การพัฒนาเกณฑ์การประเมินวัดความสามารถการเขียนสื่อสารทางวิทยาศาสตร์สำหรับนักศึกษาครูวิทยาศาสตร์

DEVELOPMENT OF AN ASSESSMENT RUBRIC FOR SCIENCE COMMUNICATION WRITING SKILLS AMONG PRE-SERVICE SCIENCE TEACHERS

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บทคัดย่อ

การสื่อสารทางวิทยาศาสตร์อย่างมีประสิทธิภาพถือเป็นรากฐานสำคัญของการศึกษาวิทยาศาสตร์ เนื่องจากช่วยให้ครูและนักเรียนสามารถถ่ายทอดแนวคิดทางวิทยาศาสตร์ได้อย่างเข้าถึง เข้าใจง่าย น่าสนใจ และสอดคล้องกับผู้รับสารหลากหลายกลุ่ม งานวิจัยนี้มีวัตถุประสงค์เพื่อพัฒนาและตรวจสอบ ความตรงเชิงเนื้อหาของเกณฑ์ประเมินสำหรับประเมินความสามารถในการสื่อสารผ่านการเขียนเชิงวิทยาศาสตร์ ซึ่งออกแบบเฉพาะสำหรับนักศึกษาครูวิทยาศาสตร์ โดยอาศัยกรอบแนวคิดทางทฤษฎีและข้อมูลเชิงประจักษ์ ตามรูปแบบการสื่อสารทางวิทยาศาสตร์แบบสนทนา (Dialogic Model of Science Communication) กลุ่มตัวอย่างเป็นนักศึกษาครูวิทยาศาสตร์ชั้นปีที่ 3 จำนวน 60 คน โดยใช้วิธีการเลือกแบบทั้งประชากร เครื่องมือที่ใช้ในการวิจัยคือเกณฑ์ประเมินการเขียนสื่อสารทางวิทยาศาสตร์ที่พัฒนาขึ้น ซึ่งประกอบด้วย 6 องค์ประกอบ และผ่านการตรวจสอบความตรงเชิงเนื้อหาโดยผู้เชี่ยวชาญ 3 คน (IOC = 0.67–1.00) การวิเคราะห์ข้อมูลใช้สถิติเชิงพรรณนา ได้แก่ ความถี่และร้อยละ

ผลการวิจัยพบว่า เกณฑ์ประเมินฉบับนี้ประกอบด้วยองค์ประกอบสำคัญ 6 ด้าน ได้แก่ 1) กลุ่มเป้าหมาย บริบท และวัตถุประสงค์ 2) การพัฒนาสาระเนื้อหา 3) แหล่งข้อมูลและหลักฐานอ้างอิง 4) การจัดลำดับและนำเสนอข้อมูล 5) ความถูกต้องของไวยากรณ์และการใช้ภาษา และ 6) การใช้สื่อประกอบ โดยปรับปรุงจากเกณฑ์ประเมินต้นแบบการสื่อสารด้วยการเขียนของวิทยาลัยชุมชนโคลัมเบียจอร์จและผ่านกระบวนการตรวจสอบจากผู้เชี่ยวชาญจำนวน 3 คน เพื่อให้มั่นใจในความตรงและความเหมาะสมสำหรับการใช้ประเมินการสื่อสารทางวิทยาศาสตร์ ในภาพรวม การทดลองใช้เกณฑ์ประเมินกับการประเมินใบความรู้ทางวิทยาศาสตร์ที่นักศึกษาจัดทำขึ้น พบจุดแข็งด้านความถูกต้องทางภาษาและการนำเสนอภาพประกอบ แต่ยังต้องปรับปรุงด้านความเชื่อมโยงของเนื้อหา ความสอดคล้องกับบริบทชีวิตจริง และความน่าเชื่อถือของแหล่งข้อมูล ผลการวิจัยนี้สะท้อนถึงความสำคัญของการมีเกณฑ์ประเมินที่เป็นระบบในการเสริมสร้างทักษะการสื่อสารทางวิทยาศาสตร์ และเสนอเครื่องมือประเมินที่มีความน่าเชื่อถือเพื่อสนับสนุนการพัฒนาครูวิทยาศาสตร์ที่สามารถถ่ายทอดองค์ความรู้สู่สาธารณชนได้อย่างมี

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ประสิทธิภาพ งานวิจัยในอนาคตควรขยายขนาดกลุ่มตัวอย่าง และศึกษาความเหมาะสมในการประยุกต์ใช้ในระดับการศึกษาและสาขาวิชาอื่นต่อไป

คำสำคัญ: การสื่อสารทางวิทยาศาสตร์, การประเมินการเขียน, การศึกษาระดับปริญญาตรี, การพัฒนาเกณฑ์ประเมิน

ABSTRACT

Effective science communication is a fundamental foundation of science education, as it enables teachers and students to convey scientific concepts in ways that are accessible, comprehensible, engaging, and responsive to diverse audiences. This study aimed to develop and examine the content validity of an assessment rubric for evaluating scientific communication through writing, specifically designed for pre-service science teachers. The rubric was developed based on theoretical frameworks and empirical evidence, guided by the dialogic model of science communication. The research instrument was a science communication writing rubric consisting of six components. The rubric was validated for content validity by three experts with an index of item-objective congruence ranging from 0.67 to 1.00. Data were analyzed using descriptive statistics, including frequency and percentage.

