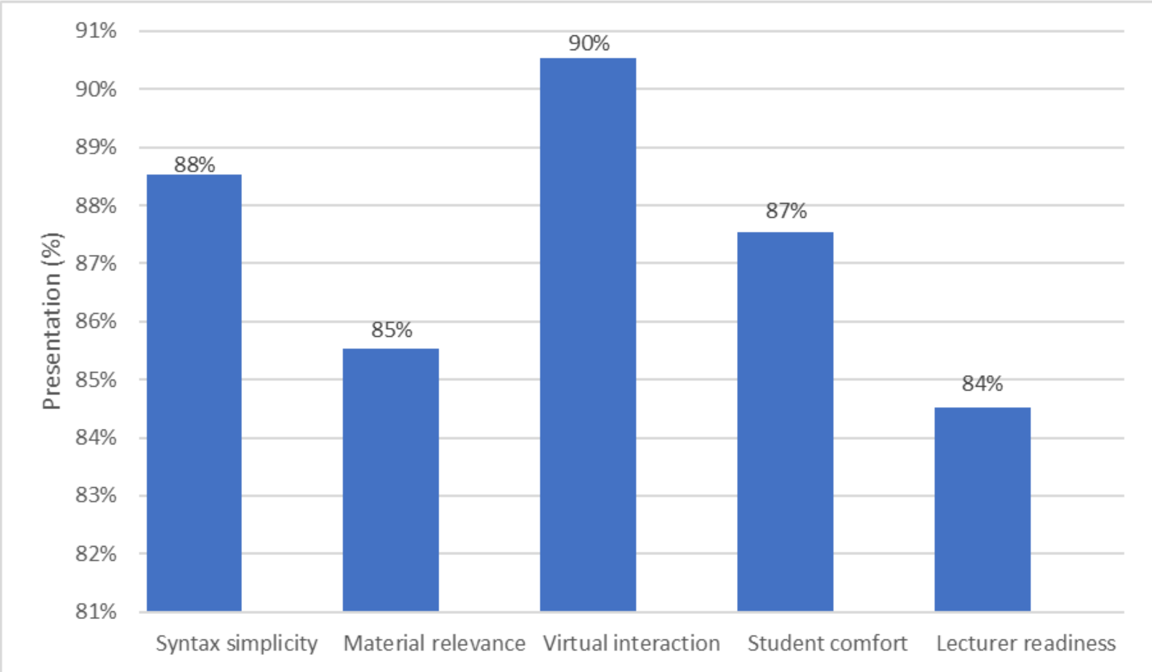

Figure 1. Practicality of the 5C Learning Model

Based on Figure 1, all five practicality aspects of the 5C learning model scored above 80%, which, according to Akker's (1999) criteria, is categorized as "very practical". This indicated that the model can be applied consistently and effectively in a real learning environment. The virtual interaction aspect recorded the highest score at 90%, suggesting that the use of virtual laboratory media strongly supports active student participation, conceptual understanding, and meaningful learning experiences. These results are reinforced by observations and interview data, where lecturers stated that virtual laboratories not only overcome the limitations of physical facilities, but also enrich the learning process through complex and interactive concept visualization of abstract concepts.

Instructional steps that are easy to comprehend and apply

The syntax of the 5C model consists of the stages: Connecting, Confrontation, Collaboration, Clarification, and Confirmation. Observations show that lecturers and students are able to implement these five stages smoothly and coherently. This systematic syntax aligns with Bruner's theory of scaffolding and his three modes of representation, enactive, iconic, and symbolic (Żądło-Treder, 2021; Jinzhi & Xuejun, 2025). Specifically, the Connecting and Confrontation stages effectively activate students' prior knowledge (initial schemata) and create cognitive dissonance, which is known to foster a meaningful learning process.

Efficient and Interactive Use of Virtual Laboratories

Virtual labs received the highest score (90%) for their ability to provide safe, flexible, and accessible real-time experimental simulations. This finding supports the research results by Hussain et al. (2022), which state that virtual laboratories save time and costs, increase student engagement, and improve concept retention in chemistry learning.

According to Gagné's information processing theory, learning occurs optimally when students receive information through meaningful stimuli and context-based repetition (Gagné in Hakim, 2012). The use of virtual laboratory visualization supports this process by reinforcing cognitive pathways, especially in strengthening long-term memory during the Clarification and

Confirmation stages of the 5C learning model.

Increased Student Engagement

Reflective interviews revealed that students felt more active and confident in presenting the results of group discussions. This aligns with Vygotsky's theory of the Zone of Proximal Development (ZPD), which states that the most effective learning occurs when students are supported in completing tasks they cannot yet do independently (Cai et al., 2025; Yousif, 2025). The collaborative approach implemented during the Collaboration stage enables peer-assisted learning, allowing students to support one another in building a deeper conceptual understanding.

Support for Class Management by Lecturers

Lecturers reported that the 5C model facilitated class management due to its clear learning structure and flexible implementation timeline. This aligns with the findings of Lo et al. (2023), who concluded that learning models with a structured syntax framework can enhance lecturers' effectiveness in delivering material and systematically monitoring student learning progress.

Relevance and Context of 21st Century Learning

The virtual laboratory-based 5C model supports the development of 21st-century learning competencies, such as digital literacy, collaboration, critical thinking, and reflection. This aligns with Walkington's (2013) perspective that meaningful learning requires the activation of prior knowledge, engagement with authentic contexts, and the integration of relevant technologies to ensure that new information is deeply internalized.

