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Tracing Sustainability Knowledge from Course Aims and Content to Learning Outcomes: An Element-Level Analysis of an Interior Architecture Curriculum

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Abstract

Curriculum studies in sustainable design commonly map themes or Sustainable Development Goals (SDGs), but such mapping does not show whether specifically named disciplinary knowledge remains identifiable in formal learning outcomes. This study therefore examines how sustainability-related knowledge is represented across course aims/content and learning outcomes in a publicly documented 2025–2026 undergraduate Interior Architecture curriculum. Across all 70 course records, aims and content from 67 records yielded 1168 named knowledge elements; 169 sustainability-related elements in 17 courses met conservative inclusion criteria across seven domains. Each element was coded as preserved, generalized, displaced, or not represented. Independent re-unitization of a predefined 14-course validation sample yielded Krippendorff's unitizing alpha of $\alpha U = 0.84$, while independent recoding of all 169 included elements yielded 81.7% pre-adjudication agreement (Cohen's $\kappa = 0.725$); final adjudicated transformation classifications were used for analysis. Overall, 45.0% were preserved at equivalent specificity, 30.2% generalized, 4.1% displaced, and 20.7% not represented. Preservation was highest for materials, water, resources, and circularity (77.8%) and indoor environmental quality, health, and safety (69.6%) but lower for climate/energy performance (22.2%) and heritage/adaptive reuse (20.7%). Leave-one-course-out estimates ranged from 41.1% to 48.3%. The study distinguishes curricular presence from outcome-level specificity and provides a transparent element-level diagnostic for examining how sustainability knowledge is formally recontextualized across curricular fields without treating documentary visibility as evidence of teaching or learning.

Keywords: interior architecture education; sustainability education; curriculum analysis; learning outcomes; knowledge recontextualization; element-level tracing; Education for Sustainable Development (ESD); Sustainable Development Goals (SDGs)

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1. Introduction

The built environment is central to the sustainability transition because decisions about buildings, materials, energy, water, health, accessibility, and reuse shape long-lived

environmental and social consequences. The United Nations 2030 Agenda frames these consequences across interconnected goals, while the latest global assessment of buildings and construction shows that the sector remains materially distant from a net-zero and climate-resilient trajectory [1,2]. Material extraction and production add a further life-cycle burden, particularly where design choices lock in carbon-intensive products, rapid replacement, and avoidable waste [3]. Interior architects participate directly in these decisions: they specify finishes and assemblies, configure environmental conditions, mediate accessibility and wellbeing, and frequently intervene in existing buildings. Sustainability is therefore not a peripheral ethical theme in interior architecture education; it is part of the knowledge base required for consequential professional judgment.

International education frameworks have accordingly moved beyond general awareness. Education for Sustainable Development (ESD) is expected to connect disciplinary knowledge with systems thinking, anticipatory reasoning, normative judgment, collaboration, and action [4,5]. More recent climate-education guidance adds a demand for scientifically accurate, justice-oriented, action-relevant curricula [6]. Professional standards for interior design likewise locate environmental systems, health, safety, wellbeing, inclusive design, materials, and responsible practice within the expected educational foundation of entry-level practitioners [7]. These agendas create a clear curriculum-design problem: programs must not only mention sustainability but also specify what students are expected to know and be able to do with that knowledge.

Higher education research has documented rapid growth in SDG and sustainability initiatives, yet it also warns against equating institutional visibility with educational depth [8–11]. Frameworks can support curriculum review, but they can also encourage broad labeling that is easier to report than to translate into disciplinary learning [12]. Transformative curriculum design requires sustainability to be connected to the epistemic substance of a field and to explicit educational expectations [13–15]. Recent work has expanded the methods used to identify and examine SDG-related content in course, curriculum, and higher-education documents, including semantic matching approaches [16–22]. Recent studies in closely related design disciplines have examined different dimensions of formal sustainability integration. Matin et al. [23] combined program-outcome mapping, thematic-intensity coding of focal architecture courses, and analysis of pedagogical documentation to examine SDG-related curricular coherence. Ardaturk and Yasar [24] audited industrial design course records to distinguish sustainability-related competency visibility, disciplinary carrier evidence, and sustainability-specific assessment alignment. Rezaeifam et al. [25] compared project/construction management courses through thematic-intensity coding and SDG alignment, with attention to life-cycle, digital, and governance dimensions. These studies extend beyond theme counting by examining curricular organization and connections among documentary components.

The present study addresses a different analytical relation within this documentary tradition: the correspondence between each explicitly named sustainability-related knowledge element in course aims/content and the complete learning-outcome set of the same course. Its distinction from these studies lies not simply in examining another discipline or including learning outcomes, but in classifying the specificity of that correspondence. Each eligible element is examined to determine whether its defining object and disciplinary function remain identifiable at equivalent specificity. If not, the analysis determines whether the element is generalized or displaced, or has no identifiable outcome counterpart. The resulting analysis distinguishes relations that course-level SDG alignment, thematic-intensity profiles, and competency-visibility classifications do not resolve by themselves.

This limitation is especially important in architecture and allied design education. Research shows diverse approaches to integrating sustainability, ranging from stand-alone

courses and technical modules to design-studio interventions and whole-program frameworks [26,27]. SDG-oriented studies have examined educators' perspectives, quantified goal contributions, mapped course structures, and developed studio guidelines [28–36]. Studio cases demonstrate that focused pedagogies can cultivate awareness and design responses related to water, climate, regeneration, and the SDGs [37–40]. At the same time, curricular change is constrained by program structures, staff expertise, disciplinary traditions, and the division between technical knowledge and design synthesis [41,42]. Program-level maps are valuable for revealing distribution, but broad correspondence to an SDG does not establish whether the named knowledge that gives that correspondence substance is retained in assessable educational intentions [23].

The distinction is equally consequential in interior architecture. Research has identified insufficient education and technical knowledge among the barriers to sustainable interior practice [43,44]. Recent teaching studies address circular retail design, student attitudes, biomimicry, eco-materials, integrated studios, and adaptive reuse [45–50]. A systematic review proposes a wide knowledge field including environmental awareness, design principles, life-cycle assessment, renewable energy, materials, indoor environmental quality, social-cultural considerations, research, interdisciplinarity, and professional responsibility [51]. Earlier studies similarly examined the educational value of industry collaboration, cross-cultural green-building approaches, and interior-design students' sustainability attitudes [52–54]. Together, this body of literature establishes what sustainable interior architecture education may encompass. It provides less evidence about whether specifically named sustainability knowledge remains identifiable at comparable specificity across course aims/content and learning outcomes within a complete curriculum.

Learning outcomes matter because they formalize the performances, understandings, or capabilities that a course publicly commits to developing. Constructive alignment treats the relation among intended outcomes, teaching activities, and assessment as a design requirement [55]. The present study addresses an earlier link in that chain: whether the knowledge named in aims and content remains identifiable when intended learning is formulated. A recontextualization-informed perspective provides a vocabulary for examining this cross-field relation. Knowledge may be selected, compressed, combined, or reframed as it is represented across curricular contexts [56–59]. Loss of specificity is not automatically a defect; generalization may be pedagogically purposeful. Nevertheless, a curriculum may name climate-responsive design, sustainable certification, adaptive reuse, or indoor-air quality in one field while expressing only generic awareness or design ability in its outcomes. In such cases, the strength and location of its formal commitment become harder to judge.

This study therefore moves from thematic mapping to element-level tracing. It examines a complete, publicly documented Interior Architecture curriculum and asks how explicitly named sustainability knowledge is represented across course aims/content and course learning outcomes. Three research questions guide the analysis:

RQ1. Which sustainability-related knowledge domains are explicitly represented in course aims and content, and where are they located by curriculum year and course status?

RQ2. To what extent are named sustainability-related knowledge elements preserved, generalized, displaced, or not represented in the corresponding course learning outcomes?

RQ3. How does content-to-outcome specificity vary by sustainability domain and curricular location, particularly between compulsory and elective provision and between specialist courses and advanced studio/capstone records?

