

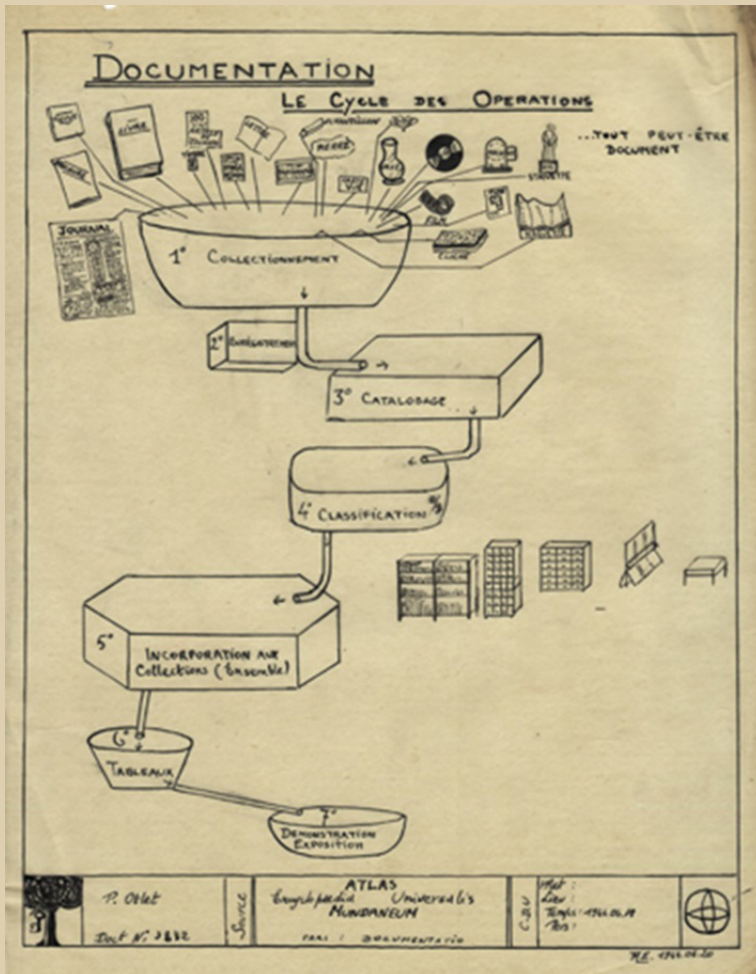
AIDa informazioni

RIVISTA SEMESTRALE DI SCIENZE DELL'INFORMAZIONE

NUMERO 3-

ANNO 43

LUGLIO-DICEMBRE 2025



AIDAinformazioni

RIVISTA SEMESTRALE DI SCIENZE DELL'INFORMAZIONE

Fondata nel 1983 da Paolo Bisogno

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Editrice: Cacucci Editore S.a.s.

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AIDAinformazioni

Anno 43

N. 3-4 – luglio-dicembre 2025

CACUCCI  EDITORE
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PROPRIETÀ LETTERARIA RISERVATA

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Contributi

Applying Integrative Levels Classification to Korean KOS Registry

Bridging Phenomena and Knowledge Systems

SoYoung Yoon*, Claudio Gnoli**, Ziyong Park*

Abstract: This study investigates the applicability of the phenomenon-based classification system ILC2 to the classification of the Korean KOS Registry. It also examines the potential of generative AI to supplement human expert validation in the classification process. To this end, approximately 450 KOS entries were classified through a three-stage cross-validation by human experts, along with classification code suggestions generated by ChatGPT. The results indicate that the phenomenon-centered ILC effectively reflects KOS topics organized around applied domains, and it can further support the identification of needs for new categories in emerging applied fields, as well as Korea- and Asia-specific subjects. Additionally, generative AI contributed to both suggesting classification notations and facilitating expert cross-checking; however, limitations were observed, such as hallucinations where the AI suggested notations not present in the ILC2 schedules. This study provides both practical and theoretical implications for the management of KOSs and the development of classification systems.

Keywords: Korean Knowledge Organization System (K-KOS), Knowledge Organization System (KOS) Registry, Integrative Levels Classification (ILC), Phenomenon-based Classification, Generative AI-assisted Classification.

1. Introduction

Knowledge organization systems (KOSs) encompass a broad range of structures designed to represent and manage knowledge resources. Depending on historical and disciplinary contexts, similar systems have been referred to using different terms (Voß 2016; Gnoli 2020). The Networked Knowledge Organization Systems (NKOS) community has contributed to clarifying such terminology by developing a dedicated KOS vocabulary, including the KOS Types Vocabulary (Zeng and DCMI NKOS Task Group 2015).

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A wide range of institutions and individuals – including those in the public sector – utilize KOSs to structure and manage knowledge resources. In today's digital information environment, nearly all platforms that provide information rely on some form of KOS, varying in type and level of complexity. Korea's KOS landscape, like those in other countries, encompasses a variety of systems developed and applied across different domains. However, there remains a lack of overarching classification frameworks that can comprehensively encompass and interlink these diverse KOSs.

