



English-Related Curricula as Sites of Geoscience Communication: Earth-System Sustainability and the Emerging Visibility of Space Sustainability in 15 Asian Universities

Weihua Zhao¹, Li Zhang¹, Lei Wei²

5 ¹ School of Liberal Arts, Suzhou Centennial College, Suzhou, 215000, China

²Department of Research and Information Technology, Suzhou Centennial College, Suzhou, 215000, China

Correspondence to: Weihua Zhao (zhaowh@scc.edu.cn)

Abstract. This study examines English-related curricular provision and its public documentary representation as potential infrastructure for geoscience communication in Asian higher education. Using comparative document analysis, it analyses 19 domain-bearing curricular segments and three contextual language-policy records linked to 18 official source documents from 15 selected research-intensive universities across Mainland China, Singapore, Japan, Hong Kong SAR, South Korea, and India. Among the 19 curricular segments, 3 were coded as Direct, 3 as Direct-adjacent, 13 as Adjacent, and none as Indirect. SEG-022 was coded as Adjacent and additionally marked with a cross-cutting Space-related exploratory flag. Communicative framing was identifiable in only four segments: three were dissemination-oriented and one showed dialogue through explicit peer collaboration; no segment documented participation through co-production, shared decision-making, or sustained public or stakeholder involvement. The remaining 15 segments were coded as Not identifiable. Earth-system, climate, ocean, environmental, geospatial, and sustainability-related knowledge is widely visible, but explicit English-mediated geoscience communication remains uncommon. Most evidence represents English-medium disciplinary access or an English-language documentary or institutional interface rather than audience-aware communication learning. Space sustainability remains weakly evidenced and is treated as an exploratory boundary case rather than an established curricular domain. The study therefore distinguishes curricular visibility from communicative transformation and shows how public curriculum documents can identify potential, but not actual classroom enactment or learning outcomes.

1 Introduction

Asia's Earth-system sustainability challenges form the primary focus of this study, while near-Earth orbital sustainability is treated as an emerging boundary case. The region is warming faster than the global average and has experienced intensified heat, climate-related hazards, glacier loss, record ocean heat, and widespread marine heatwaves (World Meteorological Organization, 2026). At the same time, the near-Earth orbital environment is becoming increasingly crowded, with about 40,000 objects currently tracked, including about 11,000 active payloads (European Space Agency, 2025). These developments show that climate change, Earth-system transformation, and emerging orbital risks are no longer confined to



30 specialist scientific communities. These developments create growing demands for public interpretation, cross-disciplinary communication, and audience-aware science communication (Besley and Dudo, 2022; Illingworth, 2023; Onstad and van der Flier-Keller, 2025). This study therefore shifts attention from outreach and public engagement to formal curriculum as a possible institutional site where future professionals and communicators may begin to interpret and mediate geoscientific knowledge.

35 This curricular perspective matters because geoscience communication may be shaped before learners enter outreach, policy, media, or stakeholder-engagement settings. Formal curricula select what counts as teachable knowledge, determine how scientific complexity and uncertainty are organized, and position learners in particular communicative roles. From this perspective, geoscientific knowledge is not simply transferred from disciplinary domains into classrooms; it is recontextualized through pedagogic discourse, institutional priorities, learning outcomes, tasks, and genres (Bernstein, 1990, 40 2000; Hordern, 2021). Climate change, for example, may be presented as technical knowledge to be mastered, a social issue to be discussed, a policy problem to be explained, or a public concern requiring accessible communication. These choices influence whether learners are positioned primarily as recipients of scientific information, disciplinary interpreters, academic presenters, professional mediators, or public science communicators.

This issue is particularly relevant in internationalized Asian higher education. English-medium instruction has expanded 45 across the region in connection with higher-education internationalization and changing language-in-education policies (Dearden, 2014; Fenton-Smith et al., 2017). English-medium courses, ESP-oriented modules, academic communication training, sustainability-related language learning, and English-facing programme descriptions may therefore provide spaces in which geoscience and Earth-system sustainability are encountered by non-specialist or cross-disciplinary learners. The Asian context is analytically important because substantial exposure to climate and environmental risk (World 50 Meteorological Organization, 2026) coincides with expanding English-medium provision and increasingly internationalized higher education (Fenton-Smith et al., 2017). Asian universities thus provide a useful context for examining where Earth-system knowledge, English-mediated curriculum, and emerging Earth–Space concerns intersect.

However, the presence of English or sustainability content should not be equated with geoscience communication. Research on English language teaching shows that environmental and SDG-related themes increasingly appear in textbooks, 55 classroom innovation, teaching materials, and curriculum design (Brown, 2024; Cordova, 2024; Liu et al., 2024; Yu et al., 2024; Dhanyamol and Sethunarayanan, 2025). Yet thematic inclusion does not necessarily involve communicative transformation. Geoscience content may remain disciplinary knowledge delivered through English, or it may be further reshaped into communication for academic, professional, policy, stakeholder, or public audiences. The analytical issue is therefore not simply whether sustainability is visible, but how specialist knowledge is selected, reorganized, and 60 communicatively framed within English-related curricular provision.



Geoscience communication research provides a useful basis for examining this distinction. Rather than being understood only as one-way transmission from experts to passive publics, geoscience communication can be conceptualized along a spectrum from dissemination to dialogue and participation (Illingworth, 2023). These orientations can also be operationalized through content analysis to examine how scientific knowledge is framed, how audiences are imagined, and what roles are assigned to communicators and publics (Onstad and van der Flier-Keller, 2025). Applied to curriculum, this raises a specific question: when Earth-system and sustainability knowledge enters English-related provision, is it organized primarily as disciplinary knowledge to be transmitted, as an issue to be interpreted and discussed, or as a basis for audience-aware communication?

Existing research leaves this curricular question underexamined. Sustainability-oriented ELT has demonstrated the growing visibility of environmental and SDG themes, while geoscience communication research has examined how Earth-system knowledge is communicated in public contexts. What remains less clear is whether university curricula connect these two processes by transforming domain-specific geoscience knowledge into English-mediated genres, learner roles, and communicative tasks. This gap is especially relevant for space sustainability. Space science, satellite technologies, remote sensing, and planetary topics may be visible in university curricula, but such visibility should not be treated as evidence of space-sustainability communication unless issues such as orbital environments, debris, governance, responsible space use, or related public risks are explicitly recontextualized. Space sustainability is therefore treated here cautiously as an exploratory sub-domain rather than as a mature curricular field.

To address this gap, the study conducts a comparative document analysis of English-related curricular provision and its public documentary representation in 15 selected research-intensive universities across six Asian higher-education systems or jurisdictions: Mainland China, Singapore, Japan, Hong Kong SAR, South Korea, and India. It examines how geoscience and Earth-system sustainability are made visible and potentially communicable in publicly available course descriptions, programme materials, syllabi, learning outcomes, and related curricular documents. Guided by recontextualization theory and geoscience communication models, the study asks:

1. How do selected research-intensive Asian universities recontextualize geoscience and Earth-system sustainability into English-related curricular provision, and to what extent is space sustainability visible as an exploratory sub-domain?
2. Where communicative framing is identifiable, how are these curricular forms represented along a continuum from dissemination to dialogue and participation?
3. What English-related mechanisms and learner roles are represented, when these can be identified?

The study contributes to geoscience communication research in three ways. First, it extends analysis beyond outreach and public-engagement settings by examining curricular provision and its public documentary representation as a potential preparatory site for communication. Second, it distinguishes English-language documentary visibility, English-medium



disciplinary access, and English-mediated geoscience communication as analytically different forms. Third, it develops a document-analysis framework for identifying when geoscience-related sustainability moves from curricular visibility toward audience-aware roles and communicative tasks. Applied linguistics and ESP/genre research are used as analytical resources, but the primary concern remains whether public curricular documents specify the transformation of Earth-system knowledge for identifiable audiences and purposes.

2 Literature review

2.1 Geoscience communication and curricular recontextualization

Geoscience communication is increasingly understood not as the one-way transmission of expert knowledge to passive publics, but as a spectrum of communicative relations ranging from dissemination to dialogue and participation (Trench, 2008; Illingworth, 2023). This shift foregrounds how audiences are imagined, how scientific uncertainty is explained, and how publics may be positioned as receivers, interpreters, discussants, or co-participants in knowledge-making (Trench, 2008; Illingworth, 2023). Recent empirical work further shows that deficit, dialogue, and participatory models can be operationalized through content analysis of geoscience communication practices, making them useful categories for examining how geoscientific knowledge is framed across institutional and public contexts (Onstad and van der Flier-Keller, 2025).

