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Science Communication Training to Develop Interdisciplinary Communication Competencies in Engineering Students

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Abstract: In an engineering landscape increasingly defined by complex collaborative projects at the cross-sections of various disciplines, the imperative for effective communication across disciplinary boundaries has become a cornerstone of professional competence. Past research establishes a clear consensus from both industry and accrediting bodies that engineers must be capable of communicating with a range of audiences, a skill often lacking in graduates who have taken an engineering programme with traditional curricula. What is lacking is the ability to communicate across disciplines, in other words, interdisciplinary communication competencies. An analysis of different approaches used to build interdisciplinary competencies in engineers revealed that they fell short in building interdisciplinary communication competencies in engineering students. The assumption of these different pedagogical approaches was that engineers should be able to easily communicate across disciplines while remaining firmly embedded within their own disciplinary framework. What they failed to consider was that this 'firm embedding in one's discipline' would become the barrier for an engineer to understand the outlook of other disciplines and develop a vocabulary which would enable them to reach out to stakeholders from other disciplines. How should interdisciplinary communication competencies be developed in discipline-based engineering students? As engineering communication scholars increasingly recognise that successful technical communication cannot be achieved through simple information delivery, this paper proposes a novel four-step science communication training approach for developing interdisciplinary competencies in undergraduate engineering students. The first step was to teach engineering students the art of writing science communication articles for non-technical audiences. The framework and process of writing science communication pieces were taught as part of an academic writing course. In this course, 230 engineering students were taught to translate technical concepts and write a piece for a non-expert audience. Secondly, after they were taught in a workshop-style class session, in small group tutorials, the students were given an opportunity to write science communication pieces on a topic of their choice, ranging from psychology to Gen-AI application, in front of their tutor, who would continually review and give feedback on the writing. The third step was for a science communication expert to review the first drafts and offer three personal sessions of writing mentorship to develop the piece into a publishable final draft. The final step was to pitch the piece to regional newspapers and have them published in the public domain if they met the editorial criteria. Initial findings reveal that engineering students, by taking the science communication training, were able to develop a variety of interdisciplinary communication competencies. Based on these findings, we propose that science communication training is an effective way for developing interdisciplinary communication competencies in engineering students, which enables them to communicate meaningfully beyond their home disciplines.

Keywords:

Interdisciplinary education, Pedagogy, Graduate Studies, Science Communication training

1. Introduction

The complex nature of today's social, economic, environmental and medical challenges extends beyond the traditional image of an engineer's responsibilities [2]. The contemporary engineering profession has moved from a domain of isolated technical optimisation to a practice centred on sociotechnical integration [1]. Educators and industry professionals have highlighted the need for engineering students to develop both professional and technical skills if engagement across communities is to be enhanced [3]. Interdisciplinary communication is a crucial skill that students need to master throughout their higher education. Developing educational strategies to build these competencies has become a high priority for higher education institutions [4]. This paper argues that structured, iterative Science Communication (SciComm) training is an effective way to develop interdisciplinary communication competencies. By training students to explain their technical home disciplines to the public, we equip them with the audience-centric mindset required to translate specialised knowledge and communicate it between internal engineering departments, thereby bridging the gap between department-specific registers of vocabulary.

2. Siloisation of engineering and the need for Interdisciplinary communication

Despite having a common founding in science and mathematics, there seems to be little that unites different specialisations of engineering. Furthermore, due to its double binding ties to the two "worlds of science and practice" [5], engineering as a profession and academic discipline has developed a "Janus-faced nature" [6]. The Scientific Orientation originated with the *École Polytechnique* during the French Revolution. It established the discipline of engineering as an applied science with a focus on "book learning" [5]. Across the Atlantic, in the USA, "as early as 1795, a crude form of engineering was being taught in the town of West Point even before the military academy was set up." By 1819, West Point started modelling itself after *École Polytechnique.* In 1850, Brown, a Baptist college, joined pioneering American schools like West Point and the University of Virginia by offering its own engineering degree, structured in the tradition of *École Polytechnique.* The program at Brown was started by Prof. William Norton, a member of the West Point faculty [24]. Simultaneously, with nations focusing on territorial unification in the late 18th and early 19th centuries, engineers became increasingly important for national plans. This political orientation of the engineering discipline shifted an engineer's role to that of a technical maestro contributing to the fortification of a nation's critical infrastructure and construction of roads, canals and shipbuilding [7]. The 19th Century saw the market emerge in direct opposition to the scientific academic model. Driven by the Industrial Revolution, this "shop culture" created a consistent dual nature in the curriculum. Numerous European regions witnessed the development of Technical Universities to boost economies [8]. Following World War II, the political orientation of the engineering discipline evolved into policy making and advising technical leaders who would "serve the civil society with results" [9]. By the 1960s and 1970s, a "Social Orientation" arose in engineering education in response to civil movements. This resulted in ethics and liberal arts courses being introduced into the engineering curriculum, thus attempting to humanize the "technically competent barbarians" produced by the strict siloisation of the past centuries [10]. This necessitated and required a vibrant training in Interdisciplinary communication, which would be the essential mechanism required for engineers to engage and collaborate beyond their discipline in solving complex, real-world challenges often described as "wicked problems" [11].