To address this gap, the present study explores the applicability and suitability of Integrative Level Classification version 2 (ILC2) for organizing Korean KOSs. As a phenomenon-based classification scheme, ILC2 supports multidimensional indexing and is designed to accommodate both natural and cultural phenomena. To test its applicability, we examine 458 KOS entries included in the K-KOS Registry and evaluate their classification under ILC2. The K-KOS Registry – used as the dataset for this study – is a curated collection of KOS entries primarily developed by Korean public institutions across diverse domains.

In addition, the study explores the potential role of generative AI – specifically ChatGPT-4o – as a support tool in the classification process. AI assistance is evaluated in terms of its ability to suggest candidate classmarks, provide interpretive rationales, and mitigate inconsistencies in expert-based classification. By combining a phenomenon-based framework with generative AI support, this study proposes a scalable and flexible approach to managing complex national-level KOS datasets.

This paper is structured as follows. Section 2 reviews the theoretical background, including KOS types, phenomenon-based classification, and recent developments in AI-assisted indexing. Section 3 outlines the data collection and classification process. Section 4 presents and analyzes the classification results. Section 5 discusses the implications of our findings and concludes with directions for future work.

2. Literature Review

2.1. Classifying Knowledge Organization Systems in KOS Registries

During the 20th century, classification schemes have been developed especially for use in library collections and bibliographies. However, already at the beginning of the century Paul Otlet also planned to classify articles, reports, films, exhibits, documentation internal to organizations etc. by the Decimal Classification (Folino 2024).

KOSs themselves are in need of being indexed for easy browsing, search and retrieval in KOS registries. As a KOS usually covers a broad domain or a set of domains, as opposed to the very specific subject matter of a book or an article, what is needed to index KOSs seems to be a general system of the whole of knowledge; assigned classes are not expected to be very specific, and associations of more than one class for the same KOS are likely (e.g. food, agriculture and health, or engineering and physics).

The Basic Register of Thesauri, Ontologies and Classifications (BARTOC) has been indexed using the Dewey Decimal Classification (DDC), the Integrative Levels Classification (ILC) and the EuroVoc thesaurus, which all have general coverage (Ledl and Gnoli 2017; Gnoli et al. 2019). Building on this approach, Park (2024) applied DDC, ILC, and the Korean Decimal Classification (KDC) to classify KOSs in the K-KOS Open Archives. Of these, ILC is the most innovative scheme.

Some studies have focused on classifying KOS types themselves. Souza, Tudhope, and Almeida (2012) analyzed various forms of KOSs by identifying multiple dimensions and organizing them into a taxonomy. Similarly, Voß (2016) extracted KOS types from Wikidata and proposed a typology-based classification of KOSs.

2.2. The Integrative Levels Classification

ILC is a general classification scheme that has been developing since 2004 by an international team coordinated by Claudio Gnoli (ISKO Italia 2024). While building on the tradition of general bibliographic classifications, it is original in that its main classes are phenomena, that is the objects of knowledge such as celestial objects, plants or languages, instead of disciplines, such as astronomy, botany or linguistics, as is usual in bibliographic classifications (Gnoli et al. 2024).

Each ILC class includes several ranks of subclasses, expressed by small caps: for example, class *q* “language” includes subclasses *qm* “morphs”, *qo* “words”, *qp* “phrases” etc., which in turn are subdivided into further ranks. Classes can be specified by facets, as in classical faceted classifications. Facets are indicated by digits and belong to a set of ten fundamental categories: 9 quality, 8 quantity, 7 part, 6 property, 5 transformation, 4 opposition, 3 agent, 2 place, 1 time, 0 perspective. Thus e.g. in class *q*, facet *q7sf* “phonemes” is introduced by digit 7 because phonemes are a part of language. This facet can be combined with subclasses in the example above to give *qm7sf* “morphs, phonemes”, *qo7sf* “words, phonemes” and so on.

While the scheme is developing continuously, edition 1 (ILC1) was frozen and published in 2011, edition 2 (ILC2) was in 2019 (Park, Gnoli, and Morelli 2020; Park et al. 2020), and edition 3 is expected to be in the coming

years. ILC2 is also available in SKOS format (<https://www.iskoi.org/ilc/skos.php>) (Binding et al. 2020).

The basic structure is similar in all editions. However, in each edition some classes are moved or developed, and the syntax of facets is partly different. In particular:

- bound facets – that is facets that are only applied within a specific class, such as phonemes (as there are no phonemes of celestial bodies or phonemes of polities: only phonemes of languages) – are introduced by *-a-* in ILC2, and by a single digit in ILC3;
- parallel facets – that is facets that take their values from another class – are introduced by *-91-*, *-92-* etc. in ILC2, and by multiple digits in ILC3;
- free facets – that is facets that may connect any two classes – are introduced by single digits in ILC2, and by *-0-*, *-10-*, *-20-* etc. in ILC3.

ILC3 can be considered the most advanced edition from both the technical and the content points of view. However, as it is not finalized yet, before its publication indexing projects and linked data applications need to use ILC2 for the purposes of information consistency.