The contribution is substantive and methodological. Substantively, the study identifies where an Interior Architecture curriculum makes environmental and social sustainability knowledge explicit and where equivalent specificity is not retained in the outcome layer.

Methodologically, it offers a transparent tracing procedure that treats the named knowledge element—not the course, keyword, or SDG label—as the unit of comparison. The analysis is deliberately bounded to the published planned curriculum and does not infer classroom enactment, assessment practice, student experience, or achieved learning.

2. Conceptual Framework

2.1. From Sustainability Presence to Disciplinary Specification

Curriculum mapping is attractive because it can render a complex program visible. When applied to sustainability, mapping can locate themes across years, courses, learning outcomes, and program structures. It can also identify areas of concentration and reveal potential omissions [16,20,23,24,26,28]. Yet the usefulness of a map depends on the resolution of its unit. A course-level or SDG-level match may group together substantively different curricular conditions: a general statement of environmental awareness, a named technical principle, a professional standard, or an explicit design performance. These conditions should not be treated as equivalent simply because they share a broad sustainability label.

The SDGs are especially useful as a common interpretive vocabulary, but they are not a curriculum in and of themselves. Their targets connect interior architecture to health, resource efficiency, energy, inclusive public space, heritage, climate education, and ecological systems [1]. They can therefore support domain construction and comparative communication. However, assigning a course or knowledge element to an SDG does not demonstrate that the goal is educationally achieved. The curricular question is whether domain-relevant knowledge is sufficiently specified to guide learning and judgment. Recent critiques of framework-based embedding make the same point: sustainability education can remain pragmatic and additive unless goals are translated into disciplinary content, competences, and learning processes [12–15].

Interior architecture makes the need for specificity unusually visible. "Sustainable design" may refer to operational energy, embodied impacts, water use, circular material flows, indoor environmental quality, universal design, social equity, heritage conservation, adaptive reuse, ecology, or several of these relations at once [43,44,51]. Each area draws on different objects and forms of judgment. A learning outcome may mention 'sustainability' without identifying the relevant material, environmental, social, or evaluative relation. Such wording may communicate aspiration without locating the knowledge needed to act. Conversely, a curriculum may contain sustainability-relevant knowledge without using an SDG label—for example, thermal comfort, indoor-air quality, accessible circulation, water conservation, or conservation of existing fabric. An analytically credible approach must therefore identify explicitly specified domain-relevant knowledge while resisting inflation from generic terms whose relation to sustainability is not sufficiently defined.

2.2. Knowledge Recontextualization and Outcome Formulation

Recontextualization provides a framework for considering how knowledge may be selected, compressed, combined, or reframed across educational representations. In professional curricula, disciplinary knowledge can be represented differently across program structures, course descriptions, teaching activities, and evaluative expectations [56–59]. These differences are consequential because curricular representations vary in what they name explicitly, what they combine, and how much disciplinary specificity they retain.

For this study, a recontextualization-informed perspective provides a vocabulary for distinguishing four documentary relations. First, a knowledge element may be preserved: its defining object and disciplinary function remain identifiable. Second, it may be generalized: a related broader category remains, but the element's defining specificity disappears. Third, it may be displaced: the outcome foregrounds a materially different object or rela-

tion. Fourth, it may not be represented in the course's stated outcomes. The four codes operationalize recontextualization through the recoverability of the named knowledge object and its disciplinary function across documentary fields. These relations describe visibility within the formal curriculum; they do not rank alternative phrasings or diagnose the instructor's intentions or classroom practice.

The distinction between preservation and generalization is crucial. Outcomes must often integrate multiple weekly topics into a manageable set of course-level expectations. Some compression is therefore necessary. The analytical issue is not whether every content phrase is repeated verbatim but whether the disciplinary object remains traceable. "Analyze thermal, acoustic, lighting and air-quality parameters in interior design" preserves named environmental knowledge even when wording changes. "Understand building materials" generalizes a content commitment to thermal-insulation materials because the specific performance relation can no longer be identified. The trace is semantic and functional rather than lexical.

2.3. Constructive Alignment as a Curriculum-Design Rationale

Constructive alignment proposes that intended outcomes should guide teaching and assessment [55]. The present analysis does not inspect teaching activities or assessment evidence. It nevertheless draws on the same logic: named knowledge must remain sufficiently identifiable in the intended-outcome layer if it is to function as an explicit formal commitment at that layer. Course-content fields and learning outcomes serve different documentary functions: content may enumerate topics, whereas outcomes commonly integrate them into broader performances. The analysis therefore does not require one-to-one repetition. A single integrative outcome can preserve several elements when their salient objects and relations remain recoverable.

Taken together, the recontextualization-informed perspective and constructive-alignment rationale support a precise analytical distinction. Sustainability presence in aims/content and sustainability specificity in learning outcomes are different curricular properties. The first indicates what a course record explicitly identifies as relevant knowledge; the second indicates whether that knowledge remains sufficiently identifiable in the formal statement of expected learning. Examining the relation between these fields can therefore reveal more than thematic prevalence while remaining appropriately bounded to the planned curriculum.

3. Materials and Methods

3.1. Study Design and Data Source

The study used a bounded documentary curriculum analysis of the publicly accessible 2025–2026 Education Information System course-information package for the undergraduate Interior Architecture program at Istanbul Aydın University, Türkiye. For source traceability, the complete 70-course inventory is cross-referenced to the archived 2025–2026 Module Handbook (IAU.InteriorDesignProgram.ModuleHandbook.pdf). Page locators in the Course Inventory sheet of Supplementary Table S1 refer to this archived document. Document analysis was appropriate because the research questions concern formal curricular representation rather than classroom behavior [60]. The package spans eight semesters and is organized as individual course records containing course identifiers, year/semester placement, course status, course aims, content descriptions, and course learning outcomes. Records are classified as compulsory, program elective, or faculty elective. The analytical corpus comprised all 70 records listed for the four-year program; no course was selected or excluded according to whether it mentioned sustainability.

The case met three requirements for the analysis: public accessibility, complete program coverage, and the availability of aims/content and learning outcomes in comparable course records. The case is not treated as statistically representative of Interior Architecture programs in Türkiye or internationally. Its value lies in applying an element-level analytical procedure to a complete formal curriculum and establishing propositions that can be examined comparatively in other programs.

3.2. Unitization of Named Knowledge

An atomic element was defined as the smallest explicitly named object, principle, condition, standard, process, or disciplinary relation that could be traced independently against the course's learning outcomes. Segmentation retained compound expressions when separation would destroy their meaning, such as "indoor air quality", "thermal-insulation materials", or "heritage conservation and adaptive reuse". Generic verbs, administrative statements, teaching activities, and unspecific references to design, users, materials, culture, legislation, or environment were not treated as knowledge elements unless a disciplinary object or relation was named.

To assess the reproducibility of element unitization independently from downstream sustainability screening and transformation coding, a second coder independently reunitized a predefined 14-course validation sample, representing 20% of the 70-course corpus, from the raw course aims/content using the same unitization rules. The validation sample covered all four curriculum years, compulsory and elective provision, and both Turkish- and English-language source text. The second coding was conducted without access to the original element list or downstream sustainability-screening, domain-assignment, or transformation-coding decisions. Agreement in the segmentation and identification of named knowledge elements was calculated before reconciliation using Krippendorff's unitizing alpha, yielding $\alpha U = 0.84$.

The procedure produced 1168 named knowledge elements from aims and content in 67 of the 70 course records. Three records did not supply text that met the unitization rule. The complete 70-course inventory, including the three records that yielded no unitizable elements, is provided in the Course Inventory sheet of Supplementary Table S1. Coding decisions were stored at the unit level with the course code, curricular location, source field, canonical element, complete source passage, linked outcome(s), and outcome excerpt. A study-specific coding manual, informed by established qualitative coding principles [61], specified the categories, decision rules, exclusion guards, and boundary examples used in the analysis. The categories themselves were developed for the research questions and documentary structure of this study.