3. The move towards Interdisciplinary communication

Interdisciplinary communication in engineering education has progressed from fragmented attempts at competency building to an integrated model. This evolution can be traced through changes in administrative structures, cultural forces and pedagogical innovations in different engineering disciplines. Historically, engineering education followed an "ad-hoc path" where technical and professional competencies were strictly separated and no understanding of how learning occurs in the other disciplines [3]. In this traditional structure, communication skills were taught as language modules by departments like Humanities as a "service subject". This pushed communication to the periphery of "hard core" engineering curricula [12]. Early attempts to address this involved multidisciplinarity, defined as the "mere juxtaposition" of disciplines [13]. This approach maintains disciplinary boundaries, rather than breaking them. The evolution towards interdisciplinary communication has been hindered due to conflicts regarding the interpretation of knowledge in different disciplines. MacIntyre held that interdisciplinary communication can only happen if "one learns the language of another discipline from within as a second-first language." To overcome these barriers, engineering education is shifting towards an interdisciplinary integration.

4. Interdisciplinary approaches in engineering education

Over the past 40 years, communication for engineering has been buffeted by several factors, including *Writing Across Curriculum/ Writing in Discipline* programs, growth of technical writing as a standalone discipline and accreditation criteria which require engineers to have communication competencies [1]. To bridge the gap between technical expertise and collaborative demands of the Industry 4.0, engineering education has increasingly adopted Outcome-Based Education (OBE) to prioritize visible competencies like communication which would directly influence employability and professional project success [15]. This theoretical shift is operationalised using curricular frameworks such as CDIO (Conceive-Design-Implement-Operate), which move beyond the mere juxtaposition of subjects by weaving professional and technical skills through the models on "block" and "link" [16]. These frameworks have aimed to cultivate "T-shaped" professionals who combine disciplinary knowledge with the horizontal ability to collaborate across disciplines developed through vertical capstone projects. A "T-shaped" engineering professional would be someone whose strength of disciplinary expertise (the vertical axis of the "T") is coupled with the ability to value and work with a broad range of people and situations (the horizontal axis of the "T") [2]. To ensure that the interdisciplinary interventions do not devolve into the "service subject" model of the 20th century, institutions implemented structural innovations like Joint Appointments. For example, communication faculty take up positions within engineering departments to cultivate a "dialogic environment" for negotiating *meaning* [14]. This structural and curricular evolution culminated in the widespread use of Project-Base Learning (PBL) as an experiential pedagogy. Engineering students are forced to integrate their disciplinary knowledge with others to solve open-ended, real-world problems [2,17].

5. Limitations of the current efforts

Despite these efforts, critical limitations remain that hinder the development of true interdisciplinary communication competencies. Students often struggle to value the contribution of other fields, a phenomenon known as "disciplinary egocentrism." This leads students to focus solely on technical aspects arising from their own discipline while ignoring the sociotechnical "whole" of a problem [18]. An analysis of 81 Science Communication course curricula by Vickery et al. in their 2023 paper found that the majority of the Science Communication training (40.7%) still view the public as a monolith lacking scientific facts. The 39.5% trainings which adopt a "Dialogue Model" improves upon the previous approach by encouraging bidirectional engagement, yet limiting itself to the author's (scientist's or an engineer's) goals [25]. Moreover, curricular frameworks assume that the integration happens naturally if students are simply allowed to be a part of multidisciplinary teams [19]. However, we argue that building interdisciplinary communication competencies requires "intentional pedagogical support" for students to translate knowledge across disciplines [20]. Students often operate under the false belief that proving technical soundness requires dense use of home-disciplinary jargon. But multiple studies from 1994 to 2020 found that the presence of jargon interferes with a reader's ability to process information, even when definitions of these terms are provided [21]. Research on interdisciplinary communicative competencies underscores the centrality of *linguistic skills* as a critical predictor of effective communication across disciplinary boundaries. Science communication educational research emphasises the need to negotiate and integrate vocabularies from diverse epistemic traditions [22]. Narrative structuring of information enhances comprehension and recall. The structure of a written piece of information, which is structured, emphasising causality and temporal sequence, aids understanding [23].