For curriculum analysis, this communicative perspective needs to be connected with theories of curricular recontextualization. Geoscientific knowledge does not enter curricula in its original disciplinary form; it is selected, simplified, reorganized, and reframed for particular learners, pedagogical purposes, and communicative situations (Bernstein, 2000; Shay, 2016). In Bernstein's terms, curriculum is a recontextualizing field in which disciplinary knowledge is relocated into pedagogic discourse and made teachable through institutional selection and transformation (Bernstein, 2000). Shay's work on curricula at disciplinary boundaries further highlights how curriculum is reshaped as knowledge moves across disciplinary, educational, and professional contexts (Shay, 2016).

This perspective is directly relevant to English-related curricula. If English-medium courses, ESP modules, academic communication training, or sustainability-themed language courses include Earth-system issues, their significance does not lie only in the presence of environmental content. The key question is whether specialist geoscientific knowledge is transformed into audience-aware explanation, public-facing genres, communicative tasks, and learner roles (Belcher, 2006; Hyland, 2008; Illingworth, 2023). Genre and ESP research is therefore important because it shows how disciplinary knowledge is mediated through communicative purposes, imagined users, rhetorical conventions, and future professional or academic needs (Belcher, 2006; Hyland, 2008). Taken together, geoscience communication theory, recontextualization theory, and genre/ESP research provide a framework for examining English-related curricula as possible preparatory spaces for geoscience communication.



2.2 Sustainability-oriented ELT and the underexamined geoscience dimension

Sustainability has become increasingly visible in English language teaching and related curriculum research. Recent reviews show that sustainability-oriented ELT has developed through empirical studies, theoretical discussion, textbook analysis, issue-based pedagogy, project-based learning, and SDG-oriented curriculum innovation (Yu et al., 2024; Dhanyamol and Sethunarayanan, 2025). Yu et al. (2024) identify a growing body of sustainability-related ELT research between 2013 and 2023, while Dhanyamol and Sethunarayanan (2025) show that studies published between 2018 and 2024 have addressed environmental sustainability through diverse pedagogical strategies and regional contexts. This literature demonstrates that English-related education can mediate sustainability issues for language learners and support awareness, discussion, and classroom engagement with global challenges.

However, this literature rarely examines geoscience-specific communicative transformation. Sustainability is often framed through broad categories such as the SDGs, environmental awareness, ecological values, global citizenship, and issue-based learning, rather than through the transformation of Earth-system knowledge into communicative roles, genres, and tasks (Cordova, 2024; Yu et al., 2024; Dhanyamol and Sethunarayanan, 2025). SDG integration can provide contexts for meaningful, issue-based learning and student engagement (Cordova, 2024), while SDG-oriented EFL curriculum research identifies concerns related to topic suitability and linguistic difficulty (Mack and Downs, 2026). The present study therefore examines sustainability-related English education not simply for thematic presence, but for evidence of communicative transformation.

2.3 Asian evidence and the need for comparative curricular analysis

Asian research confirms both the growing visibility and the limits of sustainability in English-related education. In China, Liu et al. (2024) show that environmental sustainability has entered widely used university English textbooks. In Japan, SDG-oriented EFL research highlights learner engagement as well as concerns about topic difficulty and curricular fit (Mack and Downs, 2026), while Brown (2024) identifies sustainability norms embedded in the hidden curriculum of English teaching materials. In the Philippines, Cordova (2024) shows how SDGs can be integrated into English language and literature teaching through issue-based learning and student engagement. Collectively, these studies demonstrate the increasing presence of sustainability-related issues in Asian English education, but they remain concentrated on textbooks, classroom practices, SDG-oriented pedagogy, hidden curriculum, and teacher or learner perspectives.

What remains less examined is how universities publicly organize English-related curricular provision around domain-specific geoscience communication across institutional systems. Taken together, these studies provide limited cross-institutional evidence on whether English-related sustainability curricula explicitly transform domain-specific scientific knowledge into audience-aware communicative roles, genres, and tasks (Brown, 2024; Cordova, 2024; Liu et al., 2024; Yu et al., 2024; Dhanyamol and Sethunarayanan, 2025; Mack and Downs, 2026).



Genre/ESP and geoscience communication research nevertheless provide analytical resources for identifying such
155 transformation through communicative purposes, audience orientation, genre, dialogue, and participation (Belcher, 2006;
Hyland, 2008; Illingworth, 2023; Onstad and van der Flier-Keller, 2025). The key gap is therefore not whether sustainability
appears in English-related education, but whether English-related curricula transform geoscience knowledge into
communicative roles, genres, and tasks.

This distinction is important because Earth-system sustainability and space sustainability are not treated as equivalent
160 domains. Earth-system sustainability refers to established geoscience-related concerns such as climate change, oceans,
hazards, environmental systems, and sustainability science. Space sustainability is treated more cautiously as an exploratory
sub-domain and emerging boundary case, used to test whether English-related curricula are beginning to recontextualize
near-Earth orbital issues, space debris, satellite dependence, and Earth–space technological relations for non-specialist
communication. This prevents the study from overstating space sustainability as a mature curricular field while still allowing
165 early traces of Earth–Space sustainability to be examined.

The literature therefore brings together three partly separate conversations: geoscience communication, sustainability-
oriented ELT, and Asian English-related sustainability education. Geoscience communication research provides concepts of
dissemination, dialogue, and participation (Trench, 2008; Illingworth, 2023; Onstad and van der Flier-Keller, 2025); ELT
research shows how sustainability enters language education through materials, tasks, and curriculum innovation (Yu et al.,
170 2024; Dhanyamol and Sethunaryanan, 2025); and Asian studies document its growing curricular visibility (Brown, 2024;
Cordova, 2024; Liu et al., 2024; Mack and Downs, 2026). Yet these strands have rarely been connected to examine how
universities recontextualize geoscience and emerging Earth–Space sustainability into English-related curricular knowledge
for non-specialist learners.

This study addresses that gap through comparative document analysis of selected Asian universities. Official course
175 descriptions, programme pages, syllabi, learning outcomes, and curriculum resources are treated as institutional texts that
represent how knowledge, learner roles, and educational purposes are publicly organized (Prior, 2003; Bowen, 2009). The
analysis examines not only whether geoscience and Earth–Space sustainability are visible in English-facing curricula, but
also how they are recontextualized, communicatively framed, and pedagogically organized across institutional contexts
(Bernstein, 2000; Shay, 2016; Illingworth, 2023). Applied linguistics and ESP identify English-mediated genres, tasks, and
180 learner roles, while sustainability education locates Earth-system content. The central concern remains geoscience
communication: whether curricular documents transform specialist knowledge into communicative forms that can support
public understanding, dialogue, or future participation.



3 Theoretical framework

To address the research gap, this study uses a streamlined analytical framework consisting of four linked components: recontextualization theory, geoscience communication models, genre/ESP theory, and content-domain anchoring. The framework examines how specialist geoscientific knowledge is selected, transformed, communicatively framed, and linguistically realized in English-related curricular provision. It is designed to avoid treating all sustainability-themed English provision as geoscience communication. Instead, it asks whether English-related curricula transform geoscience and Earth–Space sustainability into audience-aware genres, communicative tasks, and learner roles.

3.1 Recontextualization theory: from disciplinary knowledge to curriculum

Recontextualization theory explains how specialist knowledge is relocated from disciplinary fields into pedagogic contexts. Bernstein’s theory of pedagogic discourse emphasizes that knowledge is selected, reorganized, simplified, sequenced, and evaluated when it becomes curriculum (Bernstein, 1990, 2000). Later curriculum scholarship extends this perspective to higher education and shows that curriculum formation involves the transformation of disciplinary and professional knowledge across institutional boundaries (Shay, 2016; Hordern, 2021).

In this study, recontextualization theory is used to examine how geoscience and Earth–Space sustainability are converted into English-related curricular forms, such as course descriptions, programme aims, learning outcomes, readings, presentations, reports, science-communication tasks, or public-facing activities. This lens supports the analysis of curricular directness, knowledge selection, and pedagogic transformation. It also helps distinguish direct English-related geoscience communication provision from adjacent English-medium environmental provision and weaker forms of indirect English-facing institutional visibility.

3.2 Geoscience communication models: from dissemination to participation

Geoscience communication models provide the communicative dimension of the framework. In science communication theory, deficit, dialogue, and participation models describe different ways of relating expert knowledge to publics (Trench, 2008). The deficit model emphasizes expert-to-public transmission; the dialogue model emphasizes exchange and interpretation; and the participatory model involves publics or stakeholders in deliberation, knowledge-making, or action (Trench, 2008). Recent geoscience communication scholarship develops this logic into a dissemination-to-participation spectrum, emphasizing audience awareness, creativity, transparency, and public engagement (Illingworth, 2023). Empirical research also shows that these models can be operationalized through content analysis of geoscience communication practices (Onstad and van der Flier-Keller, 2025).