Based on analysis of quantitative and qualitative data, it can be concluded that the virtual laboratory-based 5C learning model demonstrates high practicality. The systematic implementation of its syntax supports this, the integration of interactive technology, and the active involvement of students. The model's practicality contributes to its effectiveness and sustainability as an innovative learning approach in chemistry education at the higher education level. Further evidence of its practicality is reflected in the ease with which lecturers and students follow the syntax, its flexible application in large and small classes, and the availability of comprehensive learning instruments such as lesson plans (RPS), student worksheets (LKM), observation sheets, and relational understanding assessment instruments.

Based on field observation results, the 5C syntax can be applied consistently and systematically, even by lecturers who are not yet familiar with virtual-based learning approaches. Students also showed active involvement, including peer assistance within groups and individual reflection, which are key indicators of successful implementation. This aligns with Abdel-Al Ibrahim et al. (2023), who emphasized that ZPD-based scaffolding, whether provided by teachers or peers, is highly effective in achieving learning objectives.

The results of the student response questionnaire showed that the virtual laboratory-based 5C learning model received positive appreciation, with an average practicality score exceeding 85% across aspects such as interactivity, clarity of instructions, and ease of access. This suggests that the model is not only well designed from a theoretical standpoint but also reflects the pedagogical needs of students in an increasingly digital learning environment. Notably, even in classes without direct access to physical chemistry laboratories, students were still able to experience equivalent learning outcomes through software-based simulations such as Crocodile Chemistry.

Practicality also extends to time and resource management. Lecturers can easily integrate virtual exploration activities into online and offline sessions, while students are able to access materials and complete assignments flexibly without being limited by time or location. Moreover, the 5C syntax is adaptable, allowing for improvisation based on classroom context. Experienced lecturers may enhance the Collaboration and Clarification stages with case-based discussions. In contrast, novice lecturers can still implement a simplified version of the syntax without compromising the model's core principles.

Based on the explanations above, the 5C model has been proven to offer a structured, engaging, and contextual learning experience, effectively supporting chemistry learning in the digital era. Its practicality serves as a critical foundation for the diffusion and sustainability of the model across various educational institutions. This model addresses conceptual challenges in physical chemistry learning and provides implementable solutions that respond to limitations in facilities, differences in student characteristics, and the dynamics of current digital learning. The successful implementation of the model in the Chemistry Department of Gorontalo State University demonstrates that the development of learning models must prioritize the practical dimension to create meaningful and lasting impacts in education.

CONCLUSION

The 5C Learning Model, based on virtual laboratories, demonstrates a very high level of practicality. The five syntaxes of Connecting, Confrontation, Collaboration, Clarification, and Confirmation are implemented consistently and have proven flexible for implementation in large and small classes. The model is also easily adaptable to varying student characteristics and facility availability.

Declaration by Authors

Acknowledgement: None

Source of Funding: None

Conflict of Interest: No conflicts of interest declared.

REFERENCES

1. Abdel-Al Ibrahim AK, Cuba Carbajal N, Zuta MEC, Bayat S. Collaborative learning, scaffolding-based instruction, and self-assessment: Impacts on intermediate EFL learners’ reading comprehension, motivation, and anxiety. Language Testing in Asia. 2023; 13(1):16.
2. Alnaser DSA, Forawi S. Investigating the effects of virtual laboratories on students' motivation and attitudes toward science. Science Education International. 2024; 35(2):154–162.
3. Cai L, Msafiri MM, Kangwa D. Exploring the impact of integrating AI tools in higher education using the Zone of Proximal Development. Education and Information Technologies. 2025; 30(6):7191–7264.
4. Demelash M, Andargie D, Belachew W. Enhancing secondary school students' engagement in chemistry through 7E context-based instructional strategy supported with simulation. Pedagogical Research. 2024; 9(2).
5. Dyrberg NR, Treusch AH, Wiegand C. Virtual laboratories in science education: Students’ motivation and experiences in two tertiary biology courses. Journal of Biological Education. 2017; 51(4):358–374.
6. Jinzhi H, Xuejun B. Bruner’s Three Models of Presentation Theory. In: The ECPH Encyclopedia of Psychology. Singapore: Springer Nature Singapore; 2025. p. 167–170.
7. Lo KW, Ngai G, Chan SC, Kwan KP. How students’ motivation and learning experience affect their service-learning outcomes: A structural equation modeling analysis. Frontiers in Psychology. 2022; 13:825902.
8. Phinla W, Phinla W, Mahapoonyanont N. Lessons learned from the success of model schools for 21st century learners: Enhancing educational quality through the visible learning concept. [Journal name missing]. 2024.
9. Walkington CA. Using adaptive learning technologies to personalize instruction to student interests: The impact of relevant contexts on performance and learning outcomes. Journal of Educational Psychology. 2013; 105(4):932.
10. Yousif JH. Artificial intelligence revolution for enhancing modern education using Zone of Proximal Development approach.

Applied Computing Journal. 2025; p. 386–398.

11. Yuksekgonul M, Bianchi F, Kalluri P, Jurafsky D, Zou J. When and why vision-language models behave like bags-of-words, and what to do about it?. arXiv preprint. 2022.
12. Żądło-Treder J. Iconic and symbolic representation in early mathematics teaching. Edukacja Elementarna w Teorii i Praktyce. 2021; 16(3):11–25.

How to cite this article: Nita Suleman, Astin Lukum, Masrid Pikoli, Akram La Kilo, Mursalin, Elya Nusantasri et.al. Practicality of the 5C learning model (connecting, confrontation, collaboration, clarification, confirmation) based on virtual laboratory in the implementation of physical chemistry lectures. *International Journal of Research and Review*. 2025; 12(8): 197-204 DOI: *https://doi.org/10.52403/ijrr.20250822*

******