The findings revealed that rubric comprises six key components: (1) audience, context, and purpose; (2) content development; (3) sources and evidence; (4) organization and presentation of information; (5) grammatical accuracy and language use; and (6) use of supporting media. The rubric was adapted from the written communication VALUE rubric developed by the Association of American Colleges and Universities and was validated by three experts to ensure its relevance and appropriateness for assessing overall science communication. The pilot implementation of the rubric in evaluating student-generated scientific handouts indicated strengths in grammatical accuracy and the use of visual elements. However, areas for improvement were identified in terms of content coherence, alignment with real-life contexts, and the credibility of information sources. These findings highlight the importance of having a systematic assessment tool to enhance scientific communication skills and provide a reliable instrument to support the development of science teachers capable of effectively communicating scientific knowledge to the public. Future research should expand the sample size and explore the applicability of the rubric across different educational levels and academic disciplines.

KEYWORDS: Science communication, Writing evaluation, Undergraduate Education, Rubric development

Introduction

Scientific and technological information increasingly shapes modern life, influencing decisions about vaccination, healthcare, sustainable living, and climate change. The effectiveness of such decision-making largely depends on how clearly and accessibly science is communicated. Traditionally, science communication followed the one-way "deficit model," where experts transmitted knowledge directly to the public (Van der Sanden & Meijman, 2008). However, this model has shifted toward two-way, dialogue-based approaches that emphasize interaction between communicators and audiences (Bray et al., 2012; Mulder et al., 2008). In addition to scientists,

journalists, social media practitioners, and science teachers also play a critical role in making scientific information meaningful to wider audiences (Liskauskas et al., 2019; Taranum, 2021; Yuan et al., 2017).

The goals of science communication, as identified by the National Academies of Sciences, Engineering, and Medicine (2017, pp. 3–5), extend beyond disseminating facts. They include fostering appreciation of science, influencing decisions, and incorporating diverse perspectives into societal debates. Achieving these goals requires communicators to address major obstacles, such as specialized terminology and the overwhelming volume of available information. Importantly, the ability to communicate science is not only relevant for the general public but also essential in educational contexts. Effective classroom communication allows teachers to transform complex concepts into accessible content, connect lessons to real–world issues, and cultivate critical thinking skills (Amin et al., 2022; Moemeke, 2023).

For science education in Thailand, the National Education Plan (B.E. 2017–2036) and the Basic Education Core Curriculum (B.E. 2008, revised in 2017) highlight the importance of developing 21st–century competencies, with communication skills at the forefront. Science teacher students, as future educators, must therefore be trained to communicate science effectively, both orally and in writing. While academic scientific writing (e.g., research reports) has been widely assessed with established rubrics (Timmerman et al., 2011; Willison & O'Regan, 2007), there is still a lack of well–defined assessment tools for general scientific communication, such as popular science articles designed for non–expert audiences (Baram–Tsabari & Lewenstein, 2013; Kulgemeyer & Schecker, 2013). This gap is significant because science teacher students are often required to create educational materials such as information sheets or public–oriented articles that serve as a bridge between school science and everyday contexts.

Previous studies have emphasized four critical components of effective general science writing: (1) scientific accuracy, (2) contextual relevance, (3) accessible language, and (4) appropriate use of representations (Kulgemeyer & Schecker, 2013). However, existing rubrics are either designed for evaluating general writing skills (e.g., Columbia Gorge Community College rubric) or for assessing academic scientific texts. They do not fully address the distinctive features of science communication intended for public audiences. Baram–Tsabari and Lewenstein (2013) highlighted the urgent need for instruments to evaluate scientists' public communication skills, yet comprehensive criteria for assessing science teacher students' general writing remain underdeveloped.

To address the lack of assessment tools for general science communication, it is essential to examine existing rubrics that have been widely used in evaluating scientific writing. Previous studies have developed structured criteria for assessing academic scientific writing, particularly in laboratory reports and research papers. For example, Timmerman et al. (2011) and Willison and O'Regan (2007) proposed rubrics that emphasize accuracy of content, logical structure, and the development of students' scientific reasoning. These instruments have proven effective for evaluating academic contexts but are limited when applied to general science communication intended for broader audiences.

Several studies have highlighted the distinctive requirements of communicating science to non–expert readers. Baram–Tsabari and Lewenstein (2013) stressed the importance of developing tools that assess scientists' ability to write for the public, pointing out that traditional academic rubrics do not adequately capture the qualities of effective communication for lay audiences. Kulgemeyer and Schecker (2013) identified four key elements for evaluating such writing: (1) accurate scientific content, (2) the use of contexts relevant to everyday life,

(3) accessible language that minimizes jargon, and (4) the use of visual or representational forms that enhance understanding. These components reflect essential differences between academic and general scientific writing, underscoring the need for tailored evaluation tools.

Some general writing rubrics provide useful frameworks for assessing communication skills. For instance, the written communication rubric of Columbia Gorge Community College, adapted from the AACU LEAP and SFA rubrics, outlines criteria such as context, content development, sources, organization, and mechanics (Kelly & Takao, 2002). While comprehensive, this rubric was designed for general written communication rather than specifically for scientific contexts. Consequently, although its structure overlaps with criteria identified in scientific writing studies (Tariq et al., 1998; Timmerman et al., 2011), it does not fully address the unique characteristics of science communication for public audiences.

Synthesizing across literature, six essential components emerge as central to evaluating scientific writing: (1) Audience, context, and purpose, (2) Content development, (3) Sources or/and evidence, (4) Organization and presentation, (5) Control of syntax and mechanics, and (6) Visual aids. These categories capture both the academic rigor of science writing and the accessibility required for non–expert audiences. However, no existing rubric systematically integrates these elements in the context of science teacher education, where students are expected to develop skills for bridging school science and public understanding.