6. A four-step Science Communication training framework

We propose a novel four-step science communication training approach for developing interdisciplinary competencies in undergraduate engineering students. The first step was to teach engineering students the art of writing science communication articles for non-technical audiences. The framework and process of writing science communication pieces were taught as part of an academic writing course, Integrated Communication for Engineers-I (ICE-I). In this course, 230 engineering students, enrolled in a B.Tech program at Plaksha University were taught to translate technical concepts and write a piece for a non-expert audience. Secondly, after they were taught in a workshop-style class session, in small group tutorials, the students were given an opportunity to write science communication pieces on a topic of their choice, ranging from psychology to Gen-AI application, in front of their tutor, who would continually review and give feedback on the writing. The third step was for a science communication expert to review the first drafts and offer three personal sessions of writing mentorship to develop the piece into a publishable final draft. The final step was to pitch the piece to regional newspapers and have them published in the public domain if they met the editorial criteria. Furthermore, in partnership with the Springer Nature publishers, University set up an online portal whose editorial board consisted of Subject Matter Experts from both, the University and the Springer Nature. Thus, the editorial boards of both the regional newspaper dailies and the Springer Nature online portal served as the external evaluators of the Science Communication pieces. This is in line with the 2023 work of Vickery et al. where they impress upon the need for external mechanism of evaluating publication efficacy.

7. Specifications of the intervention

This Science Communication training was designed to equip undergraduate engineering students with the ability to explain principles from their domains clearly, accurately, and meaningfully to the lay public who are equal stakeholders in their ongoing and future projects. Students learnt to simplify, narrate and adapt complex information into engaging content that remains true to students' domains. Unlike traditional academic and technical writing interventions, this training emphasised creativity, storytelling, structure and clarity. Students created three full-length articles of about 1000 to 1200 words each, written in different formats and for various audiences. Every article went through internal stages of drafting, feedback, and revision, after which the articles were validated by an independent team of editors of a regional newspaper. Through this hands-on approach, students learnt how to identify key messages, communicate technical knowledge while shaping a compelling narrative and presenting *science* to inspire the lay public to engage with the engineering disciplines.

Critically, it is the "horizontal bar" (discussed in Section 4), the translational, audience-centric dimension, that this Science Communication training directly targets. By requiring engineering students to re-encode their specialist home-discipline knowledge for a non-expert public readership, Science Communication training builds the vocabulary-bridging and perspective-taking capacity in an engineering student.

7.1 Training Outcomes required a student to:

1. Create a Science Communication Piece, ready for publishing.
2. Understand the core principles and ethics of interdisciplinary communication.
3. Interpret and translate discipline-specific concepts into language accessible to their audience.
4. Adapt cross-disciplinary vocabulary
5. Incorporate feedback to revise and improve the clarity of motivation, sharpen the narrative, and accuracy of *meaning-making*.
6. Critically assess how communication choices shape public understanding and trust in science.
7. Reflect on communication strategies to continuously increase the impact of the article, improve its credibility, and increase audience engagement.

8. Data Collection and Data Analysis

Over the course of this intervention, 230 students took part in Science Communication training. Out of the 230 students, only 172 students were able to produce a competent science communication script that satisfied the requirements of the internal Science Communication expert. It is interesting to note that only 54 of the 172 scripts met the criteria of the external editorial boards of the Springer online portal and the regional dailies. Of these 54 articles, 42 got published in regional dailies and 12 on the Springer online portal. These 54 articles served as the data which were analysed for the purpose of this research.

Each of these 54 articles had two scores each. The first score or the baseline score was assigned after the evaluation of the first draft submission. The student authors worked with the science communication mentor, and the draft went through multiple rounds of editing before the submission of the final draft. The final draft was scored as well. Both first and final submissions were assessed on the same 5 parameters given below (Section 8.1).