2.3. AI-assisted Classification

Classification is a complex intellectual activity that involves both subject analysis and symbolic transformation of the classified entity. Recent research has explored the application of AI to support this process. In particular, AI has been used to semi-automatically assist human experts in classification and subject indexing. Examples include machine learning–based approaches to assigning subject headings (Ahmed et al. 2023), as well as pilot studies using generative AI to suggest classification codes and subject terms (Noruzi 2024) once a silent repository of knowledge, is undergoing a digital metamorphosis. At the heart of this transformation is the integration of artificial intelligence (AI). Both studies utilized standard knowledge organization systems (KOS), such as the Library of Congress Subject Headings (LCSH), for AI training, and relied on MARC-formatted bibliographic records annotated by human experts for model validation. Martin (2024) also supports this view, noting that generative AI can ease the mental demands of cataloging by assisting with subject analysis and code assignment. Rather than pursuing fully automated systems, these studies aimed to reduce the time required for indexing and to complement human subjectivity with AI-generated recommendations. Given their use of external structured vocabularies like LCSH and DDC, these approaches may be seen as a form of retrieval-augmented generation (RAG).

In this context, Qin (2020) offers a more theoretical perspective, emphasizing that although knowledge organization (KO) and knowledge representation

(KR) have traditionally functioned as distinct paradigms, the advancement of AI is fostering their convergence, positioning KOSs as both organizational tools and foundational assets for reasoning and knowledge acquisition in AI environments.

3. Methodology

To provide an overview of the research process, Figure 1 summarizes the methodology in three main stages: dataset selection, data classification, and data visualization and sharing. First, 458 K-KOS entries were selected from *K-KOS Open Archives* as the dataset. Second, the data were classified through a three-step process led by two domain experts, who independently assigned and reviewed ILC codes to ensure consistency. Throughout this process, generative AI (ChatGPT) was used as a supplementary tool—providing suggestions for potentially relevant categories and highlighting comparable classification patterns—thus supporting expert decision-making without replacing it. Finally, the classified KOS resources were indexed and made publicly accessible via K-KOS Open Archives, supporting visualization, search, and reuse.

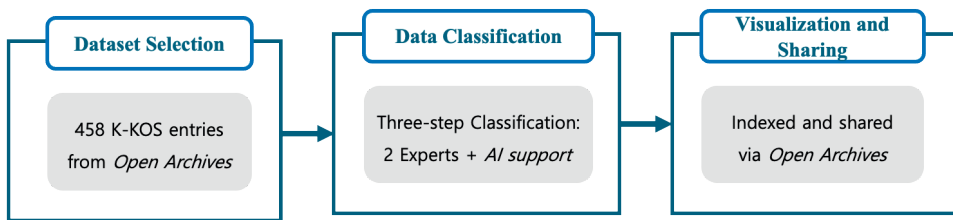


Figure 1. Overview of the methodology: dataset selection, classification, and sharing via Open Archives.

3.1. Dataset Selection

In this study, a total of 458 KOSs recorded in *K-KOS Open Archives* – the registry of the Korean KOSs (K-KOS) – were selected for analysis. K-KOS Open Archives is a publicly accessible platform that collects, curates, and shares KOSs developed by government agencies, public institutions, cultural heritage organizations, research institutes, and individual scholars. The registry encompasses a wide range of KOS types, including classification schemes and terminological resources. Each entry is accompanied by structured metadata describing the KOS’s title, description, managing organization, and relevant reference sources.

Given the applied and practice-oriented nature of many KOSs included in the registry, K-KOS provides a useful empirical context for examining the principles and applicability of ILC2. The dataset is analyzed with respect to KOS type (Table 1), managing organization (Table 2), and online service platform (Table 3).

K-KOS KOS Type	Number of KOS	ratio	NKOS KOS Types
glossary (용어집)	205	44.76%	glossary, terminology
classification scheme (분류체계)	168	36.68%	classification scheme
encyclopedia (백과사전)	34	7.43%	-
list (목록)	28	6.11%	list
dictionary (언어사전)	6	1.31%	dictionary
thesaurus (시소러스)	6	1.31%	thesaurus
name authority list (인명사전)	5	1.09%	name authority list
cataloging rules (목록규칙)	4	0.87%	-
gazetteer (지명사전)	2	0.44%	gazetteer
Total	458	100.0%	

Table 1. Distribution of KOS Types in K-KOS and Their Correspondence to the NKOS Vocabulary.

Organization	Number of KOSs
Statistics Korea	42
National Folk Museum of Korea	31
Rural Development Administration	18
National Research Institute of Cultural Heritage	12
Korea Customs Service	11
Ministry of Environment	11
Ministry of the Interior and Safety	10
Health Insurance Review & Assessment Service	8
Ministry of National Defense	8
Korea Health Industry Development Institute	8

Table 2. Distribution of Classified K-KOS by Managing Institutions (Top 10 Organizations).