In this study, geoscience communication models are used only where a document identifies an audience, output, or interaction mechanism. Dissemination refers to explicit one-way explanation or presentation; dialogue requires explicit



reciprocal exchange; and participation requires co-production, shared decision-making, or sustained public or stakeholder involvement. When these elements are absent, the framing is coded as Not identifiable rather than inferred from the absence of dialogue or participation.

3.3 Genre/ESP theory: English-related realization of geoscience communication

Genre and English for Specific Purposes theory explain how the English-related dimension of the curriculum is realized. ESP has long been understood as a learning-centred approach shaped by learners' needs, target situations, course design, materials, methodology, and evaluation (Hutchinson and Waters, 1987). Later ESP scholarship expands this focus to perceived needs, disciplinary communication, professional practice, and learners' imagined futures (Belcher, 2006). Genre theory further explains how communicative tasks are organized through recurrent rhetorical forms shaped by purposes, audiences, and discourse communities (Swales, 1990; Hyland, 2008).

In this study, genre/ESP theory helps distinguish three English-related mechanisms: English as an object of learning, English as a medium of disciplinary instruction, and English as a documentary or institutional interface. The third category records what an English-language webpage makes publicly visible; it does not establish language of instruction, communication learning, or international accessibility unless additional evidence does so.

3.4 Content-domain anchoring: keeping the analysis geoscience-specific

Content-domain anchoring is not treated as a separate theory, but as an analytical safeguard. Its purpose is to keep the study focused on geoscience and Earth–Space sustainability rather than generic sustainability education. It draws on Earth science literacy and ocean literacy frameworks (National Science Foundation, 2009; National Oceanic and Atmospheric Administration, 2024), planetary-boundaries research (Richardson et al., 2023), and space-sustainability frameworks (United Nations Committee on the Peaceful Uses of Outer Space, 2019). Earth science and ocean literacy frameworks define Earth and ocean systems as interconnected physical, ecological, and human systems. Planetary-boundaries research provides an Earth-system basis for identifying climate, biosphere, freshwater, land-system, and biogeochemical limits; the 2023 update reports that six of nine planetary boundaries had been transgressed (Richardson et al., 2023). Space-sustainability frameworks extend this concern to orbital environments, satellite systems, space debris, and the long-term sustainability of outer-space activities (United Nations Committee on the Peaceful Uses of Outer Space, 2019).

In this study, content-domain anchoring prevents generic SDG or sustainability discourse from being over-coded as geoscience communication. A curriculum item is not treated as geoscience-related simply because it mentions sustainability, environmental protection, or the SDGs. Instead, it must show a meaningful connection to Earth-system processes, climate and environmental systems, ocean systems, hazards, GIS, remote sensing, planetary systems, space sustainability, or other geoscience-relevant domains. Space sustainability is included not as an assumed equivalent to Earth-system sustainability,



but as an exploratory sub-domain and emerging boundary case that tests whether English-related curricula are beginning to recontextualize near-Earth orbital issues for non-specialist communication.

245 3.5 Analytical use of the framework

The four components work together to support the study's coding dimensions. Recontextualization theory explains how specialist geoscientific knowledge is selected and transformed into curriculum. Geoscience communication models identify whether such knowledge is framed mainly as dissemination, dialogue, or participation. Genre/ESP theory explains how English-related genres and tasks mediate this knowledge. Content-domain anchoring ensures that the analysis remains tied to geoscience, Earth-system sustainability, and cautiously defined space-sustainability concerns.

4 Methodology

4.1 Research design and methodological positioning

This study adopts a qualitative comparative document-analysis design to examine how Earth- and space-relevant knowledge is represented in English-related curricular provision and its public documentary representation. It does not investigate classroom practice, student learning, assessment performance, or teachers' intentions. Official curricular documents are treated as institutional artefacts that selectively make courses, programmes, learning outcomes, English-related mechanisms, learner roles, and communicative purposes visible (Scott, 1990; Prior, 2003; Bowen, 2009). They provide evidence of publicly represented curriculum, not of actual curriculum enactment.

The study compares documentary configurations rather than ranking universities or evaluating curricular quality. A qualitative comparative case-study approach supports cross-case interpretation while retaining sensitivity to local curricular forms, document types, source granularity, and institutional visibility (Bartlett and Vavrus, 2017; Yin, 2018). The university is the case-level unit. The analytic unit is a bounded domain-bearing curricular segment, while language-policy pages that contain no independent geoscience content are treated only as contextual records.

4.2 Sampling strategy and case selection

The sample comprises 15 selected research-intensive university cases: three in Mainland China, two in Singapore, three in Japan, three in Hong Kong SAR, three in South Korea, and one in India. Selection was purposive, ranking-informed, and constrained by documentary accessibility. The Times Higher Education Asia University Rankings 2025 served only as an external discovery frame for identifying visible research-intensive institutions (Times Higher Education, 2025). No fixed ranking threshold was used, and ranking position was not treated as evidence of curricular quality, institutional performance, or geoscience communication strength.



Final inclusion required an official public curricular source, identifiable Earth-system or geoscience-related content, a traceable English-related mechanism established either in the curricular source or a linked contextual source, and sufficient information for conservative coding. The uneven distribution of cases reflects regional breadth and document availability rather than a balanced or representative system-level sample. Institutions with less extensive English-language documentation may therefore be underrepresented.

4.3 Document search and corpus construction

The corpus was assembled from official university webpages, course catalogues, programme pages, department pages, curriculum lists, course descriptions, language-centre pages, degree handbooks, syllabi, sustainability education pages, and formal educational announcements. Searches were conducted from 10 to 15 August 2026 in two rounds: candidate identification followed by verification of official status, curricular relevance, domain content, and the English-related link.

Institution-specific searches combined university names with terms including English course, academic English, presentation, science communication, Earth system science, geoscience, geophysics, ocean science, climate, GIS, remote sensing, environmental science, sustainability, space, satellite, curriculum, syllabus, course catalogue, and programme. Concept-specific searches combined these terms across the English, geoscience, and curriculum dimensions. Third-party pages were used only to locate possible sources and were never coded without official-university verification.

The initial search produced 58 candidate records. Eighteen distinct official source documents were retained and 40 candidates were excluded. Exclusion criteria comprised duplicate records, non-official sources, non-curricular pages, generic sustainability material without identifiable geoscience content, records without an English-related link, and unavailable or unverifiable pages. The preserved audit establishes the overall counts but does not contain mutually exclusive category-level totals for the 40 exclusions; no breakdown has therefore been reconstructed or invented.

The 18 retained documents yielded 22 source-linked evidence records. Nineteen are domain-bearing curricular segments and form the directness denominator. Three language-policy records (SEG-019–SEG-021) contain no independent geoscience content and are retained only to contextualize the English-medium status of the corresponding NUS, University of Tokyo, and Yonsei cases. Appendix B reports the screening flow, source register, and contextual decisions.

4.4 Operational definition of English-related curricular provision

“English-related curricular provision” refers to curricular content and its public documentary representation in which English functions in one of three ways: as an object of learning in English, ESP, EAP, writing, presentation, or science-communication courses; as the documented medium of disciplinary instruction; or as a documentary or institutional interface through which an English-language page makes curricular provision visible. The third mechanism does not by itself demonstrate English-medium teaching, audience reach, or communication learning.

A record was eligible as a domain-bearing curricular segment only when it contained both a curriculum link and meaningful Earth-system, geoscience, ocean, climate, hazard, geospatial, planetary, or space-related content. Language-policy pages without independent geoscience content were treated as contextual records rather than curricular segments. Local-language official documents were used only to verify course identity, programme structure, or an English-related curricular link; no classroom enactment or learning outcome was inferred from webpage visibility.

4.5 Coding framework and classification rules

Coding followed directed qualitative content analysis (Hsieh and Shannon, 2005; Schreier, 2012). The codebook was informed by curricular recontextualization, geoscience communication models, genre/ESP theory, and domain-specific evidence criteria. The six dimensions were curricular directness, closed domain categories, English-related mechanism, communicative framing, learner role, and source granularity.