Publication acceptance by the editorial boards of the Springer Nature online portal and regional dailies is treated in this study as external validation of the internal rubric's construct validity, rather than as summative assessment or a standalone proxy outcome. The summative assessment instrument for this study is the five-marker rubric applied by the Science Communication expert. (Section 8.1), which produces criterion-based scores for each article. Publication acceptance, an editorially-determined judgement made by independent evaluators with no stake in the intervention, provides a complementary form of evidence: it confirms that the competencies the rubric identified and the mentorship developed were sufficient to meet real-world interdisciplinary communication standards outside the classroom. This approach aligns with the call by Vickery et al. for external mechanisms to evaluate the publication efficacy of science communication training.

8.1 Internal Review Metrics

The Internal review by the Science Communication expert was carried out based on the following metrics. These metrics were borne out of the **five markers** of an effective Interdisciplinary piece we narrowed down while reviewing Science Communication literature.

1. Accuracy and Scientific Integrity (25%): The translation of technical knowledge into non-technical or cross-disciplinary equivalents without compromising the core scientific meaning.
2. Clarity and Accessibility (20%): The strategic removal of "home-discipline" jargon and its replacement with vocabulary that bridges knowledge gaps.
3. Structure and Coherence (20%): Emphasizing temporal sequencing to organize the information in a manner that presents the evolution of conceptual or technical understanding in a storyline.
4. Engagement and Readability (15%): The use of techniques such as analogies and narrative hooks to manage readability and the burden of information overload for the reader.
5. Relevance and Context (20%): The framing of scientific information to answer the audience's "*So What?*" question to connect engineering topics to shared value and the everyday concerns of specific stakeholders.

8.2. Data Analysis of articles published on the Springer online portal

Of the 54 articles, 12 were chosen by the Springer online portal's editorial board. The analysis of these 12 articles reveals the following insights:

1. The articles selected for the Springer online portal achieved a mean final score of 78.8/ 100. This was comparatively higher than the mean score of the 42 articles chosen by the regional dailies (68.89/100). This indicates that the Springer Nature team's selection process was stringent and more rigorous than the regional dailies.
2. The data shows that the Springer online portal editorial board did not choose merely "naturally talented writers" as several chosen articles exhibited massive growth through the mentorship phase:
    a. The highest scoring article, *Article 2*, jumped from a baseline of 49/100 to 94/100.
    b. Another high-scoring article, *Article 6,* showed an improvement from 42/100 to 94/100, a significant increase of 52 points.

This suggests that the mentorship intervention was significantly effective.

3. The Springer online portal selection appears heavily weighted towards *Structure and Coherence* and *Accuracy and Scientific Integrity.*
   a. *Structure and Coherence:* The top four articles achieved a near-perfect score of 19/20 in this parameter. This shows that the Springer Nature team valued articles with a logical narrative flow. (Figure 1)