KOS Service Platform	Number of KOSs
Korean Law Information Center	56
Korean Statistical Classification	42
Encyclopedia of Korean Folk Culture	25
National Heritage Knowledge Connection	15
National Crop Pest Management System	13

Table 3. Distribution of Classified K-KOS by Service Platforms (Top 5 Plat).

KOS types were primarily categorized according to the NKOS KOS Types Vocabulary (Zeng and DCMI NKOS Task Group 2015), with certain modifications introduced to reflect the specific characteristics of K-KOS. In addition to classification schemes and glossaries, other types of resource – such as encyclopedias – also represent a notable share of the overall distribution (see Table 1). Table 2 presents the top ten managing institutions among the 198 organizations surveyed, all of which maintain at least eight KOSs. These include central government agencies such as Statistics Korea, which manages 42 KOSs primarily focused on national standard classifications, and cultural heritage institutions like the National Folk Museum of Korea, which manages 31 KOSs including glossaries and terminologies related to Korean folk culture. In terms of digital service provision, Table 3 summarizes the top five online platforms hosting K-KOSs. The Korean Law Information Center, which provides access to legal information and terminology, ranks first, followed by the Korean Statistical Classification platform, which serves as a major gateway to national statistical standards and datasets. However, unlike the Korean Statistical Classification platform operated directly by Statistics Korea, the National Library of Korea does not serve as a dedicated platform that both manages and distributes specific KOSs. Although it provides access to various glossaries and dictionaries, it does not function as the primary service or administrative body for those KOSs and is therefore excluded from the rankings.

The results indicate that classification schemes and terminological resources constitute a significant proportion of the registry. Moreover, the majority of KOSs were developed by public-sector entities, particularly government ministries and government-funded research institutes, and are disseminated via dedicated online platforms. This trend underscores the strong presence of public-sector KOSs and their alignment with national administrative functions. In light of the dominance of public-sector contributions, the overall distribution of K-KOS resources is further examined using the Business Reference Model (BRM), which provides a high-level categorization of government functions. Table 4 illustrates the distribution of KOSs across government

functions, with particularly high concentrations in cultural, industrial, and health-related domains.

BRM	Number of KOS	ratio
Culture, Sports, and Tourism	129	28.17%
Industry, Trade, and SMEs	51	11.14%
Health	48	10.48%
Agriculture and Forestry	38	8.30%
General Public Administration	37	8.08%
Environment	29	6.33%
Science and Technology	21	4.59%
Social Welfare	21	4.59%
National Defense	17	3.71%
Public Order and Safety	16	3.49%
Transportation and Logistics	14	3.06%
Education	12	2.62%
Fiscal, Tax, and Financial Affairs	12	2.62%
Communication	5	1.09%
Marine and Fisheries	5	1.09%
Regional Development	3	0.66%
Total	458	100.0%

Table 4. Functional Distribution of K-KOS According to Business Reference Model.

3.2. Data Classification

This study adopted the Integrative Levels Classification, 2nd edition (ILC2), as the classification framework. A free faceted approach was employed, allowing each KOS to be assigned multiple classification codes as appropriate. This method aligns with the general indexing needs of KOS registries, where classification tends to be broad rather than specific. As KOSs typically cover wide or cross-cutting domains – unlike books or articles that deal with narrowly defined topics – they are better indexed using a general system that accommodates multiple perspectives. BARTOC, for instance, applies ILC in a similarly free-faceted way to support browsing and retrieval without over-specification.

Given the scale and diversity of the dataset, which included 458 KOS entries, the application of full facet formulas was intentionally limited. While ILC2 theoretically supports the construction of syntagmatic “freely-faceted” combinations, fully expressing all relevant aspects of a concept could result in excessively long and potentially opaque classmarks, in absence of an automatic translator of faceted notation as experimented in other applications (Gnoli et al. 2023a, 2023b). For practical reasons, the classification process prioritized conciseness and interpretability, especially to maintain consistency across entries and support comparative analysis. Nonetheless, certain compound notations that are already enumerated in the official ILC schedules – particularly

those commonly used in web-based public versions – were selectively incorporated. These pre-formed combinations allowed for limited facet expression without necessitating complex syntactic construction.

Importantly, while this free classification approach preserves the phenomenon-based structure that is central to ILC, it does not fully leverage the expressive potential of its facet syntax. In this study, the choice of a simplified approach reflects both the practical demands of managing a heterogeneous dataset and the conceptual fit of general, high-level classifications for KOSs. At the same time, it acknowledges the trade-off involved: while the phenomenon-based logic of ILC is retained, the richness of facet-based articulation is necessarily constrained.

To ensure the consistency and reliability of the classification results, a three-step expert-based cross-review procedure was implemented. The process involved three stages – (1) initial coding by Expert 1, (2) reclassification by Expert 2 with support from generative AI (ChatGPT-4o), and (3) final review by Expert 1 – as illustrated in Figure 2. Each step was designed to complement the others, aiming to integrate multiple perspectives into the classification process.