Table 1. Operational coding framework for English-related geoscience communication provision

Coding dimension	Operational focus	Coding categories	Analytical purpose
Curricular directness	Whether domain content is explicitly linked to English or communication learning.	Direct; Direct-adjacent; Adjacent; Indirect; Excluded	Separates explicit communication learning from disciplinary access or documentary visibility.
Domain category	Closed multi-label taxonomy for the substantive content named in the record.	Earth-system/geoscience; Ocean/atmosphere; Climate/global change; Hazards/disaster; Geospatial/remote sensing; Planetary/space; Environmental sustainability/policy; Energy/resources/water	Keeps applied codes consistent and prevents generic sustainability from being over-coded.
English-related mechanism	How English is evidenced in relation to the curricular provision.	Object of learning; Medium of disciplinary instruction; Documentary/institutional interface	Distinguishes learning English, learning through English, and English-language documentary visibility.
Communicative framing	How an explicit output or interaction relates knowledge to audiences or stakeholders.	D (Dissemination); Di (Dialogue); P (Participation); NA (Not identifiable)	Prevents the absence of dialogue from being treated automatically as dissemination.
Learner role	The role explicitly or directly supported by the document.	Academic communicator; Interpreter/discussant; Public communicator; Mediator; NA	Reports roles only when documentary evidence supports them.
Source granularity	The documentary level of the source record.	Course-level; Programme-level; Institutional-context	Records document granularity without treating one level as automatically stronger than another.

Note. Domain categories form a closed multi-label taxonomy. Communicative framing and learner role are coded NA when an audience, task, output, interaction mechanism, or role cannot be identified. Source granularity describes documentary level and does not mechanically determine directness.



315 A curricular segment was coded as Direct when domain-specific content and English-mediated communication learning were both explicit. Direct-adjacent required domain content plus communication-, policy-, leadership-, presentation-, or cross-sector language but lacked a fully specified English genre, audience, or assessment task. Adjacent indicated English-medium disciplinary access or English-language documentary visibility without explicit communication learning. Indirect remained available for eligible domain-bearing segments with only a weak English-related link, although no retained
 320 curricular segment received this code after the final audit. SEG-022 was coded Adjacent on this dimension and separately marked Space-related exploratory flag = Yes.

Communicative framing was assigned independently of directness. Dissemination required an explicit one-way explanatory or presentational output; Dialogue required explicit reciprocal exchange or collaboration; Participation required co-production, shared decision-making, or sustained public or stakeholder involvement. When these features were absent, the
 325 record was coded NA. Borderline decisions, including the separation of contextual language-policy records and the reclassification of HKUST from Participation to Dissemination, are documented in Appendix B.

4.6 Coding procedure, trustworthiness, and limitations

The final audit contained 22 source-linked evidence records: 19 domain-bearing curricular segments and three contextual language-policy records. Only the 19 curricular segments were assigned a directness code. Three were Direct, three Direct-
 330 adjacent, 13 Adjacent, and none Indirect. SEG-022 was included among the Adjacent segments and was also marked with the cross-cutting Space-related exploratory flag. The three contextual records were not treated as independent segments because they contain no geoscience content.

Because the qualitative coding was conducted by one coder (WZ), the study does not report inter-coder reliability. Consistency was supported through explicit decision rules, source-linked excerpts, analytic memos, conservative treatment
 335 of borderline cases, and a final re-audit of directness, framing, learner-role, and context-record decisions. No formal second-coder or code-recode statistic is claimed because the available study record does not document such a procedure. Appendix A provides the complete evidence matrix, and Appendix B records source provenance and contested decisions.

The segment counts are not statistically independent: some official documents and university cases contribute more than one segment. Counts and percentages are therefore corpus-descriptive only and cannot be interpreted as prevalence estimates for
 340 universities or higher-education systems.

Three limitations remain. The study analyses public documentary representation rather than classroom enactment, student learning, assessment, or teacher intention. The purposive sample is uneven across systems or jurisdictions and may overrepresent institutions with extensive English-language documentation. Finally, single-coder interpretation remains a source of uncertainty despite the audit trail.



345 5 Findings

This section presents a comparative analysis of 19 domain-bearing curricular segments from 15 selected research-intensive universities across six Asian higher-education systems or jurisdictions. Three additional language-policy records are used only as contextual evidence. The analysis integrates curricular directness, domain category, English-related mechanism, communicative framing, learner role, and source granularity. Geoscience-relevant knowledge is widely visible, but explicit
 350 communicative transformation is limited. In most records, English functions as a medium of disciplinary instruction or a documentary or institutional interface rather than as an explicit object of communication learning. Table 2 presents case profiles without collapsing mixed segment-level codes into a single university-level classification.

Table 2. Case profiles of English-related geoscience communication provision

Case / system	Segment IDs	Primary domain anchor(s)	Case summary / English mechanism	Directness	Framing / role	Source
Peking University / Mainland China	SEG-001, 002, 022	Earth-system/geoscience; Planetary/space	English writing and presentation courses; English-language curriculum interface	Direct (2); Adjacent (1, space flag)	D (2), NA (1); academic communicator	Course
Tsinghua University / Mainland China	SEG-007	Environmental sustainability/policy; Energy/resources/water	Documented English-medium environmental programme	Adjacent (1)	NA; role NA	Prog.
Nanjing University / Mainland China	SEG-008	Earth-system/geoscience; Climate/global change	English-language summer-school page; exchange of ideas mentioned	Adjacent (1)	NA; interpreter/discussant	Prog.
NUS / Singapore	SEG-009–011	Earth-system/geoscience; Geospatial; Hazards	Curricular courses plus contextual English-medium source SRC-16	Adjacent (3)	NA (3); roles NA	Course + context
NTU / Singapore	SEG-004	Earth-system/geoscience; Environmental policy	Communication, leadership, and problem-solving at programme level	Direct-adjacent (1)	NA; role NA	Prog.
University of Tokyo / Japan	SEG-012	Earth-system/geoscience; Environmental sustainability	Programme content plus contextual English-medium source SRC-17	Adjacent (1)	NA; role NA	Prog. + context
Kyoto University / Japan	SEG-013	Environmental sustainability; Hazards; Resources/water	English-medium infrastructure programme	Adjacent (1)	NA; role NA	Prog.
Tohoku University / Japan	SEG-005	Earth-system/geoscience; Climate; Hazards	Communication and leadership named, without audience or task	Direct-adjacent (1)	NA; role NA	Prog.
University of Hong Kong / Hong Kong SAR	SEG-006	Earth-system/geoscience; Hazards	Group work and presentation opportunities	Direct-adjacent (1)	Di; interpreter/discussant; academic communicator	Prog.
CUHK / Hong Kong SAR	SEG-014	Earth-system/geoscience; Climate; Hazards	English-language programme page	Adjacent (1)	NA; role NA	Prog.



Case / system	Segment IDs	Primary domain anchor(s)	Case summary / English mechanism	Directness	Framing / role	Source
HKUST / Hong Kong SAR	SEG-003	Ocean/atmosphere	English writing and speaking for the general public	Direct (1)	D; public communicator	Course
Seoul National University / South Korea	SEG-015	Geospatial/remote sensing; Planetary/space	English-language course list	Adjacent (1)	NA; role NA	Course
KAIST / South Korea	SEG-016	Climate/global change; Environmental sustainability	English-language course list; climate course title	Adjacent (1)	NA; role NA	Course
Yonsei University / South Korea	SEG-017	Climate; Environmental sustainability; Resources/water	Programme content plus contextual English-medium source SRC-18	Adjacent (1)	NA; role NA	Prog. + context
IISc Bengaluru / India	SEG-018	Earth-system/geoscience; Ocean/atmosphere; Climate	English-language programme page	Adjacent (1)	NA; role NA	Prog.

Note. Directness profiles summarize domain-bearing curricular segments only. SRC-16–SRC-18 are contextual language-policy sources and do not receive independent directness codes. D = Dissemination; Di = Dialogue; NA = Not identifiable; Prog. = programme-level. Source granularity records the level of the cited documents rather than a university-level evidence score.

The directness distribution is based on the 19 domain-bearing curricular segments. Three were Direct, three Direct-adjacent, 13 Adjacent, and none Indirect. SEG-022 is included in the Adjacent count and also carries a cross-cutting Space-related exploratory flag. The three contextual language-policy records are outside the denominator. These counts describe only the assembled documentary corpus.

Table 3. Distribution of the 19 curricular segments by directness and exploratory space flag

Classification	n	% of curricular segments (N = 19)	Status
Direct	3	15.8	Mutually exclusive directness code
Direct-adjacent	3	15.8	Mutually exclusive directness code
Adjacent	13	68.4	Mutually exclusive directness code
Indirect	0	0.0	Mutually exclusive directness code
Total	19	100.0	Directness denominator
Space-related exploratory flag	1	5.3	Cross-cutting; not additive

Note. Direct, Direct-adjacent, Adjacent, and Indirect are mutually exclusive. The space-related flag is cross-cutting and does not add to the total. Percentages are corpus-descriptive and may not sum to 100% in other tabulations because of rounding. SEG-019–SEG-021 are contextual records and are excluded from the denominator.