Therefore, this study adapts and refines the Columbia Gorge Community College rubric by incorporating criteria specific to general science communication. The revised rubric provides a structured framework to evaluate how effectively science teacher students convey scientific knowledge to lay audiences. By focusing on both scientific accuracy and communicative clarity, the rubric ensures that assessment aligns with the professional competencies required of future science educators.

Objectives

To develop and validate assessment criteria for evaluating general science communication articles created by science teacher students, focusing on conveying scientific knowledge to non–expert audiences.

Hypothesis

The development of tailored assessment criteria is expected to enhance both the accuracy and consistency of evaluating general scientific communication articles produced by science teacher students, as evidenced through rubric–based scores, greater inter–rater reliability, and demonstrable improvements in students' writing performance.

Conceptual Framework

This study is grounded in three main theoretical and conceptual bases. First, the Dialogic Model of Science Communication (Bray et al., 2012; Mulder et al., 2008) emphasizes two–way interaction between communicators and audiences, highlighting the importance of clarity, relevance, and engagement. Second, the principles of popular science writing (Baram–Tsabari & Lewenstein, 2013; Kulgemeyer & Schecker, 2013) stress narrative coherence,

accessibility, and reader engagement. Third, established writing assessment frameworks (Timmerman et al., 2011; Willison & O'Regan, 2007) provide validated dimensions for evaluating written communication.

These theoretical foundations collectively inform the design of the assessment rubric, ensuring that it addresses both scientific accuracy and audience–centered communication.

The independent variable in this study is the development and application of a science communication writing assessment rubric. This rubric operationalizes key competencies through six dimensions: (1) audience, context, and purpose; (2) content development; (3) sources and evidence; (4) organization and presentation; (5) control of syntax and mechanics; and (6) visual aids.

The dependent variable is the science communication writing skills of undergraduate pre–service science teachers, as reflected through their performance across these six dimensions.

The relationship between variables is conceptualized as a direct and structured influence. The rubric functions as an instructional and evaluative mechanism that guides students to align their writing with theoretical principles. Specifically, the Dialogic Model supports audience awareness and contextual relevance, while popular science writing principles promote clarity, coherence, and engagement. As a result, the application of the rubric is expected to enhance students' ability to communicate scientific knowledge effectively to non–expert audiences.

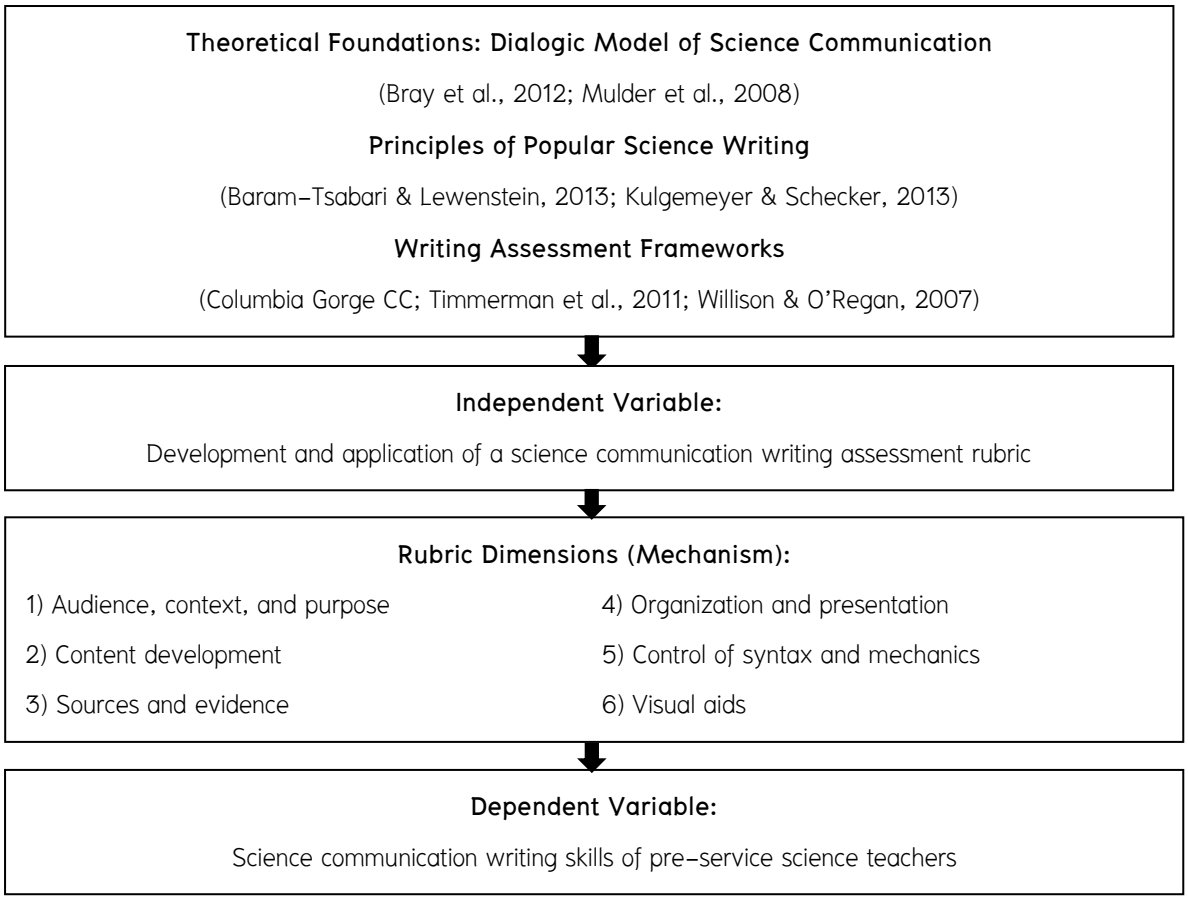


Figure 1 Conceptual framework

Research Methodology

This research focuses on guiding undergraduate students in developing educational information sheets under Strand 2: Physical Science, Standard Sc 2.1. The aim is to enhance understanding of the properties and composition of matter, the relationship between matter's properties and its structure and intermolecular forces, the principles and nature of state changes in matter, the formation of solutions, and chemical reactions. These information sheets are designed for use in teaching activities for students from Grade 1 to Grade 9 (Prathom 1 to Matthayom 3).