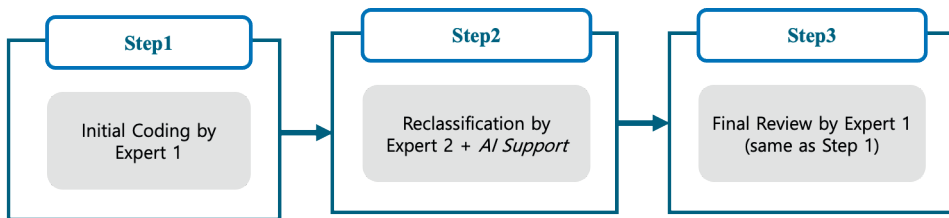


Figure 2. Three-step classification process involving expert review and generative AI support.

Step 1. Initial Coding by Expert 1

In the first step, Expert 1 assigned initial ILC2 classification codes to all K-KOS entries. The process emphasized a broad yet conservative interpretive stance, minimizing the use of multiple codes in cases involving ambiguous or polysemous subjects. Special attention was given to the structural consistency of notations, with careful consideration of the thematic domain to which each KOS entry belongs.

Step 2. Reclassification by Expert 2 with Generative AI Support

In the second step, Expert 2 reviewed the initial classifications and performed reclassification as needed. This stage allowed for more specific interpretations and the integration of multiple subject dimensions, resulting in the addition of secondary ILC2 codes where appropriate. Generative AI was em-

ployed to assist in this process by suggesting classification options and providing justifications, which facilitated alternative perspectives not initially considered. Importantly, Expert 2 evaluated all AI-generated suggestions and made the final decisions, thereby mitigating the potential risk of AI hallucinations.

To support AI-based classification, a dataset of ILC2 classmarks and captions was first compiled from the official ILC2 web service (ISKO Italia 2026). When a main class is selected, a hierarchy of subclasses appears on the landing page; the compiled dataset included most entries from rank 1 to 3, with some extending to ranks 4 or 5. A total of 2,503 ILC2 classes were collected. As illustrated in Figure 3, the ILC2 class list (left) and a translated KOS entry (right) were used to generate classification suggestions via GenAI. While the English class names provided by ILC2 served as the primary reference, Korean captions were also included to aid interpretation in the K-KOS classification context. The dataset was uploaded in CSV format to the ChatGPT-4o interface, enabling the model to suggest relevant classmarks along with justification based on each KOS record's metadata. Expert 2 consulted these AI-generated suggestions especially in cases where classification was ambiguous or diverged from Expert 1's judgment.

The image shows a screenshot of the ILC2 web interface. On the left, there is a table of ILC2 classmarks with columns for ILC2 class number, English caption, Korean caption, DDC number, and main class. A red dashed box highlights the first few rows of this table. On the right, there is a detailed KOS entry for 'Ancient wooden tablets: List of wooden tablets by site'. This entry includes an index, a list of related information, and a detailed description of the KOS entry. A red dashed box highlights the KOS entry title and description. A grey callout box points to the KOS entry title and description, stating 'KOS Entry Title and Description (auto-translated for demonstration)'.

ILC2 no.	caption_eng	caption_kor	DDC no.	main cls
a	forms; mathematical objects [formal sc	형식; 수학적 객체 [형식 과학; 논리; 수학]	DDC 510 160	a
a92	in neighbourhood	근처에 있는		a
a93	implied by; as a consequence of premi	전제로부터 암시됨		a
a94	with error	오류와 함께		a
a95	through transformation; operation; fun	변환, 작용, 함수, 사상 등을 통해		a
a96	having property	속성을 가진		a
a97	with part; element; component	부분, 요소, 구성요소의 함께		a
a98	equal to result	결과와 동일함		a
aat	elements	요소		a
aau	subsets	부분집합		a
aaw	cosets	정여집합		a
ab	individuals; instances	개체; 사례		a
ac	classes; sets; collections [set theory]	클래스; 집합; 모음 [집합 이론]		a

KOS Entry Title and Description (auto-translated for demonstration)

Ancient wooden tablets: List of wooden tablets by site

index (8-771)

- About KOS
- Related information
- Classification information
- See together
- External Links

About KOS [Edit | Edit original]

Ancient Wooden Tablets: List of Wooden Tablets by Historical Site is a list of wooden tablets organized by historical site that were registered on the National Gaya Cultural Research Institute's Ancient Korean Wooden Tablets website (Currently National Heritage Knowledge > Research DB > Ancient Wooden Tablets). A total of 512 wooden tablets excavated from 22 historical sites are registered. The list covers not only those excavated from Georjansongri Fortresses in Haman but also the entire country, and provides basic information on the excavation site, shape, size, etc. of the wooden tablets, as well as image and drawing data.

Figure 3. ILC2 classes and a KOS example used for AI-assisted classification.

Step 3. Final Review by Expert 1

In the final step, Expert 1 re-evaluated the revised classifications produced in Step 2. This review focused not only on validating the appropriateness of additional codes but also on ensuring the overall coherence and semantic clarity of the assigned notations. Rather than making extensive modifications,

this phase emphasized interpretive harmony and alignment across the dataset. Cases requiring further discussion or refinement were flagged and documented for consideration during the final analysis.