Course records contained Turkish and English wording. Fourteen included elements came from one Turkish-designated record and 155 from English-designated records; one English-designated record also contained a Turkish learning outcome. Canonical English element labels supported cross-course tabulation, while transformation decisions were made against the complete source passages and outcome sets as publicly supplied. The original wording is retained in the supporting dataset; independent back-translation was not undertaken.

3.3. Sustainability Screen and Domain Taxonomy

An element entered the sustainability subset only when its wording met one of two conditions: (a) it directly named sustainability, sustainable design, a sustainability standard, or certification; or (b) it named a domain-specific object with an established environmental or social sustainability relation in the built environment. Generic terms were excluded unless qualified by a specific relation. For example, "materials" alone was excluded, whereas

recycled materials, low-impact materials, material life cycle, or thermal-insulation materials were eligible. "User needs" was excluded, whereas accessibility, universal design, occupant health, or indoor-air quality was eligible. The screen was intentionally conservative and targeted explicitly specified sustainability knowledge rather than latent thematic associations. A generic element was not classified as sustainability-related solely because the surrounding passage contained sustainability-related language; the qualifying relation had to be identifiable in the element itself or in an indispensable qualifier directly specifying that element.

Seven domains were defined from the intersection of international sustainability/ESD frameworks, interior-design professional expectations, and the specialist literature [1,4–7,26,43,51]. The domains and indicative SDG relations are shown in Table 1. SDG relations were used to interpret the taxonomy, not to infer that the presence of an element demonstrates achievement of a goal or target.

Table 1. Sustainability-domain taxonomy, inclusion anchors, and interpretive SDG relations.

Domain	Operational Scope and Inclusion Anchors	Indicative SDG Target(s)	Exclusion Guard
D0. Explicit sustainability concepts, standards, and certifications	Sustainability/sustainable design; green-building standards; certification systems; explicit sustainability principles	4.7	Generic environmental awareness without a named sustainability object
D1. Climate, energy, and environmental performance	Climate-responsive design; energy efficiency; passive strategies; insulation; heat transfer; environmental performance	7.3; 11.6; 13.3	Generic climate, heat, or building-technology references without a performance relation
D2. Materials, water, resources, and circularity	Recycled/low-impact materials; life cycle; water conservation; resource efficiency; waste prevention; circular design	6.4; 12.2; 12.5	Unqualified references to materials, construction, water, or products
D3. Indoor environmental quality, health, and safety	Indoor-air quality; thermal/acoustic/lighting comfort; healthy interiors; built-environment health and safety relations	3.9; 11.6	Generic comfort, safety, occupational-health-and-safety, or user references without a named built-environment environmental or health relation
D4. Inclusion, accessibility, and social equity	Universal design; accessibility; inclusive use; equitable participation; design for diverse abilities	10.2; 11.7	Generic user needs or social context without an inclusion/accessibility relation
D5. Heritage conservation and adaptive reuse	Conservation of built heritage; restoration; adaptive reuse; retention of existing fabric; cultural continuity	11.4	History/style content without a conservation or reuse relation
D6. Ecology, landscape, and human–environment relations	Ecological design; biodiversity; biophilia; sustainable landscape; human–environment relations with a specified ecological or sustainability dimension	11.6; 13.3; 15.9	Generic landscape, nature, environment, or human–environment references without a specified ecological or sustainability relation

Note: SDG relations organize interpretation; they are not measures of SDG achievement.

Applying these conservative rules identified 169 sustainability-related elements in 17 course records. Of these 169 elements, 32 (18.9%) met criterion (a) by directly nam-

ing sustainability, sustainable design, a sustainability standard, or certification, whereas 137 (81.1%) met criterion (b) by naming a domain-specific object with an established environmental or social sustainability relation. In the final taxonomy, the criterion-(a) elements comprised D0, while the criterion-(b) elements were distributed across D1–D6. Where an element plausibly touched more than one domain, it was assigned one primary domain according to its defining object. This avoided multiple counting in descriptive totals. The full phrasing and any secondary matches remained in the unit-level analytical record. The supporting dataset reports the complete 1168-element screening frame, the 169 included analytical units, and the complete outcome sets for the 17 course records containing eligible elements. The seven-domain model reflects both environmental and social sustainability relations in built-environment practice. A domain-restricted sensitivity analysis retained D0, D1, D2, and D6, excluding D3, D4, and D5. This analysis examined the sensitivity of the preservation estimate to domain selection rather than isolating exclusively environmental knowledge, because D0 also includes social and economic dimensions of sustainability.

3.4. Content-to-Outcome Transformation Coding

Each eligible sustainability element was compared with the complete set of learning outcomes in the same course. The comparison asked whether the element's defining object and disciplinary function remained identifiable, not whether identical words reappeared. Four mutually exclusive transformation codes were applied (Table 2). The four codes describe documentary relations between curricular fields rather than an observed temporal sequence in curriculum writing.

Table 2. Decision rules for content-to-outcome transformation coding.

Code	Decision Rule	Evidence Threshold	Illustrative Trace
Preserved	The defining knowledge object and its disciplinary function remain identifiable at equivalent specificity.	Explicit semantic/functional correspondence in one or more outcomes.	"Thermal comfort" → outcome names heat, light, sound, and air components and their integration into design (IMT112).
Generalized	A related broader category remains, but the source element's defining specificity is lost.	A defensible relation exists, but the named object/performance cannot be recovered.	"Thermal-insulation materials" → "explain the properties of building materials" (IMT228).
Displaced	The outcome redirects the element toward a materially different object, mechanism, or relation.	An outcome is relevant to the topic area but changes the substantive focus.	"Heat-dissipation mechanisms" → "understands heat insulation" (IMT223).
Not represented	No corresponding learning outcome is identifiable in the course record.	No explicit semantic or functional match across the complete outcome set.	"Sustainable-building certifications" → no corresponding outcome (IMS202).

The illustrative traces in Table 2 are concise English renderings of the analyzed course-record language. When more than one learning outcome was relevant, the element was linked to all pertinent outcomes and assigned the highest-fidelity relation demonstrably supported by the text. A preserved classification required an explicit semantic match at equivalent specificity. A broader outcome with a recognizable relation but without the defining specificity was coded as generalized. Displaced was reserved for a stated outcome that redirected the element toward a materially different object or relation; it was not used when no outcome correspondence existed. Where no corresponding learning outcome could be identified, the element was coded as not represented.

Further boundary examples clarified the distinctions. An integrative outcome naming heat, light, sound, and air preserved several separately named comfort elements. By contrast, "thermal comfort" was generalized when an outcome referred only to physical environment and building physics. Conservation of traditional building elements was displaced when the relevant outcome concerned documenting their present condition without retaining the conservation relation. Selecting the highest demonstrable fidelity across a course's complete outcome set favored preservation and therefore avoided inflating the non-preserved category.

The seven displaced relations involved changes, rather than simple broadening, of the defining object or function: conservation or the cultural function of traditional building elements became documentation of existing conditions; heat-dissipation mechanisms or envelope precautions became heat insulation; technical knowledge became theoretical knowledge; and the historical emergence or development of sustainability concepts became current developments and practices. Unit-specific rationales are reported in the supporting dataset.

3.5. Analytical Procedure and Quality Controls

Corpus construction, unitization, sustainability screening, domain assignment, and content-to-outcome coding followed a two-pass rule-based procedure. The first pass unitized course aims/content and applied the sustainability inclusion and domain rules. The second pass compared each included element with the complete learning-outcome set of the same course and assigned one transformation code. Unit-level records retained the source passage, domain assignment, relevant outcome(s), outcome excerpt, transformation code, and decision rationale. Dataset integrity checks covered duplicate identifiers, missing fields, invalid domain or transformation codes, and consistency between unit-level records and aggregate summaries. Course, domain, year, semester, course-status, and transformation totals were recomputed from the final adjudicated unit-level dataset.

Independent recoding was conducted for all 169 included sustainability-related elements using the predefined four-category rules. The independent coding record contained the named knowledge element, complete supporting source passage, and complete learning-outcome set of the corresponding course. For each element, relevant outcome(s) were identified, a transformation code was assigned, and a rationale was recorded. The two sets of transformation classifications were compared before adjudication. Raw percentage agreement and unweighted Cohen's kappa were calculated for the four nominal categories.