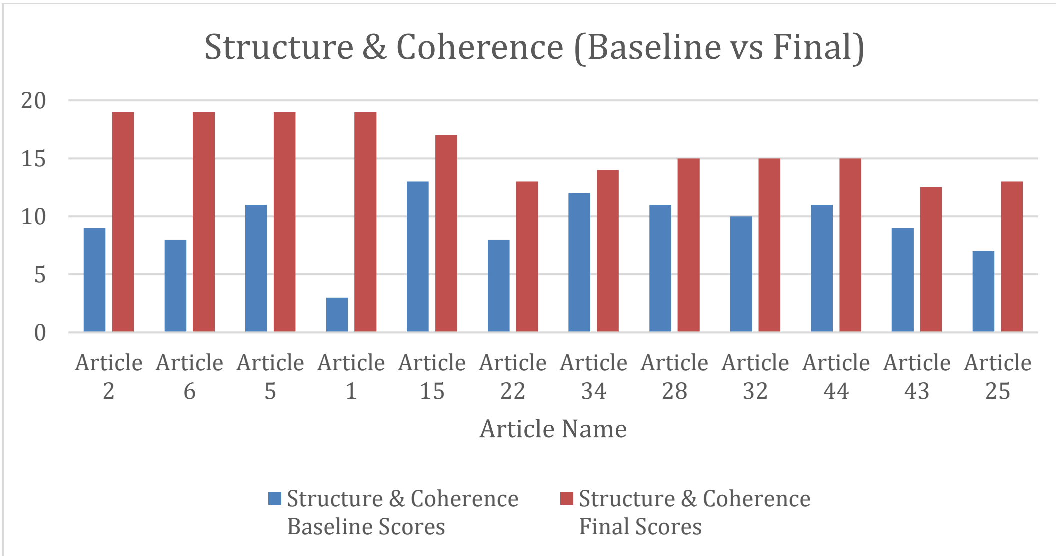

Figure 1: Structure and Coherence of the Springer online portal articles (Baseline Score vs Final Score)

   b. *Accuracy and Scientific Integrity:* The Springer online portal team paid greater attention to the efficacy of the technical-vocabulary translation from the "home discipline" to that of the target audience. In this parameter, the Springer online portal articles' final scores were consistently high with articles reaching 20-24 out of 25 marks. (Figure 2)

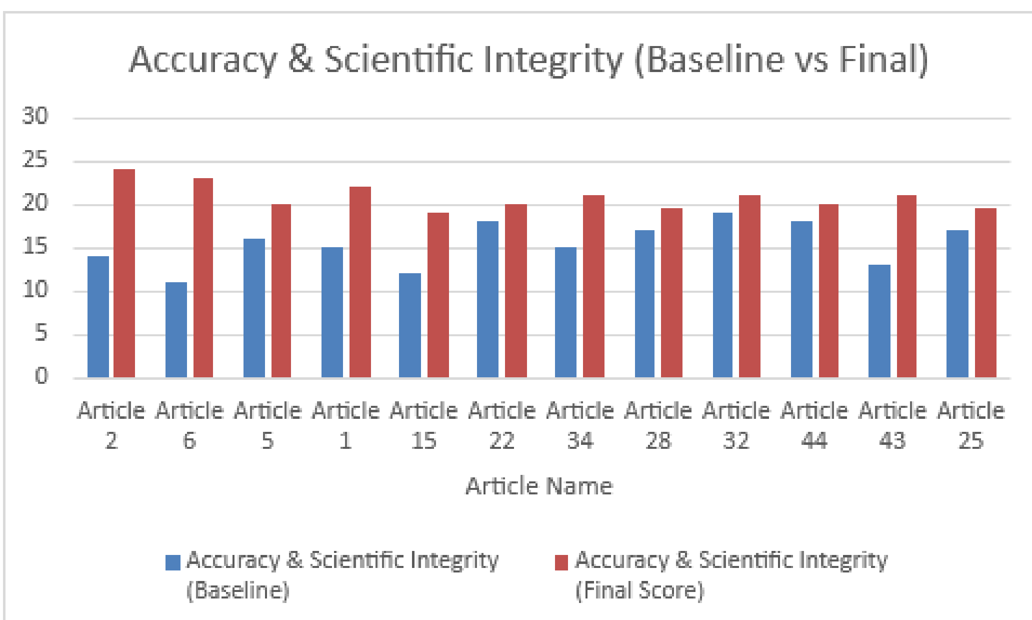

Figure 2: Accuracy and Scientific Integrity of the Springer online portal articles (Baseline Score vs Final Score)

8.3. Data Analysis of the articles published in the regional dailies

An analysis of the scores for the 42 articles selected for Regional Dailies, the following data insights emerged:

1. The 42 articles regional dailies achieved a mean Final Score of 68.89/100. This marked a significant improvement of 18.2 points from the mean Baseline score of the 42 articles (50.69/100).
2. The highest growth from baseline to Final submission was seen in the following two parameters: *Clarity and Accessibility* and *Relevance and Context.*
    a. *Article 14* demonstrated highest growth amongst the regional daily articles, specifically an increase from 4/20 to 17.5/20 in *Clarity and Accessibility* and from 4/20 to 18/20 in *Relevance and Context.*
    b. *Article 30* followed a similar trajectory, moving from a Baseline score of 4/20 to 17/20 in *Relevance and Context.*

These significant improvements, particularly on these two parameters, demonstrate that the newspaper publications are primarily looking for an author's ability to translate their technical understanding such that it answers the *"So What?"* question of the audience in a vocabulary suitable for the said audience.