4. Results and Findings

4.1. Results of classification

4.1.1. Overview of Classification Results

In this study, a total of 458 K-KOS entries were classified using the Integrative Levels Classification, 2nd edition (ILC2). The classification process was divided into three sequential steps, and the results at each stage were summarized according to the top-level ILC2 classes, as shown in Table 5 and Table 6. While the overall patterns across Step 1, Step 2, and Step 3 remained broadly similar, closer examination reveals certain variations. These similarities and differences can be analyzed by comparing cases in which the assigned class remained consistent throughout the process versus those in which reclassification occurred between steps.

Class_no	Class_name	Step 1	Step 2	Step 3
<i>a</i>	forms	1	1	1
<i>d</i>	energy	9	9	11
<i>f</i>	molecules	4	4	4
<i>h</i>	celestial bodies	3	3	3
<i>i</i>	rocks	1	1	1
<i>j</i>	land	21	25	29
<i>m</i>	organisms	12	34	41
<i>n</i>	populations	17	18	18
<i>o</i>	instincts	1	1	1
<i>p</i>	consciousness	-	1	1
<i>q</i>	language	17	17	19
<i>r</i>	rituals	16	15	15
<i>s</i>	communities	30	59	70
<i>t</i>	polities	60	50	44
<i>u</i>	enterprises	48	46	38
<i>v</i>	technologies	89	61	54
<i>w</i>	artifacts	31	38	38
<i>x</i>	artworks	65	41	41
<i>y</i>	knowledge	33	34	29
Total		458	458	458

Table 5. K-KOS classification results by top-level ILC2 classes at each step (excluding multi-class assignments).

Class_no	Class_name	Step 1	Step 2	Step 3
<i>a</i>	forms	1	3	3
<i>d</i>	energy	9	11	11
<i>f</i>	molecules	4	4	4
<i>b</i>	celestial bodies	3	3	3
<i>i</i>	rocks	1	1	1
<i>j</i>	land	21	28	29
<i>m</i>	organisms	17	48	48
<i>n</i>	populations	21	26	27
<i>o</i>	instincts	1	1	1
<i>p</i>	consciousness	-	8	8
<i>q</i>	language	17	18	21
<i>r</i>	rituals	16	16	16
<i>s</i>	communities	33	125	123
<i>t</i>	polities	61	62	62
<i>u</i>	enterprises	49	81	92
<i>v</i>	technologies	96	84	83
<i>w</i>	artifacts	31	53	54
<i>x</i>	artworks	65	45	45
<i>y</i>	knowledge	35	56	54
Total		481	673	685

Table 6. K-KOS classification results by top-level ILC2 classes at each step (including multi-class assignments).

4.1.2. Cases with Consistent Classification Across Steps

During the classification process from Step 1 to Step 3, a total of 187 entries retained the same classification code between Step 1 and Step 2, and 438 entries showed consistency between Step 2 and Step 3. Notably, 179 KOS entries maintained an identical classification code across all three steps. Consistency was particularly high for KOS entries dealing with specific applied domains or well-defined subjects. This group included KOSs related to astronomy, mathematics, physics, satellites, minerals, climate, agriculture, national defense, law, fine arts, architecture, and performing arts. Representative examples of such cases are presented in Table 7.

KOS name	Assigned ILC code
Minerals Classification (광물분류)	<i>ib</i> “minerals” [mineralogy]
Climate Technology Classification (국가 기후기술 분류체계)	<i>jal</i> “climates” [climatology]
Legal Terms (법률용어)	<i>tay</i> “regulations; institutions; legal order; law; norms; rules; acts” [jurisprudence; legal theory]
Korea Performing arts box office Information System Genre Classification System (공연예술통합전산망 장르분류 체계)	<i>xmWr</i> “performing arts; shows”

Table 7. Examples of classification changes and ILC entries (Step 1–2).

In addition, an analysis of the distribution of KOS entries based on the top-level ILC categories reveals a clear tendency toward classifications in applied and socially oriented domains. Specifically, a greater number of KOS entries were assigned to categories such as *s* “communities”, *t* “polities”, *u* “enterprises”, and *v* “technologies”, rather than to more abstract or theoretical categories like *a* “forms”, *d* “energy”, and *f* “molecules”, which appear earlier in the ILC schedules. Among these, *s* “communities” and *v* “technologies” consistently emerged as the most frequently assigned categories across all classification steps. These findings suggest that KOSs are more closely aligned with the applied and societal domains in ILC.

4.1.3. Cases of Classification Changes Across Steps

In cases where classification codes were changed throughout the three steps, it was observed that Step 2 introduced a more expansive and integrative perspective compared to the conservative and inclusive approach of Step 1. This shift led to a more active incorporation of multiple thematic aspects. As shown in Step 3 of Table 6, which includes all assigned notations, an average of approximately 1.5 ILC codes was assigned per KOS. Some classes experienced particularly significant increases when multiple codes were allowed. For instance, the class *s* “communities” included 70 entries under single-code assignments, but this number rose to 123 when multiple codes were considered. Similarly, *u* “enterprises” increased from 38 to 92 entries. This trend suggests that certain sets of ILC classes are better suited to capturing the complexity of hybrid or interdisciplinary KOS themes.