The research team reviewed the 31 classification disagreements against the source passages, complete outcome sets, and decision rules, and recorded a final code, linked outcome(s), and rationale for each case. All reported analyses use the final adjudicated classifications; both pre-adjudication code sets are retained in Supplementary Table S1. The two reliability assessments addressed different analytical stages. Krippendorff's unitizing alpha ($\alpha U = 0.84$) evaluated independent segmentation and identification of named knowledge elements in the 14-course validation sample, whereas the 81.7% raw agreement and Cohen's $\kappa = 0.725$ evaluated four-category transformation coding on the fixed set of 169 included sustainability-related elements. Sustainability screening, primary-domain assignment, and bilingual normalization were not independently replicated. The supplement also provides the coding comparison, confusion matrix, adjudication record, and formula-based analytical summaries.

Two robustness checks examined the stability of the principal preservation estimate. First, a leave-one-course-out analysis recalculated the preservation rate after removing each sustainability-bearing course in turn. Second, a domain-restricted sensitivity analysis retained D0, D1, D2, and D6. Additional diagnostic subsets examined the three specialist

sustainability/adaptive-reuse electives and the advanced studio/capstone records containing eligible elements.

Because the corpus is the complete published curriculum of one program rather than a probability sample, the analysis uses descriptive counts, percentages, and course-equal summaries. No population inference is claimed. The element-weighted preservation rate was calculated across all eligible elements, so courses contributed to this estimate in proportion to the number of eligible elements they contained. For the course-equal summary, a preservation rate was first calculated separately for each of the 17 sustainability-bearing courses and the arithmetic mean of these course-level rates was then calculated, giving each course equal weight regardless of element count. The course-level median was calculated from the same 17 within-course preservation rates. These summaries therefore describe different distributions: the element-weighted estimate summarizes coded elements, whereas the course-equal mean and median summarize variation across courses. Multiple elements could originate from the same source passage and course record; element-weighted percentages therefore describe coded documentary units rather than statistically independent observations. They do not measure instructional time, credit weight, curricular importance, or student exposure. The comparison also does not assume that content and outcomes should have equal granularity; it asks only whether an explicitly named knowledge object remains recoverable in the outcome layer.

3.6. Ethical and Interpretive Boundaries

The study analyzed publicly accessible institutional curriculum records and involved no human participants, personal data, student work, or confidential material. Ethical approval and informed consent were therefore not applicable. "Not represented" means that a corresponding outcome was not visible in the analyzed course record. It does not mean that the topic was not taught, discussed, assessed, or learned. Similarly, preservation in a published outcome does not establish the quality of instruction or achieved competence.

4. Results

4.1. Corpus Coverage and Curricular Distribution

Of the 1168 named knowledge elements extracted from 67 course records, 169 (14.5%) met the sustainability inclusion rule. These elements occurred in 17 of the program's 70 course records (24.3%). Thus, documented sustainability-related elements were concentrated in a subset of records with different thematic and curricular positions (Figure 1).

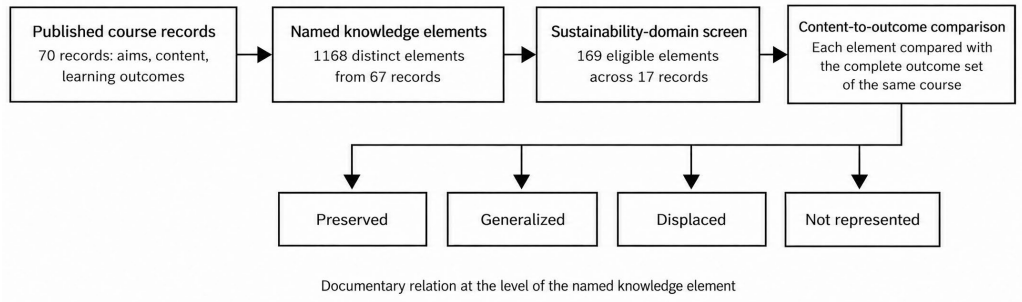


Figure 1. Analytical sequence from the complete set of course records to element-level content-to-outcome documentary relations. Arrows indicate the analytical sequence and the assignment of eligible elements to the four mutually exclusive transformation categories.

Year 4 contained the largest annual share, with 79 of the 169 documented elements (46.7%), followed by Year 2 with 61 (36.1%), Year 3 with 15 (8.9%), and Year 1 with 14 (8.3%). Program electives contained 83 elements (49.1%), compulsory courses 85 (50.3%), and one

faculty elective contributed a single element (0.6%). The near parity between compulsory and program-elective element totals should not be interpreted as equivalent curricular access: the elective total was distributed across six program electives, whereas the compulsory total occurred across ten courses. Figure 2 separates these patterns by curricular dimension: Panel A shows the distribution and transformation composition of eligible elements across curriculum years, whereas Panel B compares the corresponding composition in compulsory and program-elective courses.

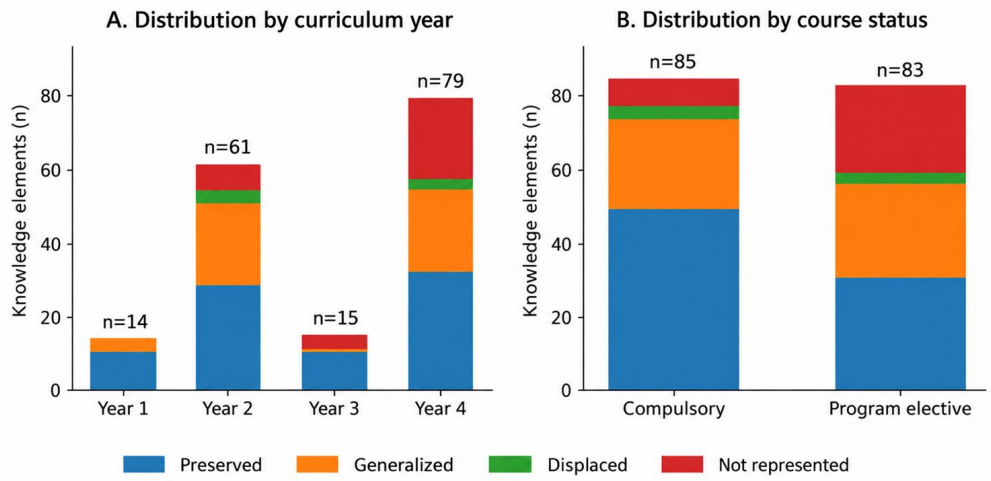


Figure 2. Distribution and transformation of documented sustainability-related knowledge elements by curriculum year and course status. (**A**) Distribution by curriculum year, showing eligible element counts and the composition of preserved, generalized, displaced, and not represented classifications across Years 1–4. (**B**) Distribution by course status, comparing compulsory and program-elective records using the same transformation categories. The single faculty-elective element is omitted from Panel (**B**) and reported in the text.

4.2. Overall Content-to-Outcome Transformation

Seventy-six of the 169 sustainability-related elements were preserved in at least one course learning outcome at equivalent specificity (45.0%). Fifty-one were generalized (30.2%), seven displaced (4.1%), and 35 not represented (20.7%). Consequently, 93 elements (55.0%) did not retain equivalent specificity in the outcome layer. The course-equal mean preservation rate was 34.2% and the median 22.7%, both below the element-weighted rate. The three summaries answer different descriptive questions. The 45.0% element-weighted rate gives greater influence to courses contributing more eligible elements, whereas the 34.2% course-equal mean gives each of the 17 sustainability-bearing courses the same weight regardless of element count. The 22.7% median further indicates that at least half of these courses had preservation rates at or below 22.7%. The lower course-based summaries therefore reveal substantial course-level unevenness and indicate that the 45.0% aggregate should not be interpreted as the preservation rate of a typical sustainability-bearing course. These overall results are summarized in Table 3.

Table 3. Corpus coverage and overall transformation profile.