5.1 Direct cases: English-related geoscience communication is rare and concentrated

Direct English-related geoscience communication is uncommon and highly focused. Of the 15 universities examined, Peking University and HKUST offer the most unambiguous direct evidence, as both clearly link domain-specific geoscience or ocean-science content with English-mediated communication learning.

370 Peking University is classified as direct because its School of Earth and Space Sciences curriculum incorporates English-language presentations of geophysics research. This connects a defined geoscience discipline with an academic communication task conducted in English. Here, English is integral to the learning activity itself, not just the medium for conveying curricular information. Students are cast as academic communicators who articulate disciplinary knowledge in English. Nevertheless, the intended audience appears chiefly academic or specialist, rather than general-public or
 375 stakeholder-oriented. Thus, PKU exemplifies direct—but primarily academic—geoscience communication.

HKUST provides the clearest public-oriented Direct segment. Its ocean-science-linked English course specifies popular-science writing and speaking for a general audience. This evidence supports Dissemination because learners produce one-way explanatory outputs for non-specialists. It does not establish Participation, which would require co-production, shared decision-making, or sustained public or stakeholder involvement.

380 Together, these two cases demonstrate that direct provision arises only where both domain-specific content and direct English or communication learning are evident. Such instances do exist but remain localized within particular curricular contexts rather than being broadly institutionalized across the corpus.

5.2 Direct-adjacent cases: communicative potential without full transformation

NTU, Tohoku University, and HKU exhibit greater communicative potential than typical adjacent English-medium or
 385 English-facing provision, yet the available evidence falls short of justifying a direct classification. These cases reflect a spectrum between disciplinary access and direct geoscience communication.

NTU integrates Environmental Earth Systems Science with communication, public affairs, leadership, and problem-solving. These elements justify a Direct-adjacent classification, but they do not identify a specific interaction mechanism, English-mediated genre, audience, or assessment task. Communicative framing and learner role are therefore coded NA.

390 Tohoku University displays a comparable Direct-adjacent pattern. Its Dynamic Earth programme names communication and leadership skills alongside Earth-system change and disasters, but the public document does not specify a reciprocal exchange, public audience, or English-mediated communication task. Its communicative framing is therefore coded NA rather than Dialogue.



395 HKU also occupies a Direct-adjacent position. Its Earth System Science curriculum identifies group-project learning, collaboration with other students, and presentation opportunities. These features support Dialogue through explicit peer interaction and identify interpreter/discussant and academic-communicator roles, although a public-facing English genre is not specified.

5.3 Adjacent provision: English-medium and documentary infrastructures dominate

400 The majority of curricular segments fall into the Adjacent category. Tsinghua, NUS, the University of Tokyo, Kyoto, CUHK, SNU, KAIST, Yonsei, IISc Bengaluru, Nanjing, and PKU's space-science segment contain identifiable Earth-system, environmental, climate, geospatial, ocean, hazard, resource, or planetary content, but no explicit English-mediated communication-learning design.

405 Tsinghua and NUS illustrate two documentary routes to adjacency. Tsinghua's programme explicitly documents English-medium environmental study. NUS provides domain-bearing course records whose English-medium context is established by a separate language-policy source. The contextual source supports interpretation of the curricular segments but is not counted as an independent geoscience segment.

410 SNU and IISc Bengaluru likewise provide identifiable domain content through English-language documentary interfaces, but their public pages do not specify English communication tasks, audiences, or learner roles. Adjacent provision should therefore be interpreted as potential curricular infrastructure, not as demonstrated communication training or international accessibility.

5.4 Domain specificity is strong, but communicative transformation is weaker

415 Domain content is clearly identifiable across the corpus, including Earth-system science, climate, ocean and atmosphere, geospatial analysis, hazards, planetary and space topics, environmental sustainability, and energy or water issues. These labels follow the closed multi-label domain taxonomy in Table 1.

420 Identifiable domain content does not itself establish communicative transformation. In most records, the documents do not specify an audience, genre, interaction mechanism, or learner role. Claims are therefore limited to documented curricular content and English-related mechanisms rather than inferred training outcomes.

The findings support a two-stage recontextualization interpretation. First, geoscience knowledge enters curricular provision and becomes teachable. Second, in the smaller set of Direct or Direct-adjacent records, it begins to be reorganized through English writing, presentation, collaboration, or public explanation. Only the first stage is widely visible in the corpus.



5.5 Communicative framing is usually not identifiable

Only four of the 19 domain-bearing curricular segments provide sufficient evidence for a D–Di–P classification. SEG-001, SEG-002, and SEG-003 are coded Dissemination because they specify academic writing, academic presentation, or public-oriented writing and speaking. SEG-006 is coded Dialogue because it explicitly links communication with group-project
425 learning and collaboration among students.

No segment documents Participation as defined in this study. HKUST addresses a general public audience, but its writing and speaking outputs remain explanatory rather than co-produced or jointly governed. Generic references to communication skills, leadership, policy, cross-sector engagement, or exchanging ideas in NTU, Tohoku, Nanjing, and KAIST are insufficient to establish reciprocal interaction and are coded NA.

430 The remaining 15 segments are therefore coded Not identifiable. This pattern does not demonstrate that dissemination dominates actual teaching; it shows that most public curricular documents do not provide enough information to classify their communication orientation.

5.6 Space sustainability remains an exploratory sub-domain

Space-related content appears only faintly and inconsistently across the corpus. Earth and Space Sciences, planetary science,
435 remote sensing, satellite-related topics, and Earth–Space domains emerge in select cases—notably PKU and SNU. Yet these instances do not prominently frame such material as space sustainability. Themes like near-Earth orbital sustainability, space debris, satellite governance, responsible space use, and public communication of orbital risk have not yet crystallized into well-developed English-related curricular strands.

This distinction is significant because space science and space sustainability are not synonymous. A curriculum may
440 incorporate planetary science, satellite technology, remote sensing, or satellite geophysics without engaging with the long-term stewardship of orbital environments, debris mitigation, orbital congestion, governance frameworks, responsible operational practices, or societal reliance on space infrastructure. Consequently, the corpus reflects primarily space-science or satellite-related visibility rather than English-mediated communication centered on space sustainability.

SEG-022 is therefore coded Adjacent on curricular directness and additionally marked with the Space-related exploratory
445 flag. This preserves space-science visibility in the analytic corpus without treating the course title as evidence of space-sustainability communication. Space sustainability remains a boundary case rather than a consolidated empirical finding.



5.7 Illustrative cross-case patterns by system or jurisdiction

Because the sample is purposive and uneven—three cases each in Mainland China, Japan, Hong Kong SAR, and South Korea, two in Singapore, and one in India—the comparison does not support representative system-level conclusions. The patterns below are illustrative configurations among the selected cases.

Within this corpus, Direct academic communication appears in PKU and Direct public-oriented communication in HKUST. Direct-adjacent provision appears in NTU, Tohoku, and HKU, while Adjacent provision occurs across all six systems or jurisdictions through various combinations of English-medium study and English-language documentary visibility. These differences describe the selected records rather than causal effects of national or regional systems.

Accordingly, cross-case interpretation is restricted to how domain content, English-related mechanisms, and explicitly documented communication features combine in this corpus. It should not be read as a ranking of institutions or as an estimate of provision across Asian higher education.

5.8 Synthesis: from curricular visibility to communicative transformation

Across the 19 curricular segments, explicit English-mediated geoscience communication is localized, while Adjacent provision is more common. Communication framing is identifiable in only four segments, and the available documents do not establish participation. SEG-022 shows space-science visibility but no explicit space-sustainability communication. The principal result is therefore a distinction between publicly documented curricular visibility and evidence of communicative transformation.

6 Discussion

The findings suggest that English-related curricula may function as preparatory infrastructures for geoscience communication, but public documents often stop at disciplinary or documentary visibility. The discussion therefore focuses on the visibility–transformation distinction, two-stage recontextualization, the limits of communicative-framing inference, and curriculum-development implications.

6.1 From curricular visibility to communicative transformation

Curricular visibility is not equivalent to communicative transformation. An English-medium programme or English-language curriculum page may document access to Earth-system, climate, ocean, hazard, geospatial, or sustainability content, but it does not show that learners practise communicating that knowledge to an audience. Documentary visibility, medium of instruction, and communication learning must therefore remain analytically separate.



Communicative transformation requires evidence that specialist knowledge is reorganized for a purpose, audience, genre, interaction, or learner role. This requirement explains why most records are Adjacent and why communicative framing is coded NA for 15 segments. It also prevents webpage language from being treated as evidence of classroom practice, student competence, or public engagement.