Population and Sample

The population consisted of third-year undergraduate students enrolled in the Bachelor of Education Program in Learning Management with a major in Science Education at Kasetsart University, Kamphaeng Saen Campus. All 60 students in the cohort were invited to participate, and therefore a census approach was employed rather than sampling. The group is representative of pre-service science teachers at this stage of the program.

Research Instrument

The primary instrument was a rubric developed for assessing students' science communication skills. These skills were operationalized through six rubric dimensions: accuracy of scientific content, clarity of explanation, contextualization, organization and coherence, language accessibility, and use of visual/illustrative elements. Each dimension was rated at four performance levels (excellent, proficient, developing, and needs improvement).

The rubric development followed a systematic process:

1) Literature review: Existing frameworks for science communication and written communication rubrics were examined to identify essential components.

2) Draft construction: An initial version of the rubric was created, aligning theoretical insights with the needs of pre-service science teachers.

3) Expert validation: Three experts in science education and communication reviewed the rubric for content validity, clarity, and relevance. Their feedback was incorporated into revisions. The content validity of the rubric was evaluated by three experts in science education and science communication using the Index of Item-Objective Congruence (IOC). The IOC values for all rubric components ranged from 0.67 to 1.00, indicating that all items were considered relevant and appropriate. In addition, the experts rated the rubric highly in terms of clarity and relevance, and provided minor suggestions regarding wording and descriptor specificity, which were subsequently revised to improve the precision and usability of the rubric.

4) Pilot testing: The rubric was trialed with a small group of students (n = 9) from a previous cohort to check usability, clarity of descriptors, and inter-rater consistency. The pilot testing was conducted with a group of nine students from a previous cohort to examine the usability of the rubric, the clarity of its descriptors, and inter-rater consistency. The results indicated that the rubric was generally practical and applicable for evaluating students' scientific communication writing tasks. Both assessors reported that the rubric could be implemented without difficulty, suggesting satisfactory usability in an educational context.

In terms of clarity, most descriptors were considered clear and comprehensible. However, minor revisions were required to improve the precision of wording and to reduce ambiguity in certain criteria, particularly in

the dimensions of audience, context, and purpose, and organization and presentation. These refinements were made to ensure more consistent interpretation of performance levels.

Regarding inter–rater consistency, initial independent scoring revealed discrepancies in 5 out of 9 cases, mainly in the dimensions of audience, context, and purpose, organization and presentation, and control of syntax and mechanics. These differences were subsequently discussed and resolved through a consensus process, leading to a shared understanding of the rubric criteria. Following this calibration, full agreement between the assessors was achieved, indicating strong inter–rater consistency.

Overall, the pilot testing confirmed that the rubric was suitable for use in assessing science communication writing, while also highlighting specific areas for refinement to enhance clarity and scoring reliability.

5) Finalization: Based on expert input and pilot testing, the rubric was refined and confirmed as the final assessment tool.

Reliability was addressed by using two independent assessors, both experts in science education, with specialization in educational measurement and evaluation as well as science communication, were involved in the scoring process. Inter–rater reliability was established at 1.0 after discussion and reconciliation of initial discrepancies.

Data Collection

Data collection was carried out over a four–week period, from January to February 2025. The process consisted of three main stages.

In the first stage, students were introduced to the learning task and provided with guidelines for developing educational information sheets under Strand 2: Physical Science, Standard Sc 2.1. The objectives, expected outcomes, and assessment criteria were clearly explained to ensure a shared understanding of the task requirements.

In the second stage, students were given one week to independently develop their scientific information sheets. These materials were designed to communicate scientific concepts to non–expert audiences, particularly primary and lower secondary school students.

In the final stage, the completed student work was collected and evaluated using the developed rubric. Two independent assessors conducted the evaluation separately. The initial scores were then compared, and any discrepancies were discussed and resolved through consensus to ensure scoring consistency. The finalized scores were subsequently recorded for data analysis.

Data Analysis

Each participating student produced one educational information sheet designed for a learning activity under Strand 2: Physical Science, Standard Sc 2.1. Students were given one week to complete the assignment.

The completed works were evaluated using the rubric by two independent raters. Initial scoring was compared, and any discrepancies were resolved through discussion until full consensus was reached. The agreed rubric scores were then recorded for analysis.

Descriptive statistics, including frequency distributions and percentages, were used to summarize students' performance across the six rubric dimensions. The analysis focused on identifying overall performance patterns as well as strengths and areas for improvement in students' science communication skills.

The rubric, score distributions, and examples of evaluated work were presented to ensure clarity, consistent formatting, and alignment with the research objectives, as shown in Table 1 and Figure 1.

Results

This study focused on crafting a general communication writing framework for scientific content, often referred to as popular science writing. This type of writing communicates scientific concepts beyond specific scientific communities and aims to promote public understanding of science (Burns et al., 2003). According to the published research by Baram–Tsabari and Lewenstein (2013), seven key aspects of popular science writing were identified: clarity/language, content, knowledge organization, style, analogy, narrative, and dialogue. When compared with the general writing rubric of Columbia Gorge Community College, which outlines six components; (1) Audience, context, and purpose; (2) Content development; (3) Source and evidence; (4) Organization and presentation; (5) Control of syntax and mechanics; and (6) Visual aids, one notable difference was observed. Unlike the rubric by Baram–Tsabari and Lewenstein (2013), the Columbia Gorge rubric does not explicitly include analogy.