Indicator	Result
Course records in the published program	70
Records containing unitizable named knowledge	67
All named knowledge elements	1168
Sustainability-related elements	169 (14.5% of all elements)
Courses containing sustainability-related elements	17 (24.3% of all records)

Table 3. *Cont.*

Indicator	Result
Preserved	76 (45.0%)
Generalized	51 (30.2%)
Displaced	7 (4.1%)
Not represented	35 (20.7%)
Course-equal preservation	Mean 34.2%; median 22.7%

Note: Percentages may not sum to 100.0 because of rounding.

4.3. Variation by Sustainability Domain

The largest domain was indoor environmental quality, health, and safety, containing 46 elements (27.2% of the sustainability subset), of which 32 were preserved (69.6%). Materials, water, resources, and circularity was smaller (nine elements) but had the highest preservation rate (77.8%). Inclusion, accessibility, and social equity comprised 27 elements, of which 51.9% were preserved.

The lowest preservation occurred in heritage conservation and adaptive reuse (20.7%), climate, energy, and environmental performance (22.2%), and ecology, landscape, and human–environment relations (23.5%). Explicit sustainability concepts, standards, and certifications showed 34.4% preservation, while 28.1% were not represented. Domain profiles are reported in Table 4 and Figure 3. Because D1 and D2 each contained only nine elements, their rates should be interpreted with the corresponding counts.

Table 4. Transformation profile by sustainability domain.

Domain	Courses (*n*)	Elements *n* (%)	Preserved *n* (%)	Generalized *n* (%)	Displaced *n* (%)	Not Represented *n* (%)
Explicit sustainability concepts, standards, and certifications	6	32 (18.9%)	11 (34.4%)	9 (28.1%)	3 (9.4%)	9 (28.1%)
Climate, energy, and environmental performance	5	9 (5.3%)	2 (22.2%)	3 (33.3%)	2 (22.2%)	2 (22.2%)
Materials, water, resources, and circularity	3	9 (5.3%)	7 (77.8%)	0 (0.0%)	0 (0.0%)	2 (22.2%)
Indoor environmental quality, health, and safety	7	46 (27.2%)	32 (69.6%)	13 (28.3%)	0 (0.0%)	1 (2.2%)
Inclusion, accessibility, and social equity	4	27 (16.0%)	14 (51.9%)	7 (25.9%)	0 (0.0%)	6 (22.2%)
Heritage conservation and adaptive reuse	4	29 (17.2%)	6 (20.7%)	12 (41.4%)	2 (6.9%)	9 (31.0%)
Ecology, landscape, and human–environment relations	4	17 (10.1%)	4 (23.5%)	7 (41.2%)	0 (0.0%)	6 (35.3%)

The domain profiles also showed different patterns of reduced specificity. In heritage conservation and adaptive reuse, generalization accounted for 41.4% of the elements and non-representation for 31.0%. In ecology, landscape, and human–environment relations, the corresponding shares were 41.2% and 35.3%. Climate, energy, and environmental performance contained only nine elements and a displaced share of 22.2%; each element therefore changes the domain percentage by 11.1 points.

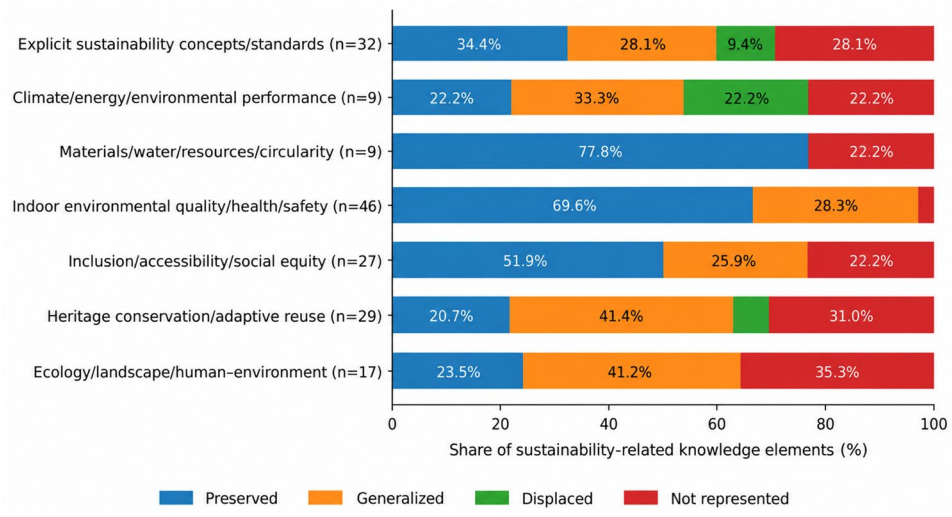


Figure 3. Content-to-outcome transformation profile by sustainability domain. Percentages are calculated within each domain; very small segments are not labeled inside the bar. Percentages may not sum to 100.0% due to rounding.

4.4. Course Status, Year, and Course-Level Concentration

Compulsory courses preserved 47 of 85 sustainability-related elements (55.3%), compared with 29 of 83 elements in program electives (34.9%). The program-elective subset also had a higher proportion of not-represented elements (32.5% versus 9.4%). The single faculty-elective element was generalized and is reported separately.

Year-level preservation was not monotonic. Year 1 preserved 78.6% of its 14 elements, all within one course; Year 2 preserved 42.6% of 61; Year 3 preserved 66.7% of 15; and Year 4 preserved 36.7% of 79. These figures describe the records containing eligible elements and should not be read as a developmental trajectory. Year 4 contained the largest volume of sustainability-related content, but this concentration was not accompanied by higher outcome-level specificity. The complete year and course-status profiles are provided in Table 5.

Table 5. Transformation profile by curriculum year and course status.

Location	Courses (*n*)	Elements (*n*)	Preserved *n* (%)	Generalized *n* (%)	Displaced *n* (%)	Not Represented *n* (%)
Year 1	1	14	11 (78.6%)	3 (21.4%)	0 (0.0%)	0 (0.0%)
Year 2	7	61	26 (42.6%)	23 (37.7%)	4 (6.6%)	8 (13.1%)
Year 3	3	15	10 (66.7%)	1 (6.7%)	0 (0.0%)	4 (26.7%)
Year 4	6	79	29 (36.7%)	24 (30.4%)	3 (3.8%)	23 (29.1%)
Compulsory	10	85	47 (55.3%)	26 (30.6%)	4 (4.7%)	8 (9.4%)
Program elective	6	83	29 (34.9%)	24 (28.9%)	3 (3.6%)	27 (32.5%)

Course counts include only records containing at least one eligible sustainability element. The single faculty-elective element was generalized and is reported in the text rather than included in percentage comparisons.

Figure 4 separates course-level thematic concentration from outcome-level preservation: Panel A maps the distribution of eligible elements across sustainability domains for each course, whereas Panel B reports the corresponding within-course preservation rates. Several courses were highly domain-specific: IMT112 concentrated on indoor environmental quality; IMT218 on heritage; IMS419 on inclusion/accessibility; and IMS424 on explicit sustainability concepts and standards. Other records distributed their elements across multiple domains. Preservation varied sharply even among records with a clear

sustainability identity, demonstrating that a specialist title or dense content description did not guarantee outcome-level specificity.