6.2 Recontextualization as a two-stage curricular process

Recontextualization theory provides a way to explain this difference. Bernstein's account of pedagogic discourse emphasizes that disciplinary knowledge is selected, relocated, reorganized, and evaluated when it enters curriculum (Bernstein, 1990, 2000). Hordern similarly shows that knowledge is transformed as it moves across disciplinary, educational, and professional contexts (Hordern, 2021). The present findings suggest that English-related geoscience communication may involve two analytically distinct stages of recontextualization.

In the first stage, specialist geoscience knowledge is transformed into teachable curricular knowledge. Earth-system science, climate change, ocean science, GIS, remote sensing, hazards, planetary science, or sustainability science is selected and organized into courses, programmes, learning outcomes, and disciplinary activities. This transformation is widely visible in the corpus and explains why substantial domain specificity can coexist with limited evidence of explicit communication learning. At this stage, geoscience knowledge has entered the curriculum, but it remains primarily organized around disciplinary understanding and application.

A second transformation occurs when that curricular knowledge is reorganized for communicative purposes. Here, students are expected not merely to understand or apply specialist knowledge, but to reshape it through audience-oriented genres and roles: for example, presenting research, producing popular-science texts, preparing policy briefs, communicating uncertainty, briefing stakeholders, or explaining scientific issues to non-specialists. Knowledge is therefore transformed from something that is teachable into something that is also communicable.

This distinction provides a conceptual explanation for why a geoscience-rich curriculum is not necessarily a geoscience communication curriculum. Strong disciplinary content and English-medium delivery may indicate completion of the first stage without evidence of the second. Direct-adjacent provision is especially informative in this respect because it marks curricular sites where communication skills, presentation, leadership, policy interpretation, or cross-sector engagement begin to appear, but where audience, genre, or English-mediated communicative purpose remains incompletely specified.

The two-stage model therefore adds a temporal and transformational dimension to curricular recontextualization. Recontextualization need not stop when disciplinary knowledge becomes teachable. For science communication purposes, a further transformation may be required in which teachable disciplinary knowledge is reorganized into audience-aware



communicable knowledge. This provides a more precise explanation of the gap identified in the corpus between strong domain visibility and comparatively weak communicative transformation.

505 **6.3 What limited framing evidence means for geoscience communication**

The revised D–Di–P coding shows that the principal documentary pattern is not dissemination dominance but limited identifiability. Three Direct segments specify one-way academic or public explanatory outputs, and one Direct-adjacent segment specifies reciprocal peer collaboration. Most other records contain no audience, output, or interaction mechanism and therefore cannot support a framing classification.

510 This distinction is methodologically important. Coding every disciplinary course as Dissemination would confuse knowledge provision with a communication act, while treating public-oriented writing as Participation would collapse audience orientation into co-production. Participation requires evidence that publics or stakeholders help shape knowledge, decisions, or sustained activity; no retained segment provides such evidence.

515 The absence of these features from public documents does not demonstrate their absence from classrooms. It identifies a limit of the documentary evidence and a target for future syllabus, assignment, observation, and interview research. Curriculum developers may nevertheless use the gap diagnostically by specifying audiences, genres, reciprocal interaction, and stakeholder roles when such outcomes are intended.

520 Space sustainability illustrates the same boundary. Space-science and remote-sensing visibility is documented, but orbital stewardship, debris governance, responsible use, and public deliberation are not. The cross-cutting flag therefore identifies an exploratory opportunity without converting space science into evidence of space-sustainability communication.

6.4 Implications for English-related geoscience communication curricula

525 Curriculum development should focus not only on adding geoscience topics but also on making the intended transition from disciplinary knowledge to communicative activity explicit. A programme documented as English-medium may broaden language access, but documents alone do not establish accessibility, communication learning, or outcomes. Communication objectives should therefore specify what learners do, for which audiences, through which genres or interactions, and how that work is assessed.

One practical direction is to organize learning through genres and audiences. Rather than treating climate change, oceans, GIS, hazards, or space debris solely as topics, curricula can require learners to reshape specialist knowledge through academic presentations, policy briefs, popular-science articles, stakeholder briefings, data stories, or risk-communication



530 tasks. Genre-based design makes audience, communicative purpose, rhetorical choices, and knowledge transformation visible and assessable.

The findings also suggest that movement from Adjacent to more Direct provision need not require the creation of entirely new courses. Existing English-medium environmental programmes, Earth-system courses, sustainability curricula, geospatial training, disaster studies, and science-policy provision already constitute important disciplinary infrastructures. These can be
 535 extended through audience analysis, genre-based assignments, stakeholder simulations, public-facing assessment, and reflective consideration of how scientific knowledge changes when communicated beyond specialist settings. Direct-adjacent provision is particularly useful in this regard because it identifies curricular spaces where communication-related capacities already exist and could be made more explicitly geoscience-focused and audience-aware.

Space sustainability should be approached with similar caution. The present evidence does not justify treating it as an
 540 established English-related curricular field. Nevertheless, emerging issues such as satellite dependence, space debris, Earth observation, responsible orbital use, and congestion provide suitable contexts for connecting Earth–Space science with communication, governance, and public understanding.

Overall, the principal implication is that the development of English-related geoscience communication curricula does not depend simply on more geoscience content in English. It depends on whether curricula create a second stage of
 545 recontextualization in which disciplinary knowledge is deliberately reshaped for audiences, genres, purposes, and public contexts. In this sense, English-related curricula can function as preparatory infrastructures for geoscience communication, but they become communication curricula only when communicative transformation itself becomes an explicit object of learning.

7 Conclusion

550 This study examined English-related curricular provision and its public documentary representation across 15 selected research-intensive universities in six Asian higher-education systems or jurisdictions. The final audit distinguished 19 domain-bearing curricular segments from three contextual language-policy records and analysed only the 19 curricular segments for directness.

Three segments were Direct, three Direct-adjacent, 13 Adjacent, and none Indirect. SEG-022 was included in the Adjacent
 555 count and separately marked with the Space-related exploratory flag. Direct evidence is concentrated in academic geological writing or presentation and public-oriented ocean-science communication. Most other records document English-medium disciplinary access or English-language curricular visibility without an explicit audience-aware communication task.

Communicative framing was identifiable in only four segments: three Dissemination and one Dialogue; none met the threshold for Participation. This result replaces the stronger claim that dissemination dominates the corpus. The more defensible conclusion is that public curricular documents usually provide insufficient evidence about communication outputs, interaction mechanisms, and learner roles.

The study contributes a distinction among documentary visibility, English-medium disciplinary access, and English-mediated geoscience communication, together with a two-stage recontextualization account of how disciplinary knowledge may become both teachable and communicable. Its conclusions remain limited to the purposively assembled documentary corpus. Uneven case numbers, clustered segments, English-language visibility, and single-coder interpretation preclude prevalence or system-level inference. Future work should examine syllabi, assignments, classroom enactment, and learner outcomes and should investigate space sustainability as a distinct communication domain rather than inferring it from space-science visibility.

Appendix A: Segment-level evidence and coding matrix

The audit contains 22 source-linked evidence records: 19 domain-bearing curricular segments and three contextual language-policy records. Table A1 identifies the documentary evidence, directness treatment, exploratory flag, and source granularity. Table A2 reports domain, English mechanism, communicative framing, learner role, and the rationale for each decision. SEG-019–SEG-021 are retained for context but are not included in the directness denominator.