By actively embracing multiple notations and leveraging generative AI suggestions in Step 2, a greater number of classification codes could be applied than in Step 1. As shown in Table 2, Step 1 resulted in 458 code assignments, while Step 2 yielded 673, and Step 3 reached 685 in total. A breakdown of the 271 changed notations between Step 1 and Step 2 is summarized in Table 8.

Type of Change	Frequency (Step 1→Step 2)	Frequency (Step 2→Step 3)
Change in the number of codes (Single → Multiple)	95	18
Specification within the same class	99	-
Change to a different upper-level class	86	3
Total	271	20*

Table 8. Types and Frequencies of Classification Code Changes Between Step 1 and Step 2.

* One case involved both a change in class and a change in the number of codes. The total count excludes this overlap.

As shown in Table 8, a total of 271 classification codes were changed from Step 1 to Step 2. Among these, 95 cases involved changes from a single classification code to multiple codes, 99 cases involved the addition of more specific codes within the same main class, and 86 cases involved changes to entirely different classes based on a revised perspective. Representative examples of each type are presented below.

- 1) change in the number of codes (Single → Multiple)
 - *Business Reference Model* (정부기능분류체계)
 - [step 1] *tal* “civil service; public sector; community services; public administration”
 - [step 2] *tal + sp* “public institutions; public bodies; services of general interest”
- 2) specification within the same class
 - *Terms of vehicle emission gas* (배출가스 용어사전)
 - [step 1] *ny* “ecosystems; biomes; biocores” [environmental sciences]
 - [step 2] *nyal* “pollution”
- 3) change to a different upper-level class
 - *Anatomical Terminology* (해부학 용어)
 - [step 1] *yite* “medical science”
 - [step 2, 3] *mao* “organs; systems” [anatomy]

Next, the changes from Step 2 to Step 3, as shown in Table 8, indicate that an additional 23 classification codes were modified. Specifically, 19 entries were assigned multiple codes, 3 entries were further specified within the same class, and 2 entries were reassigned to different classes. These results suggest that the active expansion of classification codes in Step 2 was further extended in Step 3. Representative examples of each change type are summarized below.

- 1) change in the number of codes (Single → Multiple)
 - *Classification of Automobile Parts* (자동차 분류맵)
 - [step 1] *wver* “cars”
 - [step 2] *wver + uaqst* “tariffs” Some hallucinations required
- 2) change to a different upper-level class

- *Glossary of National Land* (국토용어사전)
 [step 1] *ux* “transport”
 [step 2] *j* “land; landforms; regions; geographical features”

4.2. Web-Based Access to Classified KOS Resources

The classified entries were published via the K-KOS Open Archives to promote transparent reuse, offering searchable indexes and multilingual access. Originally developed in Korean, the platform now includes an English-language interface to enhance accessibility and facilitate international interoperability. Figure 4 illustrates how K-KOS resources are organized using ILC2 within the platform.

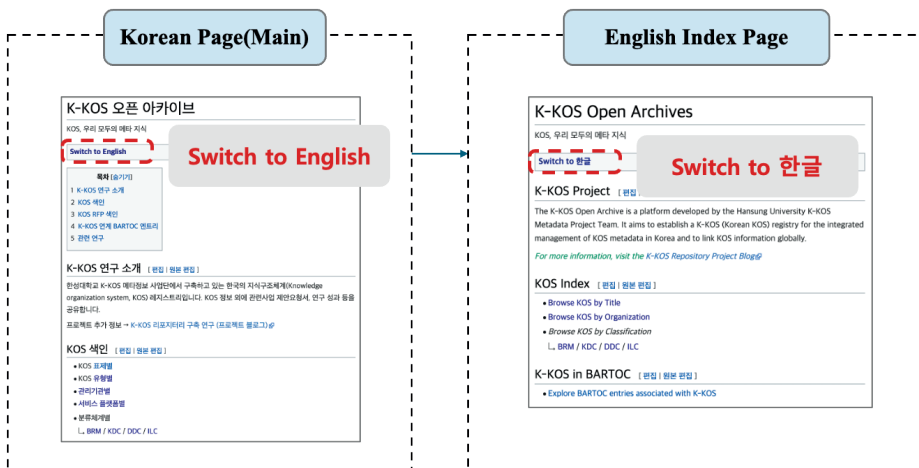


Figure 4. Language toggle interface between the Korean main page and the English index page of K-KOS Open Archives (K-KOS Metadata Project Team 2026).