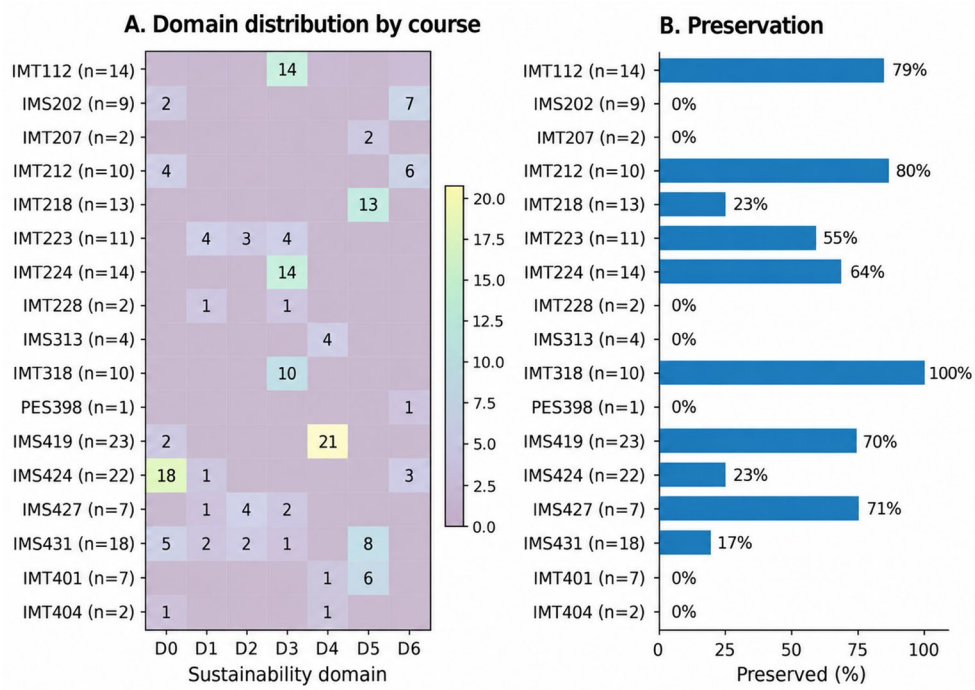


Figure 4. Course-level concentration and preservation of sustainability-related knowledge elements. (**A**) Domain distribution by course: each heat-map cell reports the number of eligible elements assigned to D0–D6 in the corresponding course. (**B**) Within-course preservation: bars report the percentage of eligible elements preserved at equivalent specificity in each course. D0, explicit sustainability concepts/standards; D1, climate/energy/environmental performance; D2, materials/water/resources/circularity; D3, indoor environmental quality/health/safety; D4, inclusion/accessibility/social equity; D5, heritage/adaptive reuse; D6, ecology/landscape/human–environment relations. Percentages for courses with very small element counts should be interpreted with the corresponding *n*. Course titles are listed in Table A1.

4.5. Specialist Electives and Advanced Studio/Capstone Records

Three program electives with explicit sustainability or adaptive-reuse orientations—IMS202, IMS424, and IMS431—contained 49 eligible elements. Only eight were preserved at full specificity (16.3%); 41 were generalized, displaced, or not represented (83.7%). The pattern was not driven by a single transformation category. Some knowledge was compressed into broad sustainability or ecological language, while other named topics, such as certification systems, particular ecological strategies, or specific adaptive-reuse relations, were not identifiable in the outcomes.

The advanced studio/capstone diagnostic subset comprised IMT401 and IMT404, the two records of these course types containing eligible sustainability-related elements. Together they contained nine eligible elements. None was preserved at equivalent specificity; one was generalized and eight were not represented. For example, "sustainability in adaptive reuse" and "disabled-friendly design criteria" in IMT401 had no identifiable outcome correspondence, while "technology in adaptive reuse" was generalized to the ability to use new techniques and technologies. The result does not show that sustainability was absent from studio teaching or student projects. It indicates that the public learning outcomes of these two records did not retain the specificity of the sustainability-related knowledge named in their aims/content.

4.6. Independent Validation, Robustness Checks, and Diagnostic Subsets

Independent re-unitization of the predefined 14-course validation sample yielded Krippendorff's unitizing alpha of $\alpha U = 0.84$ before reconciliation. This assessment concerned agreement in the segmentation and identification of named knowledge elements and was conducted separately from the subsequent transformation-coding reliability assessment. Independent recoding yielded identical transformation classifications for 138 of the 169 elements (81.7% agreement; Cohen's $\kappa = 0.725$). The remaining 31 elements (18.3%) were adjudicated against the source passages, complete outcome sets, and predefined decision rules. Agreement statistics were calculated before adjudication, and all substantive analyses were based on the final adjudicated classifications. The complete pre-adjudication comparison and unit-level adjudication decisions are provided in Supplementary Table S1.

The principal preservation estimate was stable to course-level influence. In the leave-one-course-out analysis, removing each of the 17 sustainability-bearing courses in turn produced preservation estimates ranging from 41.1% to 48.3%, around the primary estimate of 45.0%. The domain-restricted sensitivity analysis yielded a preservation rate of 35.8% (24/67) for D0, D1, D2, and D6, compared with 45.0% in the full seven-domain dataset.

The diagnostic subsets showed greater concentration of reduced specificity. The three specialist sustainability/adaptive-reuse electives contained 49 elements, of which eight (16.3%) were preserved. The two advanced studio/capstone records contained nine eligible elements, none of which was preserved at equivalent specificity. These subset results are descriptive and should be interpreted with their corresponding element and course counts (Table 6).

Table 6. Robustness checks and diagnostic subsets.

Analysis	Corpus	Preservation Result	Purpose/Scope
Primary analysis	169 elements	76 (45.0%)	All seven domains
Leave-one-course-out	146–168 elements per iteration	41.1–48.3%	Influence of any single course
Domain-restricted subset (D0, D1, D2, D6)	67 elements	24 (35.8%)	Sensitivity to domain selection
Specialist sustainability/adaptive-reuse electives	49 elements	8 (16.3%)	IMS202, IMS424, IMS431
Advanced studio/capstone records	9 elements	0 (0.0%)	IMT401, IMT404

5. Discussion

5.1. Presence and Preservation Are Different Curriculum Properties

The central result is straightforward but consequential: the curriculum contained a substantial and thematically diverse body of sustainability-related knowledge, yet fewer than half of the named elements remained visible at equivalent specificity in course learning outcomes. This finding does not contradict program-level SDG mapping. It clarifies what such mapping cannot by itself establish. A course can contribute language to an SDG map while leaving the substantive knowledge behind that contribution only broadly or inconsistently expressed in the outcome layer.

This distinction responds to a recurring problem in higher education sustainability work. The higher-education literature documents expanding attention to the SDGs [8–11,19,21], while curriculum-embedding studies show that broad frameworks can facilitate action across disciplines [17,20,22]. Yet the same literature warns that labeling and institutional intention may outpace transformation of the curriculum's disciplinary core [12–15,18]. The present results locate that tension within course records. Sustainability was not absent; outcome-level specificity was uneven. This unevenness should not be interpreted as evidence that sustainability knowledge is uniquely prone to specificity reduction. Because

the study did not include a matched non-sustainability comparison, it cannot determine whether comparable content-to-outcome compression also characterizes other curricular knowledge fields.

The transformation categories add explanatory resolution. Generalized elements (30.2%) retained a related broader idea but no longer made the defining object or relation recoverable at equivalent specificity. Such compression may be pedagogically defensible where outcomes integrate multiple topics and should not be equated with non-representation. By contrast, 20.7% of the elements had no identifiable outcome correspondence, while displacement was uncommon (4.1%). The central issue is therefore not whether every content item is repeated in an outcome, but which disciplinary objects and relations remain sufficiently identifiable when expected learning is formally stated.

5.2. Uneven Translation Across Sustainability Domains

The domain results complicate any unitary judgment about sustainability integration. Indoor environmental quality, health, and safety showed relatively strong preservation (69.6%), consistent with the established professional importance of lighting, acoustics, thermal comfort, air quality, health, and occupant performance [7,43,51]. Materials, water, resources, and circularity also showed high preservation (77.8%), although the domain contained only nine elements. The pattern is consistent with the possibility that comparatively concrete material and environmental relations are more readily specified in course outcomes, but the small domain count does not support a stronger inference.

By contrast, climate/energy/environmental performance (22.2%), heritage conservation and adaptive reuse (20.7%), ecology/landscape/human–environment relations (23.5%), and explicit sustainability concepts, standards, and certifications (34.4%) showed lower preservation. This matters because recent built-environment education research calls for climate knowledge to be integrated across professional degrees rather than isolated in specialist provision [27]. Interior interventions also have life-cycle consequences through material replacement and the treatment of existing building fabric [2,3,44]. Adaptive reuse can connect environmental conservation with sociocultural continuity, as recent interior-design pedagogy demonstrates [50]. Where such relations are explicitly named in course content but become broader in the outcome layer, the formal specificity of the curricular commitment is reduced.