9. Results and Findings

The score distribution indicates consistent high performance by students who underwent the science communication training and mentorship. They demonstrated their ability to translate technical vocabulary of their "home discipline" to the target popular language of their audience. From the data analysis, this research presents students' ability to translate their technical knowledge into the language of the target audience as evidence of interdisciplinary communication competencies developed in students.

Across all five assessment markers in all 54 externally validated articles (Table1), the mean aggregate baseline score was 50.50/100, which improved to a mean aggregate final score of 71.08/100. This was an absolute gain of 20.58 scores, representing an overall improvement of approximately 40.74%. At the marker level, the highest proportional gains were recorded in Relevance and Context (+61.05%), Structure and Coherence (+55.54%), and Clarity and Accessibility (+54.36%), demonstrating that the mentorship intervention was most transformative in precisely the competencies central to interdisciplinary communication: stripping home-discipline jargon [21], structuring knowledge as accessible narrative [23], and connecting technical content to the stakeholder's "So What?" question. The comparatively modest gain in Accuracy and Scientific Integrity (+19.05%) reflects that students entered the intervention with a relatively stronger baseline in their technical home domain, consistent with what Borrego and Newswander [4] identify as "disciplinary grounding" as a pre-existing strength in engineering graduate education.

The Five Markers	Average Baseline Score	Average Final Score	Delta (%)
Accuracy & Scientific Integrity (25)	13.75	16.37	19.05
Clarity & Accessibility (20)	8.61	13.29	54.36
Structure & Coherence (20)	9.29	14.45	55.54
Engagement & Readability (15)	9.48	11.88	25.32
Relevance & Context (20)	9.37	15.09	61.05

Table 1: Average Scores of each competency at Baseline and Final Submission of the 54 externally validated articles

The results of the data analysis show that students who began with the lowest baseline scores made the greatest improvements after the mentorship intervention, thus demonstrating that the intervention was particularly effective for students with the weakest communication competencies.

A gain of nearly 40% spread across students of varying baseline interdisciplinary communication competencies through a single course-embedded intervention demonstrates that interdisciplinary communication competency is not a trait of naturally gifted writers alone but a measurable skill, teachable within resource constraints of an existing course.

The 54 science communication articles written by engineering students not only met the criteria of the Science Communication expert but also were accepted for publishing in both the Springer online portal and regional dailies, which is evidence that the science communication mentorship intervention was successful in helping student authors translate complex scientific concepts and ideas into the vocabulary register of the common informed reader. This publishing acceptance is evidence that the students who took this course have now learnt the art of effective interdisciplinary communication of technical knowledge to other stakeholders. This distinguishes the intervention from internally graded writing assessments and strengthens confidence in the generalisability of the competency gains observed.

10. Discussion

A key advantage of this Science Communication training model over existing interdisciplinary-competency building approaches such as Joint Appointments, CDIO restructuring, or dedicated PBL programmes, is that it does not require significant institutional restructuring. It is designed to be delivered within an existing academic writing course, using the institution's existing tutor network, and scaled incrementally rather than through systemic overhaul. Three conditions support its replicability, scalability and sustainability. First, faculty involvement need not take the form of new appointments. Faculty from students' home disciplines and from the disciplines of their intended audiences (public health, environmental science, social science etc.) can be invited on a voluntary basis to contribute feedback during a single session per cohort in the drafting stage. This provides students with authentic cross-disciplinary perspectives without creating new administrative roles. Over time, this informal cross-faculty exchange can evolve naturally into shared pedagogical norms consistent with what Wenger [26] describes as a community of practice: a self-sustaining mechanism for sharing best practices that requires institutional support but not institutional restructuring. Second, the external publisher partnership, which for this study were Springer Nature and regional newspaper dailies, is the element most critical to sustainability and requires no new hires. It requires a one-time institutional agreement that, once established, provides a renewable external editorial standard for successive cohorts. Third, regarding the inaccessible usage of LLMs by students; in this intervention, students were permitted to use AI tools for research, that is sourcing literature and developing conceptual understanding of their target discipline, but all writing was required to be students' own. This distinction is pedagogically essential. The cognitive act of translating specialised knowledge into a lay register is precisely the interdisciplinary competency this training model builds, delegating this to an LLM would hollow out the intervention entirely. No LLM-for-writing compliance was maintained through two independent layers: during science communication expert's internal reviews of students' drafts and the AI protocols adopted by the external editorial boards themselves**.**

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