For this study, the written communication rubric of Columbia Gorge Community College, originally adapted from the Written Communication VALUE Rubric developed by the American Association of Colleges and Universities under the Liberal Education and America's Promise (LEAP) initiative, was further refined. To address the lack of specific details pertinent to scientific communication, descriptions for each performance level were expanded to better align with the unique requirements of scientific writing. The refined rubric is detailed in Table 1.

When the researcher applied the evaluation criteria to assess students' work individually, it was found that all evaluators reached the same rating level, except for the work of five students out of a total of nine. In these cases, discrepancies arose in the assessment of audience, context, and purpose, organization and presentation, and control of syntax and mechanics. To resolve these differences, the researchers reviewed the scores collaboratively until achieving complete agreement on all ratings (inter–rater reliability = 1). As an example, the researcher provides a sample of a scientific communication information sheet along with the evaluation results and rationale for the scoring, demonstrating alignment in all assessment components. Refer to Figure 1–2 and Table 2–3 for details.

Table 1 Criteria for evaluating science writing communication that is adapted from the written communication rubrics of Columbia Gorge Community College (n.d.).

Criteria	4 (Mastery)	3 (Accomplished)	2 (Developing)	1 (Beginning)	0 (Not Demonstrated)
Audience, context, and purpose	Demonstrate a thorough understanding of science's context, audience, and purpose that is wholly responsive to the assigned task(s) and applied consistently through all elements of the work.	Demonstrate adequate consideration of science's context, audience, and purpose and a clear focus on the assigned task(s).	Demonstrate some attention to science's context, audience, purpose, and to the assigned task(s).	Demonstrate minimal attention to science's context, audience, purpose and to the assigned task(s).	Fail to meet minimum criteria in addressing the audience, science's context, and purpose for writing.

Table 1 (Cont.).

Criteria	4 (Mastery)	3 (Accomplished)	2 (Developing)	1 (Beginning)	0 (Not Demonstrated)
Content development	Use appropriate, relevant, and compelling science content and ideas that illustrate the writer's command and deep understanding of the subject, skillfully shaping the whole work.	Use appropriate, relevant, and compelling science content to accurately explore ideas within the subject and shape the whole work.	Use appropriate and relevant science content to develop and accurately explore ideas through most of the work.	Use appropriate and relevant science content to accurately develop simple ideas in some parts of the work.	Fail to meet minimum criteria in addressing science content development.
Source or/and evidence	Demonstrate skillful use of high quality, credible, relevant sources to develop ideas that are appropriate for the communicated scientific topics.	Demonstrate consistent use of credible, relevant sources to support ideas that are appropriate for the communicated scientific topics.	Demonstrate an attempt to use credible and relevant sources to support ideas that are appropriate for the communicated scientific topics.	Demonstrate an attempt to use sources to support ideas in the communicated scientific topics.	Fail to meet minimum criteria in demonstrating the use of sources to support ideas in the communicated scientific topics.
Organization and presentation	Demonstrate consistent, skillful, and thoroughly detailed attention to organization, presentation, and stylistic choices as appropriate to the communicated scientific topics.	Demonstrate consistent and skillful organization and presentation as appropriate to the communicated scientific topics.	Follow expectations for a consistent system of basic organization and presentation as appropriate to the communicated scientific topics.	Attempt to use a consistent system for basic organization and presentation as appropriate to the communicated scientific topics.	Fail to meet minimum criteria in organization and presentation.
Control of syntax and mechanics	Use graceful language that skillfully communicates in science to readers with clarity and fluency and is nearly error–free.	Use straightforward language that conveys in science to readers with clarity. The language at work has few errors.	Use language that generally conveys in science to readers, although writing may include some errors.	Use language that sometimes impedes in science because of errors in usage.	Fail to use language that demonstrates control of syntax and mechanics.
Visual aids	Visual aids effectively support the communication of purposes and ideas; aids are integrated into the presentation seamlessly, thus fostering a full understanding of the message's science content.	Visual aids generally support the communication of the students' ideas and purposes; the aids effectively amplify or resonate the presentation of ideas and foster a good understanding of the message's science content.	Visual aids support the communication of the students' ideas and purposes but are only partially useful or science informative.	Visual aids do not particularly support the communication of the students' ideas and purpose; they are insufficient to be of much use as they do little to elevate understanding.	Visual aids are virtually non–existent, serve no purpose, or are not credible.