The domain-restricted sensitivity analysis yielded 35.8% preservation (24/67) in D0, D1, D2, and D6, compared with 45.0% (76/169) overall. This difference is partly compositional: D3 and D4 together contained 73 elements, of which 46 were preserved (63.0%), so excluding them removes a comparatively high-preservation portion of the corpus. One possible, but untested, explanation is that D3/D4 include relatively discrete performance- or user-related objects—such as indoor-air quality, thermal comfort, universal design, and accessibility—that may be more readily retained when course content is reformulated as learning outcomes. This interpretation remains case-specific and should not be read as evidence of a general disciplinary mechanism. Importantly, D5 was also excluded from the restricted subset and had a low preservation rate (20.7%; 6/29), so the 35.8% estimate should not be interpreted as a simple environmental-versus-social contrast. Future applications of element-level tracing should therefore interpret aggregate preservation rates alongside domain composition and domain-specific results and define the inclusion or exclusion of social-sustainability-related domains a priori. The restricted analysis tests sensitivity to taxonomy scope rather than isolating exclusively environmental knowledge, because D0 itself includes social and economic dimensions.

5.3. Concentration in Later Years and Electives

Year 4 contained the largest annual share of documented sustainability-related elements (46.7%), while program electives accounted for 49.1% of the total. Concentration in later curricular stages can be pedagogically reasonable because students may require foundational design and technical knowledge before engaging more complex sustainability relations. Specialist electives can likewise support depth and emerging topics. The structural consideration is that knowledge located in optional provision is not necessarily encountered consistently across the student cohort, particularly when preservation was lower in program electives (34.9%) than in compulsory courses (55.3%). Because element counts do not measure enrolment or instructional weight, these findings concern documentary location rather than actual student exposure.

The pattern parallels concerns in architectural education about fragmented integration, specialist-course dependence, and the institutional work required for curriculum change [26,41,42]. It also provides a program-level counterpart to evidence from focused studio interventions [31,34,36–40]. Individual studios can support substantial sustainability learning, while a curriculum-wide structure also requires visible connections between specialist knowledge and integrative design stages. The present case contained strong pockets of sustainability-related content, but their documentary connections to outcome-level specificity were uneven.

5.4. Sustainability Specificity in Advanced Studio and Capstone Records

Within the two advanced studio/capstone records containing eligible sustainability-related elements, none of the nine elements was preserved at equivalent specificity; one was generalized and eight were not represented. Design studios are commonly positioned as settings in which technical, social, environmental, and esthetic knowledge are synthesized [31,34,36–40]. In these two records, however, the stated outcomes did not make the specifically named sustainability relations visible at equivalent specificity.

This finding concerns the documentary outcome layer only. Studio briefs, critiques, juries, assessment rubrics, and student projects were outside the dataset. The result therefore does not indicate an absence of sustainability teaching or design activity. Rather, it shows that the formal learning outcomes of these records did not explicitly retain the sustainability-related knowledge identified in their aims/content. Advanced outcomes need not enumerate every technical criterion, but they can identify the environmental, material, inclusion, or reuse relations expected to inform integrative design judgment.

Within this framework, ‘adequate preservation’ in an integrative studio outcome should not be treated as a lower studio-specific threshold or as a separate coding category. It means satisfying the existing Preserved criterion within a synthesis-oriented performance statement: the salient knowledge object and its disciplinary function must remain recoverable at equivalent specificity even when several elements are combined in one outcome. For example, an outcome such as ‘develop and justify an adaptive-reuse proposal that integrates sustainability principles, accessibility criteria, and conservation constraints’ could preserve several named relations within a single studio performance, whereas ‘develop an adaptive-reuse proposal using appropriate design criteria’ would generalize those relations because their defining objects are no longer identifiable. Likewise, an outcome such as ‘synthesize a graduation project that evaluates material choices in relation to life-cycle impacts and indoor environmental quality’ can retain multiple sustainability relations without requiring a separate outcome for each. These examples are illustrative rather than prescriptive; the operative test remains whether the named knowledge object and its disciplinary function remain recoverable, not whether the outcome repeats the original content wording or enumerates every technical criterion.

5.5. Implications for Curriculum Design and Review

The proposed trace can support curriculum review at three levels. First, domain-level results identify where sustainability knowledge is abundant but weakly specified in outcomes. Second, course-level results distinguish strong outcome articulation from mere content density. Third, program-level location analysis shows whether specialist and compulsory provision connect to integrative stages.

A practical review process could begin with a limited set of high-consequence knowledge relations rather than attempting to repeat every content item in outcomes. Course teams can ask: What must remain identifiable for this course's sustainability commitment to be educationally meaningful? Which outcome requires students to use that knowledge? At what later point is it integrated or revisited? These questions follow constructive-alignment logic [55] while recognizing that disciplinary knowledge may be recontextualized as it is represented across curricular fields [56–59].

The results also caution against indiscriminate outcome expansion. Overloaded outcomes can become unreadable and unassessable. The aim is selective precision: naming the material, environmental, social, or heritage relation that grounds a broader capability. For example, "evaluate interior design alternatives" becomes more informative when the basis of evaluation includes material life cycle, indoor environmental quality, accessibility, or conservation constraints. Such changes make sustainability knowledge visible without turning holistic design judgment into a checklist.

5.6. Methodological Contribution

Relative to the closely related curriculum studies [23–25], the methodological contribution concerns the relation being classified. The procedure links each eligible sustainability-related knowledge element to the complete learning-outcome set of its own course and distinguishes preservation, generalization, displacement, and non-representation. This allows elements associated with the same broad sustainability theme or competency category to be distinguished according to their outcome-level specificity. Domain-, course-, year-, and status-level summaries then locate these relations within the curriculum. The approach therefore complements analyses of thematic coverage, curricular coherence, and documented assessment alignment by providing an element-level account of how named knowledge is represented across aims/content and learning outcomes.

For researchers adapting the procedure to other disciplines, three safeguards are important. First, unitization should identify the smallest independently traceable knowledge object, principle, condition, standard, process, or disciplinary relation; compound expressions should remain intact when splitting would alter their meaning, and generic terms should not be treated as elements unless a disciplinary object or relation is explicitly specified. Second, in bilingual or multilingual records, original source passages and learning-outcome wording should remain the evidentiary basis for coding; standardized or canonical labels may support cross-course or cross-case tabulation but should not replace the source-language text in analytical decisions, and any translation-validation procedure should be documented separately. Third, preserved and generalized should be distinguished by recoverability rather than lexical repetition: an intentionally synthetic outcome may still be classified as preserved when the defining knowledge object and its disciplinary function remain identifiable at equivalent specificity, whereas a broader thematic statement should be classified as generalized when that specificity can no longer be recovered. Each element should be assessed against the complete relevant outcome set, with the highest-fidelity relation demonstrably supported by the text assigned.

The method can be examined beyond interior architecture. Outcome-based programs with sufficiently detailed aims/content and learning outcomes could apply the procedure to

climate literacy, circularity, accessibility, ethics, digital practice, or other cross-cutting knowledge fields. This methodological transferability should not be conflated with empirical generalizability. The preservation rates, domain profiles, and curricular-location patterns reported here are specific to the single program analyzed and should not be assumed to characterize other institutions, accreditation systems, or national contexts. Comparative multi-program studies are required to determine whether similar patterns recur across institutions, accreditation systems, languages, disciplines, and countries. The method is diagnostic rather than evaluative in isolation: preservation indicates formal documentary visibility, not educational quality or achieved competence.

5.7. Limitations and Future Research

The interpretation is bounded by six principal scope conditions. First, the analysis concerns one program at one institution and does not estimate the prevalence of any preservation pattern across Interior Architecture education. The numerical results reported here—including the overall preservation rate and the domain-, year-, and course-status profiles—are case-specific and should not be generalized beyond this program without comparative multi-program evidence. Second, the corpus represents only the published planned curriculum; course delivery, studio briefs and critiques, assessment criteria, student work, and achieved learning were not examined. Accordingly, a classification of 'Not represented' indicates only that no identifiable corresponding outcome was found in the analyzed course record and should not be interpreted as evidence that the topic was absent from teaching, studio activity, assessment, or student learning. Third, documentary granularity varies across course records. More detailed course descriptions naturally provide more elements for tracing; course-equal summaries and the leave-one-course-out analysis show that the principal preservation pattern was not dependent on any single element-rich course.