Table A1. Documentary evidence and directness treatment for 19 curricular segments and 3 contextual records

Segment ID	University	Source ID	Evidence excerpt	Directness treatment	Source granularity
SEG-001	Peking University	SRC-01	Academic Essay Writing in English: Geological Sciences	Direct	Course-level
SEG-002	Peking University	SRC-01	English Presentation of Geophysics Research	Direct	Course-level
SEG-003	The Hong Kong University of Science and Technology	SRC-02	LANG 3025 develops ability to communicate ocean science knowledge to the general public through effective writing and speaking skills.	Direct	Course-level
SEG-004	Nanyang Technological University	SRC-03	equips students with leadership, communication and problem-solving skills to address complex environmental challenges	Direct-adjacent	Programme-level
SEG-005	Tohoku University	SRC-04	understanding of the Earth and global environmental changes ... communication skills, practical skills ... and leadership skills	Direct-adjacent	Programme-level
SEG-006	The University of Hong Kong	SRC-05	work with other students and possess an adequate level of communication skills ... group project learning and presentation opportunities	Direct-adjacent	Programme-level
SEG-007	Tsinghua University	SRC-06	International Master Program ... covers areas including environmental engineering and science, management, and planning.	Adjacent	Programme-level
SEG-008	Nanjing University	SRC-07	The theme is 'Global Change and Dual Carbon Technology.' ... study cutting-edge topics and exchange ideas in Earth System Science.	Adjacent	Programme-level
SEG-009	National University of Singapore	SRC-08	GE2103 - Our Planet: An Earth Systems Science Perspective	Adjacent	Course-level
SEG-010	National University of Singapore	SRC-08	GE2215 - Introduction to GIS	Adjacent	Course-level
SEG-011	National University of Singapore	SRC-08	GE3231 - Natural Hazards	Adjacent	Course-level
SEG-012	The University of Tokyo	SRC-09	broad-based, inter- and multidisciplinary understanding of Environmental Systems and Global Sciences	Adjacent	Programme-level



Segment ID	University	Source ID	Evidence excerpt	Directness treatment	Source granularity
SEG-013	Kyoto University	SRC-10	All lectures and research guidance are provided in English ... addressing environmental issues in various countries	Adjacent	Programme-level
SEG-014	The Chinese University of Hong Kong	SRC-11	Global climate change, natural hazards, environmental pollution, ecosystem degradation	Adjacent	Programme-level
SEG-015	Seoul National University	SRC-12	Earth and Planetary Remote Sensing	Adjacent	Course-level
SEG-016	KAIST	SRC-13	GG5.50004 Science of Climate Change	Adjacent	Course-level
SEG-017	Yonsei University	SRC-14	global issues surrounding energy, global warming, and water	Adjacent	Programme-level
SEG-018	Indian Institute of Science, Bengaluru	SRC-15	sound foundation in the theory of the earth-atmosphere-ocean-climate system	Adjacent	Programme-level
SEG-019	National University of Singapore	SRC-16	The medium of instruction used in the University is English, unless specified otherwise.	Not coded: contextual record	Institutional-context
SEG-020	The University of Tokyo	SRC-17	students admitted through PEAK are expected to take courses offered primarily in English	Not coded: contextual record	Institutional-context
SEG-021	Yonsei University	SRC-18	Language of Instruction: All courses are conducted in English.	Not coded: contextual record	Institutional-context
SEG-022	Peking University	SRC-01	Introduction to Space Sciences and Applications	Adjacent; Space-related exploratory flag = Yes	Course-level

575 Note. Direct, Direct-adjacent, Adjacent, and Indirect are mutually exclusive codes for domain-bearing curricular segments. SEG-022 is Adjacent and additionally carries the Space-related exploratory flag. SEG-019–SEG-021 are contextual records and are not directness-coded. Source IDs correspond to Appendix B.

Table A2. Coding profile and rationale for 19 curricular segments and 3 contextual records

Segment ID	Domain category or record status	English-related mechanism	Communicative framing	Learner role	Coding rationale
SEG-001	Earth-system/geoscience	Object of learning	D	Academic communicator	English writing and geological sciences are explicitly combined.
SEG-002	Earth-system/geoscience	Object of learning	D	Academic communicator	English presentation is explicitly tied to geophysics research.
SEG-003	Ocean/atmosphere	Object of learning	D	Public communicator	Writing and speaking for a general public audience are explicit; no co-production or shared decision-making is documented.
SEG-004	Earth-system/geoscience; Environmental sustainability/policy	Medium of disciplinary instruction	NA	NA	Communication and problem-solving are named, but no audience, genre, interaction mechanism, or learner role is specified.
SEG-005	Earth-system/geoscience; Climate/global change; Hazards/disaster	Documentary/institutional interface	NA	NA	Communication skills are named, but reciprocal exchange and a specific role are not documented.
SEG-006	Earth-system/geoscience; Hazards/disaster	Documentary/institutional interface	Di	Interpreter/discussant; Academic communicator	Group-project learning, work with other students, and presentation opportunities support reciprocal peer interaction.
SEG-007	Environmental sustainability/policy; Energy/resources/water	Medium of disciplinary instruction	NA	NA	The programme documents English-medium environmental study but no communication output or role.
SEG-008	Earth-system/geoscience; Climate/global change; Environmental sustainability/policy	Documentary/institutional interface	NA	Interpreter/discussant	‘Exchange ideas’ supports a discussant role, but the document does not specify the interaction mechanism sufficiently for a Dialogue code.



Segment ID	Domain category or record status	English-related mechanism	Communicative framing	Learner role	Coding rationale
SEG-009	Earth-system/geoscience	Medium of disciplinary instruction	NA	NA	English-medium context relies on SRC-16; no communication task or role is documented.
SEG-010	Geospatial/remote sensing	Medium of disciplinary instruction	NA	NA	English-medium context relies on SRC-16; no communication task or role is documented.
SEG-011	Hazards/disaster	Medium of disciplinary instruction	NA	NA	English-medium context relies on SRC-16; no communication task or role is documented.
SEG-012	Earth-system/geoscience; Environmental sustainability/policy	Medium of disciplinary instruction	NA	NA	English-medium context is supplied by SRC-17; the excerpt is programme-level domain evidence.
SEG-013	Environmental sustainability/policy; Hazards/disaster; Energy/resources/water	Medium of disciplinary instruction	NA	NA	English medium is explicit, but no communication output, interaction, or role is documented.
SEG-014	Earth-system/geoscience; Climate/global change; Hazards/disaster; Environmental sustainability/policy	Documentary/institutional interface	NA	NA	Domain content is explicit; the page does not establish instruction language or communication learning.
SEG-015	Geospatial/remote sensing; Planetary/space	Documentary/institutional interface	NA	NA	The English-language course list shows domain visibility but not instruction language or communication learning.
SEG-016	Climate/global change; Environmental sustainability/policy	Documentary/institutional interface	NA	NA	A climate course is visible, but policy dialogue, interaction, and learner role are not specified.
SEG-017	Climate/global change; Environmental sustainability/policy; Energy/resources/water	Medium of disciplinary instruction	NA	NA	The major supplies domain content; English-medium context is supplied by SRC-18.
SEG-018	Earth-system/geoscience; Ocean/atmosphere; Climate/global change	Documentary/institutional interface	NA	NA	The programme page shows domain content but no English communication learning or identifiable role.
SEG-019	Contextual language-policy record	Contextual evidence of English medium	NA	NA	No independent geoscience content; used only with NUS curricular segments.
SEG-020	Contextual language-policy record	Contextual evidence of English medium	NA	NA	No independent geoscience content; used only with the University of Tokyo curricular segment.
SEG-021	Contextual language-policy record	Contextual evidence of English medium	NA	NA	No independent geoscience content; used only with the Yonsei curricular segment.
SEG-022	Planetary/space	Documentary/institutional interface	NA	NA	Space-science visibility is explicit; the segment is Adjacent and separately flagged, but space-sustainability and communication learning are not documented.

Note. D = Dissemination; Di = Dialogue; P = Participation; NA = Not identifiable. Domain labels use the closed multi-label categories in Table 1. Learner roles are reported only when directly supported by the excerpt or linked document.



Appendix B: Official source register and notes on borderline or context-dependent cases

Appendix B records source provenance, screening flow, and contested decisions. The search identified 58 candidate records; 18 distinct official source documents were retained and 40 candidates were excluded under the criteria listed in Sect. 4.3. The preserved audit does not contain mutually exclusive reason counts or a candidate-level log for all exclusions, so those details are not reconstructed. The 18 retained sources support 19 domain-bearing curricular segments and three contextual language-policy records. Table B1 lists the sources, and Table B2 documents directness, context, framing, and exploratory-flag decisions.