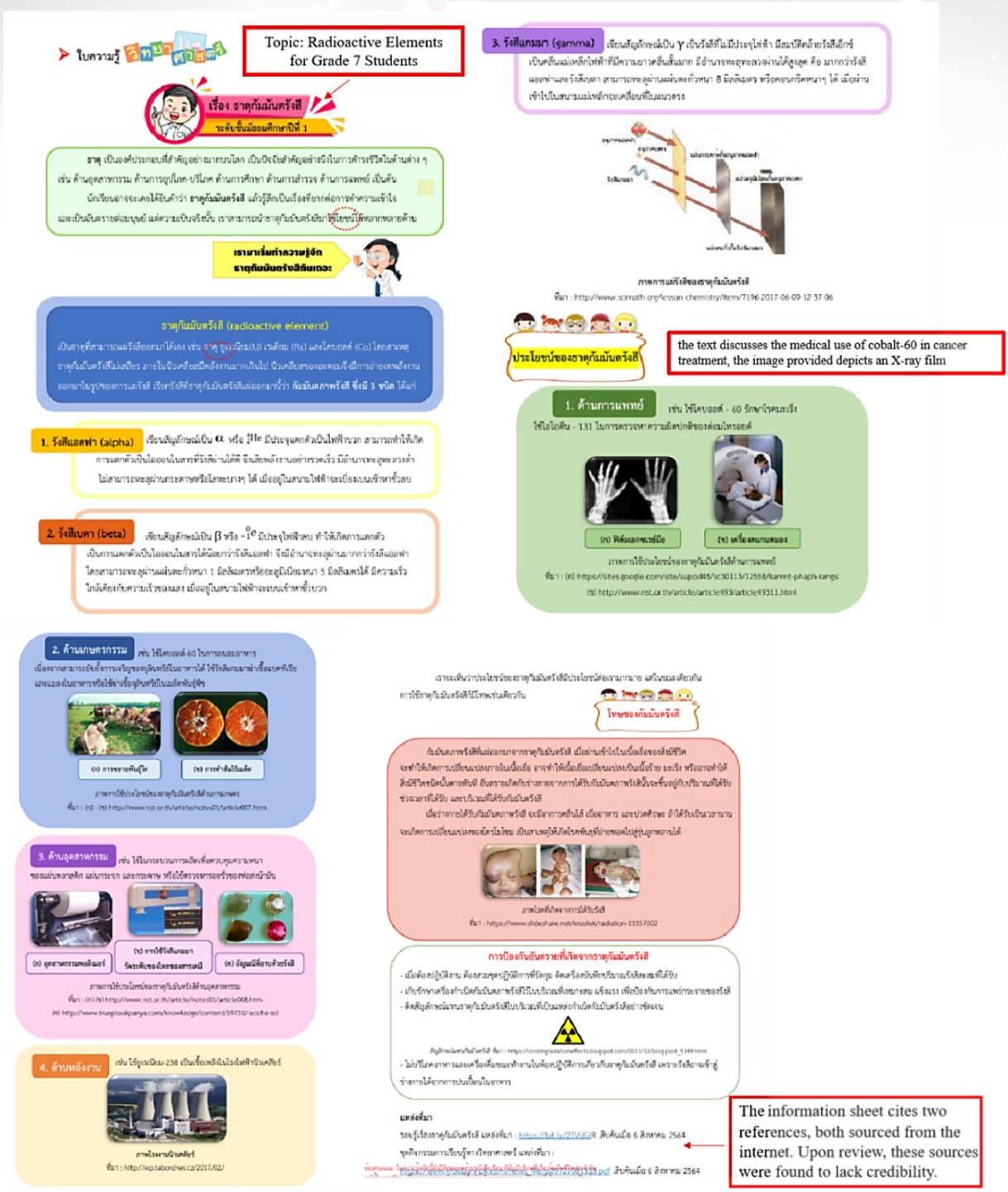


Figure 1 An example of a knowledge information sheet on radioactive substances is presented, containing detailed information on the definition of radioactive elements, the types of radioactivity, the benefits of radioactive elements, the hazards associated with radioactive elements, and measures for radiation protection.

The scores presented in Table 1 represent performance levels based on a five-point rubric scale ranging from 0 to 4, where 4 indicates “Mastery,” 3 “Accomplished,” 2 “Developing,” 1 “Beginning,” and 0 “Not Demonstrated.” The scores were assigned by two independent assessors with expertise in science education, educational measurement and evaluation, and science communication. The final scores reported in the table were agreed upon through a consensus process following independent evaluation.

Table 2 The evaluation results of the work presented in Figure 1, along with the rationale for the assigned scores, are provided.

Audience, context, and purpose	Content development	Source or/and evidence	Organization and presentation	Control of syntax and mechanics	Visual aids
2	2	2	2	2	2

Audience, context, and purpose (Score: 2/4): The information sheet clearly states its title and identifies the intended student audience, which is appropriate. It provides definitions for key scientific terms such as “radioactive element”, “alpha radiation”, “beta radiation”, and “gamma radiation”. It also includes examples of both the benefits and risks of radioactive elements, along with safety precautions. However, the content lacks real–world applications, which limits its relevance and makes it harder for readers to connect the information to practical situations. Content development (Score: 2/4): The scientific content is accurate and suitably explained. However, the material is divided into separate sections without clear links between them. This disjointed structure prevents readers from understanding how the concepts are related. Source or/and evidence (Score: 2/4): The sheet cites two online sources, but these sources lack credibility. Additionally, the images used are not properly cited, which reduces the reliability of the supporting materials. Organization and presentation (Score: 2/4): While the content is organized under clear headings, the lack of integration between sections makes the overall presentation feel disconnected, reducing coherence and logical flow. Control of syntax and mechanics (Score: 2/4): The language used is grammatically correct and communicates the intended meaning. However, some typographical errors are present, which affect the clarity and professional appearance of the sheet. Visual aids (Score: 2/4): The images do not always align with the accompanying text. For example, while the content discusses the medical use of cobalt–60 in cancer treatment, the image shown is of an X–ray film, which does not match the context.

This evaluation highlights areas for improvement in the design and development of educational information sheets, particularly in ensuring contextual relevance, credible sourcing, and alignment between visual aids and textual content.