Fourth, semantic unitization, bilingual normalization, sustainability screening, primary-domain assignment, and transformation coding require analytical judgment. Fourteen included elements came from one Turkish-designated record and 155 from English-designated records; one English-designated record also contained a Turkish learning outcome. Canonical English labels facilitate cross-course tabulation, while the supporting dataset retains the supplied source passages, complete outcome sets, explicit rules, and unit-level decision rationales. Because independent back-translation was not undertaken, minor cross-linguistic nuance shifts introduced through canonical English normalization cannot be excluded; however, these labels were used for cross-course tabulation rather than as substitutes for the complete source passages and outcome sets used in transformation decisions. The reported pre-adjudication agreement (81.7%) and Cohen's $\kappa = 0.725$ quantify reliability only for transformation classification on the fixed set of 169 included sustainability-related elements. Element unitization was evaluated separately through an independent 14-course re-unitization exercise, which yielded Krippendorff's unitizing alpha of $\alpha U = 0.84$. Sustainability screening, primary-domain assignment, and bilingual normalization were not independently replicated, and neither of the reported reliability statistics should be interpreted as validating those analytical stages. Independent replication of these remaining stages in future applications would provide a stronger basis for assessing the reliability of the full analytical procedure across analysts, languages, and institutional contexts. Fifth, the SDG links are interpretive and organize established sustainability relations rather than measure SDG performance. Sixth, the study does not compare sustainability-related elements with a matched non-sustainability subset and therefore cannot determine whether specificity reduction is distinctive to sustainability knowledge or reflects a broader characteristic of outcome formulation. A direct test of this question would require applying the

same unitization and transformation rules to a matched set of non-sustainability knowledge elements—such as construction, history, or representation/drafting content—so that sustainability-related and other curricular knowledge can be compared under equivalent analytical conditions.

Future research can apply the procedure across multiple Interior Architecture programs and connect formal outcomes with enacted and assessed evidence. Sequential designs could compare course records with studio briefs, assessment rubrics, student portfolios, and interviews while maintaining the distinction among intended, enacted, assessed, and achieved curricula. Longitudinal studies could also examine whether targeted changes in outcome formulation improve continuity across prerequisite, studio, and capstone stages.

6. Conclusions

This study examined a problem that broad sustainability maps cannot resolve: whether specifically named sustainability knowledge remains identifiable when course aims and content are represented in learning outcomes. Across a complete Interior Architecture curriculum, sustainability-related knowledge was substantively present but unevenly specified across the two curricular fields. Of 169 eligible elements, 45.0% were preserved at equivalent specificity, 30.2% were generalized, 4.1% were displaced, and 20.7% were not represented in the stated outcomes. Year 4 contained the largest annual share of sustainability-related elements, while program electives accounted for almost half of the total; neither location was associated with uniformly stronger preservation. Leave-one-course-out estimates remained close to the primary result, and the domain-restricted sensitivity analysis yielded 35.8% preservation.

The study's main contribution is to distinguish curricular presence from outcome-level specificity. This distinction is relevant beyond the present case because sustainability and SDG frameworks can make curricular themes visible without showing whether the disciplinary knowledge underlying those themes remains identifiable in formal statements of expected learning. Element-level tracing provides a transparent way to examine that relation while distinguishing preservation, generalization, displacement, and non-representation rather than treating all forms of correspondence as equivalent.

Rather than establishing a general empirical pattern for Interior Architecture education, this case identifies a curriculum-review question that can be examined comparatively: whether outcomes retain the material, environmental, health, inclusion, heritage, or ecological relations that give a broader capability its disciplinary specificity. This does not require outcomes to reproduce every content item. Rather, it supports selective precision in identifying the knowledge relations expected to inform professional judgment.

The implications remain bounded to the published planned curriculum. Course outcomes are neither the whole curriculum nor evidence of student attainment, but they are consequential public statements of expected learning. Comparative application across programs and connection with teaching, assessment, and student work can test the wider reach of the element-level approach and clarify how formal curricular specificity relates to enacted and achieved learning.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su182010532/s1, Supplementary Table S1 (Sustainability Screening and Content-to-Outcome Dataset) provides the complete 70-course inventory with source locators and unitization notes, the complete 1168-element screening frame, the independent 14-course unitization-validation summary, including sample composition, blinding conditions, and Krippendorff's unitizing alpha ($\alpha U = 0.84$), the 169-unit final adjudicated dataset, complete learning-outcome sets for the 17 eligible course records, both pre-adjudication transformation-coding records, agreement statistics, unit-level adjudication decisions and rationales, and formula-based analytical summaries.

The source course-information package is publicly available through Istanbul Aydin University's Education Information System (https://ebs.aydin.edu.tr/index.iau?BK=33&Page=Dersicerikleri; accessed on 30 July 2026).

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Data Availability Statement: The official course-information package is publicly accessible through Istanbul Aydın University's Education Information System at https://ebs.aydin.edu.tr/index.iau?BK=33&Page=Dersicerikleri (accessed on 30 July 2026). Supplementary Table S1 provides the complete 70-course inventory with source locators and unitization notes, the complete 1168-element screening frame, the independent 14-course unitization-validation summary, including sample composition, blinding conditions, and Krippendorff's unitizing alpha ($\alpha U = 0.84$), the 169-unit final adjudicated dataset, complete outcome sets for the 17 eligible course records, both pre-adjudication transformation-coding records, agreement statistics, adjudication rationales, and formula-based analytical summaries.

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. Course-level distribution and transformation of sustainability-related knowledge elements. Course titles are presented in English; the supporting dataset retains the original-language course titles where supplied.

Course	Year	Sem.	Status	Elements	Preserved *n* (%)	Gen.	Disp.	Not Rep.
IMT112—Foundations of Interior Architectural Design II	1	2	Compulsory	14	11 (78.6%)	3	0	0
IMT207—Architectural Surveying and Measured Drawings	2	3	Compulsory	2	0 (0.0%)	0	2	0
IMT223—Building Technology in Interior Design III	2	3	Compulsory	11	6 (54.5%)	3	2	0
IMS202—Sustainable Design and Green Practices in Interior Architecture	2	4	Program elective	9	0 (0.0%)	1	0	8
IMT212—Interior Design Methods II	2	4	Compulsory	10	8 (80.0%)	2	0	0
IMT218—Restoration	2	4	Compulsory	13	3 (23.1%)	10	0	0
IMT224—Building Technology in Interior Design IV	2	4	Compulsory	14	9 (64.3%)	5	0	0

Table A1. *Cont.*

Course	Year	Sem.	Status	Elements	Preserved *n* (%)	Gen.	Disp.	Not Rep.
IMT228—Building Materials in Interior Design II	2	4	Compulsory	2	0 (0.0%)	2	0	0
IMS313—Universal Design in Interior Architecture	3	5	Program elective	4	0 (0.0%)	0	0	4
IMT318—Form, Light and Color	3	6	Compulsory	10	10 (100.0%)	0	0	0
PES398—Principles of Landscape Design	3	6	Faculty elective	1	0 (0.0%)	1	0	0
IMS419—Universal Design in Interior Design	4	7	Program elective	23	16 (69.6%)	7	0	0
IMS427—Textile in Interior Design	4	7	Program elective	7	5 (71.4%)	2	0	0
IMS431—Revitalization in Interior Design	4	7	Program elective	18	3 (16.7%)	2	0	13
IMS424—Sustainability in Interior Design	4	8	Program elective	22	5 (22.7%)	12	3	2
IMT401—Interior Design V	4	8	Compulsory	7	0 (0.0%)	1	0	6
IMT404—Graduation Project	4	8	Compulsory	2	0 (0.0%)	0	0	2

Gen., generalized; Disp., displaced; Not rep., not represented.

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