Table B1. Register of the 18 official source documents represented in the audit

Source ID	University	Source details	Official URL	Source role
SRC-01	Peking University	School of Earth and Space Sciences curriculum; Official course catalogue; document date: n.d.; last verified: 15 August 2026.	https://english.pku.edu.cn/curriculum/11313.html	three bounded segments are coded from one catalogue page.
SRC-02	The Hong Kong University of Science and Technology	LANG 3025 Science Communication in English (Ocean Science); Official language-centre course page; document date: n.d.; last verified: 15 August 2026.	https://cle.hkust.edu.hk/courses/lang3025	strongest task-level evidence.
SRC-03	Nanyang Technological University	Bachelor of Science in Environmental Earth Systems Science and Public Policy and Global Affairs; Official degree programme page; document date: n.d.; last verified: 15 August 2026.	https://www.ntu.edu.sg/education/undergraduate-programme/bachelor-of-science-in-environmental-earth-systems-science-and-public-policy-and-global-affairs	Used for direct-adjacent communication-skills evidence.
SRC-04	Tohoku University	WISE Program for Sustainability in the Dynamic Earth — Overview; Official graduate programme overview; document date: n.d.; last verified: 15 August 2026.	https://syde.tohoku.ac.jp/english/program/overview/	Programme-level Earth/global-change and communication-skills evidence.
SRC-05	The University of Hong Kong	Major in Earth System Science — Online Syllabuses and Regulations; Official online syllabus/regulations; document date: AY2024; last verified: 15 August 2026.	https://webapp.science.hku.hk/sr4/servlet/enquiry?AdmissionYear=2024&Code=MajorInEarthSystemSc&Type=Major	PLO6 supplies group-project and presentation evidence; English-specificity remains weak.
SRC-06	Tsinghua University	2026 English Master Program in Environmental Science, Engineering and Management; Official programme/admissions page; document date: 2026; last verified: 15 August 2026.	https://www.env.tsinghua.edu.cn/info/1366/9864.htm	Official English master programme; environmental rather than narrowly geoscience-specific.
SRC-07	Nanjing University	Call for application: The 2nd International Summer School on Earth System Science; Official summer-school announcement; document date: 2024; last verified: 15 August 2026.	https://www.nju.edu.cn/en/info/4502/10171.htm	Short-term event; curricular inclusion treated conservatively as short-term curricular evidence.
SRC-08	National University of Singapore	Undergraduate Courses — Department of Geography; Official course catalogue/list;	https://fass.nus.edu.sg/geog/undergraduate-courses/	One page yields three bounded geoscience-related course segments.



Source ID	University	Source details	Official URL	Source role
		document date: AY2026–27 page; last verified: 15 August 2026.		
SRC-09	The University of Tokyo	PEAK — Environmental Sciences: Program Overview; Official programme overview; document date: n.d.; last verified: 15 August 2026.	https://peak.c.u-tokyo.ac.jp/courses/es/index.html	Domain programme evidence; English-medium context is supplied separately by SRC-17.
SRC-10	Kyoto University	International Course in Management of Civil Infrastructure; Official programme homepage; document date: n.d.; last verified: 15 August 2026.	https://www.ce.t.kyoto-u.ac.jp/mci/en/index.html	Explicit English-medium provision plus environmental problem-solving.
SRC-11	The Chinese University of Hong Kong	B.Sc. in Earth and Environmental Sciences; Official degree programme page; document date: n.d.; last verified: 15 August 2026.	https://www.sci.cuhk.edu.hk/academic/undergraduate-studies/programmes-offered/eesc/	Strong domain evidence; English mechanism is only an English-facing interface on this page.
SRC-12	Seoul National University	School of Earth and Environmental Sciences — Graduate Courses; Official course list; document date: n.d.; last verified: 15 August 2026.	https://sees.snu.ac.kr/en/academics/graduate/courses	Course visibility is strong; language-of-instruction and communication tasks are not shown.
SRC-13	KAIST	Graduate School of Green Growth and Sustainability — All Courses; Official course list; document date: n.d.; last verified: 15 August 2026.	https://gggs.kaist.ac.kr/english/list-of-subjects	Climate/sustainability course evidence; geoscience specificity is borderline.
SRC-14	Yonsei University	Underwood International College — Energy and Environmental Science and Engineering; Official major/programme page; document date: n.d.; last verified: 15 August 2026.	https://uic.yonsei.ac.kr/undergraduate.php?mid=m02_03_02	Domain programme evidence; English-medium context is supplied separately by SRC-18.
SRC-15	Indian Institute of Science, Bengaluru	Centre for Atmospheric and Oceanic Sciences — Programs; Official programme page; document date: 2023 programme start; last verified: 15 August 2026.	https://caos.iisc.ac.in/Programs.html	Earth–atmosphere–ocean–climate programme evidence; English role not explicit.
SRC-16	National University of Singapore	Education at NUS — Medium of Instruction; Official institutional language-policy page; document date: n.d.; last verified: 15 August 2026.	https://www.nus.edu.sg/registrar/academic-information-policies/non-graduating/education-at-nus	Contextual language-of-instruction source for NUS; used to establish English-medium context alongside SRC-08.
SRC-17	The University of Tokyo	PEAK — Programs in English at Komaba; Official programme/instruction-language page; document date: n.d.; last verified: 15 August 2026.	https://peak.c.u-tokyo.ac.jp/	Contextual English-medium source for the University of Tokyo PEAK case; used alongside SRC-09.
SRC-18	Yonsei University	Underwood International College — Admissions information; Official institutional/programme information page; document date: n.d.; last verified: 15 August 2026.	https://uic.yonsei.ac.kr/admission.php?mid=m04_05	Contextual language-of-instruction source for Yonsei UIC; used alongside SRC-14.

590 *Note.* “Last verified” refers to live re-verification on 15 August 2026. SRC-16–SRC-18 are contextual language-of-instruction sources and do not independently establish geoscience content; they are interpreted only together with the corresponding domain-bearing curricular sources.



Table B2. Borderline, contextual, and communicative-framing decisions

Segment / case	Coding issue	Final treatment	Evidence-based rationale
SEG-004 / NTU	Direct vs Direct-adjacent	Direct-adjacent	Communication is named, but no specific English genre, audience, or assessment task is identified.
SEG-005 / Tohoku	Direct vs Direct-adjacent	Direct-adjacent	Domain and communication skills co-occur, but no dedicated English-mediated public genre is specified.
SEG-006 / HKU	Direct-adjacent vs Adjacent	Direct-adjacent	Group-project collaboration and presentation are explicit, but a public-facing English genre is not.
SEG-008 / Nanjing	Short-term provision	Adjacent	Earth-system content is explicit in a summer school, but no English communication genre or assessment is stated.
SEG-015 / SNU	Adjacent vs Indirect	Adjacent	The course list provides domain content; claims are limited to documentary visibility.
SEG-016 / KAIST	Adjacent vs Indirect	Adjacent	Climate content is explicit; communication and geoscience specificity are limited.
SEG-018 / IISc	Adjacent vs Indirect	Adjacent	Earth-atmosphere-ocean-climate content is explicit; no communication learning is documented.
SEG-003 / HKUST	Participation vs Dissemination	Dissemination	Public-oriented writing and speaking are explicit, but co-production, shared decision-making, and sustained public involvement are not.
SEG-004 / NTU	Dialogue vs NA	NA	Generic communication and problem-solving language does not specify reciprocal exchange.
SEG-005 / Tohoku	Dialogue vs NA	NA	Communication skills and cross-sector language do not establish a documented dialogue mechanism.
SEG-006 / HKU	Dissemination vs Dialogue	Dialogue	Work with other students and group-project learning provide explicit reciprocal peer interaction.
SEG-008 / Nanjing	Dialogue vs NA	NA	The phrase 'exchange ideas' does not specify a sufficiently bounded interaction task.
SEG-016 / KAIST	Dialogue vs NA	NA	A climate course title does not establish policy dialogue or mediation.
SEG-019 / NUS	Language-only evidence	Contextual record; not directness-coded	The source establishes institutional English-medium context but contains no geoscience content.
SEG-020 / University of Tokyo	Language-only evidence	Contextual record; not directness-coded	The source establishes PEAK English-medium context but contains no independent geoscience content.
SEG-021 / Yonsei	Language-only evidence	Contextual record; not directness-coded	The source establishes UIC English-medium context but contains no independent geoscience content.
SEG-022 / Peking University	Directness plus exploratory flag	Adjacent; Space-related exploratory flag = Yes	The course title establishes space-science visibility, but not space-sustainability framing or communication learning.

595 Note. These decisions separate directness, communicative framing, contextual evidence, and the cross-cutting exploratory flag. NA means that the public document does not provide sufficient evidence for D, Di, or P.

Code and data availability

600 No custom code was used in this study. The derived analytic materials currently available with the manuscript comprise the 19-segment coding matrix, three contextual records, source-linked excerpts, source register, access dates, and borderline-
 decision notes in Appendices A and B. The official university webpages are third-party materials and remain subject to their original access conditions. A complete repository package should additionally contain the full codebook, candidate-level exclusion log, analytic memos, archive filenames, and permissible webpage snapshots. At the time of this version, no persistent repository identifier had been assigned; accordingly, no repository DOI is reported or invented.



Author contributions

605 Weihua Zhao conceptualized and designed the study, conducted the case selection, data collection, coding and analysis, and led the preparation and revision of the manuscript. Li Zhang contributed to data collection, source verification, and manuscript preparation and revision. Lei Wei contributed to data collection and manuscript preparation and revision. All authors reviewed and approved the final manuscript.

Competing interests

610 The authors declare that they have no conflict of interest.

Ethical statement

This study was based exclusively on publicly available institutional and curricular documents and did not involve human
615 participants, personal data, or intervention. Therefore, ethical approval was not required.

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