Figure 2 is the educational information sheet designed to pique readers’ curiosity about the intricate process of sugar production. This process unfolds across five key stages, each critical to ensuring the purity and quality of the final product. These stages include: 1) Remelting; dissolving raw sugar to prepare it for refinement, 2) Carbonatation process; cleaning the syrup and reducing its color through chemical purification, 3) Crystallization; inducing the formation of sugar crystals under carefully controlled conditions, 4) Centrifugating; separating sugar crystals from the remaining syrup using high–speed spinning, 5) Drying; removing residual moisture to produce the final, refined sugar product. The information sheet delves into the science behind sugar crystallization, exploring its definition, the factors influencing it, such as temperature, concentration, and time, and the different types of crystallization processes. Through clear explanations and engaging visuals, this resource aims to make complex scientific concepts accessible and stimulating for learners of all levels.



Figure 2 Example of an educational information sheet on sugar crystallization.

Table 3 presents the evaluation results of a second example of a student-generated scientific information sheet, assessed using the same rubric and scoring criteria as described in Table 2.

Table 3 The evaluation results of the work presented in Figure 2, along with the rationale for the assigned scores, are provided.

Audience, context, and purpose	Content development	Source or/and evidence	Organization and presentation	Control of syntax and mechanics	Visual aids
4	3	3	3	4	2

Audience, context, and purpose (Score: 4/4): The information sheet effectively identifies the target audience by specifying the appropriate grade level for learners. The context is clearly established, linking the sugar production process to the scientific concept of crystallization. This connection provides learners with a practical application of scientific knowledge, enhancing both relevance and engagement. Content development (Score: 3/4): The information sheet introduces scientific knowledge on crystallization by explaining the steps involved in the process and categorizing types of crystallization based on methods used. While the content is informative, it could benefit from further elaboration to deepen understanding. Source or/and evidence (Score: 3/4): The sources of all images used in the information sheet are cited, and references are provided at the end of the document. However, the inclusion of additional reputable sources for the textual content could strengthen the credibility and depth of the material. Organization and presentation (Score: 3/4): The information sheet follows a logical sequence, presenting an overview of sugar, the sugar production process, and an in-depth explanation of crystallization as a key step in the production. The narrative flow is coherent, but the transitions between sections could be improved to create a smoother progression of ideas. Control of syntax and mechanics (Score: 4/4): The language used is grammatically correct and effectively conveys the intended meaning. There is one minor syntactical error, but it does not significantly impact the overall clarity or readability of the text. Visual aids (Score: 2/4): The visuals provided to explain the sugar production process are small and lack sufficient detail. Additionally, there is no clear connection between the five production steps and the corresponding images. Enhancing the quality and integration of visual aids would significantly improve the information sheet's educational value. Overall remarks: The information sheet demonstrates a strong alignment with its educational objectives, providing learners with insights into the scientific principles underlying sugar crystallization. However, to achieve a higher level of excellence, the content could be expanded, the visuals enhanced, and the narrative flow refined to create a more comprehensive and engaging learning resource.

The rubric was first piloted with a group of nine students from a previous cohort. During this pilot test, discrepancies in scoring emerged in the evaluation of five students' work, particularly in the criteria of audience, context, and purpose, organization and presentation, and control of syntax and mechanics. These differences were discussed until consensus was reached, resulting in full inter-rater reliability. The finalized rubric was then applied to the full cohort of 60 students.

Table 4 summarizes the distribution of scores across the six rubric dimensions. The overall trend indicates that students performed relatively well in control of syntax and mechanics (100% at Level 3) and visual aids (91.7% at Level 2). By contrast, the lowest scores were observed in source and evidence, where 86.7% of

students failed to cite credible references, and in audience, context, and purpose, where 95% scored at Level 1, indicating limited ability to situate content in real-life or educationally relevant contexts.

Table 4 Number and percentage of third-year students across each score level based on the scientific communication writing evaluation criteria.

Criteria	Number of students at each evaluation level (percentage)				
	4 (Mastery)	3 (Accomplished)	2 (Developing)	1 (Beginning)	0 (Not Demonstrated)
Audience, context, and purpose	0 (0.00)	0 (0.00)	3 (5.00)	57 (95.00)	0 (0.00)
Content development	0 (0.00)	0 (0.00)	60 (100.00)	0 (0.00)	0 (0.00)
Source or/and evidence	0 (0.00)	0 (0.00)	0 (0.00)	8 (13.33)	52 (86.67)
Organization and presentation	0 (0.00)	9 (15.00)	42 (70.00)	9 (15.00)	0 (0.00)
Control of syntax and mechanics	0 (0.00)	60 (100.00)	1 (11.11)	0 (0.00)	0 (0.00)
Visual aids	0 (0.00)	5 (8.33)	48 (91.67)	0 (0.00)	0 (0.00)

These findings suggest that while students demonstrate strengths in language accuracy and basic use of visuals, they face significant challenges in integrating credible sources and contextualizing scientific information for target audiences.

Conclusion

This study developed and validated a rubric for assessing science communication writing skills, specifically for undergraduate science teacher students. The rubric, adapted from the Columbia Gorge Community College framework and informed by the Dialogic Model of Science Communication, incorporates six dimensions: audience, context, and purpose; content development; sources or/and evidence; organization and presentation; control of syntax and mechanics; and visual aids.

Application of the rubric to 60 student-created information sheets revealed clear trends in students' performance across rubric dimensions. Specifically, students demonstrated strength in linguistic accuracy and basic visual use, whereas they performed poorly in contextualization and credible source citation. These weaknesses indicate that pre-service teachers still approach science writing from a fact-transmission perspective rather than an audience-centered, dialogic approach.

The findings confirm the rubric's utility in highlighting specific areas of weakness that must be addressed in teacher education programs. By focusing on contextualization, source credibility, and visual literacy, rubric

provides a practical tool to support the professional development of science teacher students as effective communicators of scientific knowledge.

Discussion

The findings of this study support the research hypothesis that the development and application of a structured assessment rubric can enhance the evaluation and understanding of students' science communication writing skills. The rubric enabled clear identification of students' strengths and weaknesses across multiple dimensions, particularly in linguistic accuracy, visual representation, contextualization, and source credibility. This confirms that a theoretically grounded and systematically designed rubric can improve both the consistency of assessment and the visibility of students' performance patterns.

However, the results also reveal that students demonstrated uneven performance across dimensions. While most students performed well in terms of control of syntax and mechanics and basic use of visual aids, they showed significant weaknesses in contextualization and the use of credible sources. These findings suggest that, although students possess fundamental writing skills, they still lack the ability to adapt scientific content for non-expert audiences.

This pattern can be explained through the Dialogic Model of Science Communication (Bray et al., 2012; Mulder et al., 2008), which emphasizes the importance of interaction between the communicator and the audience. The students' difficulty in connecting scientific content to real-life contexts indicates a limited awareness of audience needs, reflecting a reliance on a traditional deficit-oriented approach, where information is transmitted without sufficient consideration of audience engagement (Besley et al., 2021). Recent studies have similarly reported that pre-service teachers often struggle to contextualize scientific knowledge and make it meaningful for learners (Amin et al., 2022; Moemeke, 2023).

In addition, the lack of credible source use observed in this study aligns with recent research emphasizing the importance of information literacy which is increasingly critical in the context of widespread online content (McGrew et al., 2018) and source evaluation in science communication (Elvianasti et al., 2022; Taranum, 2021). The high proportion of students who failed to cite reliable sources suggests that they may not yet possess adequate skills in evaluating digital information, which is increasingly critical in the context of widespread online content.

Furthermore, the partial effectiveness of visual aids observed in this study reflects challenges in visual literacy. Although students included images in their work, these visuals were often poorly aligned with the content. This finding is consistent with recent literature indicating that the integration of visual representations requires explicit instruction to ensure that visuals support, rather than hinder, conceptual understanding (Amin et al., 2022; Bobek & Tversky, 2016; Moemeke, 2023).

Overall, the findings highlight that the research hypothesis is partially supported. While the rubric proved effective as an assessment and diagnostic tool, the results indicate that improving students' science communication skills requires not only assessment but also targeted instructional interventions. The rubric, therefore, serves as both an evaluative and pedagogical tool that can guide the development of more effective, audience-centered science communication practices among pre-service teachers.

Suggestions

Practical Implications

The findings of this study provide several practical implications for improving science teacher education and enhancing students' science communication skills.

1. Explicit instruction on contextualization should be integrated into the curriculum. Given that 95% of students performed at Level 1 in the dimension of audience, context, and purpose, instructional activities should be designed to help students connect scientific concepts to real-life situations and learners' everyday experiences. This can be achieved through task-based learning, case-based scenarios, or context-driven writing assignments.

2. Source evaluation and citation skills should be systematically strengthened. As 86.7% of students failed to cite credible sources, teaching strategies should emphasize identifying reliable scientific information, applying appropriate citation practices, and critically evaluating the credibility of online and digital resources.

3. Visual literacy should be explicitly developed as part of science communication training. The findings revealed that visual elements were often misaligned with the content; therefore, instruction should focus on selecting, designing, and integrating visuals that effectively support conceptual understanding and prevent misconceptions.

4. Structured assessor training and calibration should be implemented to ensure consistency and reliability in rubric-based assessment. Providing opportunities for practice scoring and discussion among assessors can enhance shared understanding and improve inter-rater agreement.

Recommendations for Future Research

Future research should further expand and refine the application of the developed rubric to strengthen its contribution to science education.

1. The rubric should be applied in different educational contexts and institutions to examine its adaptability and effectiveness across diverse settings.

2. Future studies could include larger and more diverse samples to enhance the generalizability of the findings and provide a broader understanding of students' science communication abilities.

3. Longitudinal or pre-post research designs should be employed to investigate the impact of rubric-based instruction on students' development of science communication skills over time.

4. Future research may explore additional variables related to science communication, such as students' metacognitive awareness, attitudes toward science writing, or digital literacy, to better understand factors influencing their performance.

5. Further refinement of the rubric through iterative testing and feedback from both instructors and students is recommended to improve its clarity, usability, and effectiveness as an assessment tool.

Original Contribution to Knowledge

This study provides several novel contributions to the field of science education and science communication assessment.

First, it develops a context-specific rubric designed explicitly for evaluating science communication writing intended for non-expert audiences. While existing rubrics primarily focus on academic scientific writing, this study integrates key principles from the Dialogic Model of Science Communication and popular science writing to address the unique demands of public-oriented science communication.

Second, the study offers an empirically validated framework consisting of six dimensions—audience, context, and purpose; content development; sources and evidence; organization and presentation; control of syntax and mechanics; and visual aids specifically tailored for pre-service science teachers. This contributes to a structured and theoretically grounded assessment tool that bridges the gap between scientific accuracy and communicative accessibility.

Third, the findings provide new insights into the specific strengths and weaknesses of pre-service science teachers in science communication writing. In particular, the study highlights a persistent tendency toward fact-transmission approaches, alongside deficiencies in contextualization and source credibility. These insights extend current understanding of how future teachers engage with science communication tasks.

Finally, this study contributes a practical and adaptable assessment tool that can be applied, tested, and further refined in diverse educational contexts. It thus supports both instructional design and assessment practices aimed at developing effective science communicators in the 21st century.

Author Contributions

Nichakorn Pathumrangsan: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Writing – Original Draft.

Kulthida Nugultham: Methodology, Validation, Supervision, Writing – Review & Editing.

Nantarat Kruea-In: Conceptualization, Supervision, Validation, Writing – Review & Editing.

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