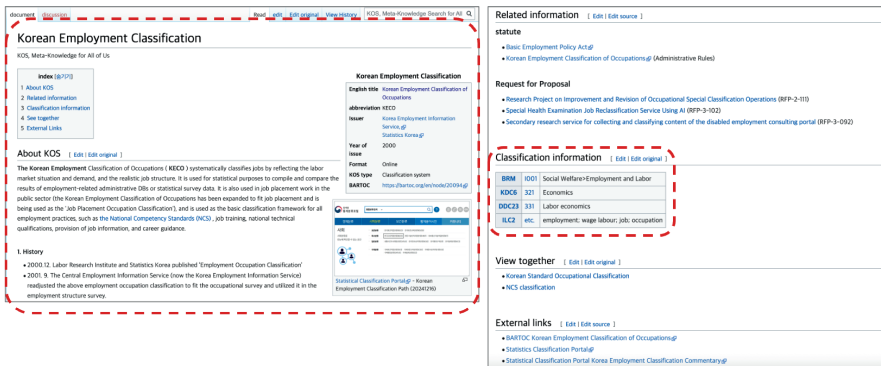


Figure 5. Screenshot of *Korean Employment Classification of Occupations* on K-KOS Open Archives (Automatically translated by Google Chrome) (K-KOS Metadata Project Team 2025).

Figure 5 provides an example of a detailed KOS entry—Korean Employment Classification of Occupations—in which classification information is displayed alongside KOS metadata. The classification index supports browsing by BRM, KDC, DDC, and ILC schemes. The page also includes external links to corresponding KOS entries in BARTOC, thereby enhancing interoperability and visibility within the broader KOS ecosystem.

4.3. Discussion

This section discusses the implications of the classification process and results from three interrelated perspectives. First, it examines how well the principles of ILC align with the inherent characteristics of Knowledge Organization Systems (KOSs) (4.3.1). Second, it evaluates the applicability of ILC to Korean KOSs and emerging technological domains, while identifying areas for potential refinement (4.3.2). Third, it reflects on the use of generative AI as a support tool in the classification workflow, highlighting both its contributions and limitations (4.3.3).

4.3.1. Phenomenon-Based and Multi-Dimensional Classification in ILC

This section discusses two key aspects of applying ILC to KOS classification: (1) the conceptual suitability of ILC’s phenomenon-based structure, and (2) the implications of assigning multiple class codes in a free classification manner.

First, the ILC framework enabled the classification of KOS entries based on the phenomena or entities they describe, rather than the disciplinary fields to which they belong. This contrasts with traditional academic classification systems – such as Dewey Decimal Classification (DDC) – which typically impose a subject hierarchy aligned with academic domains. For instance, a KOS on “disaster management” could be directly assigned to *spr* “emergency services; rescue services” in ILC, without requiring a disciplinary framing under meteorology, civil engineering, or public safety. The results shown in Table 9 – based on single-class assignments only – highlight this conceptual alignment. A significant number of KOS entries were classified under *s* “communities” (12.9%), *t* “polities” (10.9%), and *v* “technologies” (13.3%). These classes reflect real-world phenomena and functions of KOSs in applied contexts such as governance, technological infrastructure, and social organization. In contrast, more abstract or scientific classes like *a* “forms”, *d* “energy”, or *f* “molecules” were rarely used.

Second, the use of multiple ILC class assignments reveals a distinct strategy for representing the multidimensionality of KOS content. In disciplinary-based

systems such as the DDC, assigning multiple numbers often implies coordination among disciplinary perspectives. In contrast, within ILC, multiple assignments indicate coexisting aspects of the same KOS entry, consistent with a free classification approach. As shown in Table 10, when multiple codes are included, the share of entries classified under *s* “communities” increases to 18.6%, while *v* “technologies” accounts for 12.5%, and *u* “enterprises” for 12%. These increases reflect the prevalence of hybrid or context-rich KOSs that span social, technological, and economic domains. However, the current study employed a simplified, free approach that allowed juxtaposition of classes without constructing fully faceted classmarks. While this method enhanced interpretability and practical feasibility, it limited the expressive potential of ILC’s facet syntax. Thus, although ILC supports multidimensional representation in principle, its full capacity was only partially realized under the current approach.

Class No.	Class Name	Step 3 (Count)	Step 3 (%)
<i>a</i>	forms	1	0.2
<i>d</i>	energy	11	2
<i>f</i>	molecules	4	0.9
<i>h</i>	celestial bodies	3	0.7
<i>i</i>	rocks	1	0.2
<i>j</i>	land	29	5.5
<i>m</i>	organisms	41	7.4
<i>n</i>	populations	18	3.9
<i>o</i>	instincts	1	0.2
<i>p</i>	consciousness	1	0.2
<i>q</i>	language	19	3.7
<i>r</i>	rituals	15	3.3
<i>s</i>	communities	70	12.9
<i>t</i>	polities	44	10.9
<i>u</i>	enterprises	38	10
<i>v</i>	technologies	54	13.3
<i>w</i>	artifacts	38	8.3
<i>x</i>	artworks	41	9
<i>y</i>	knowledge	29	7.4
Total		458	100

Table 9. Step 3 Classification Results of K-KOS by ILC2 Main Classes (Excluding Multiple Assignments).

Class No.	Class Name	Step 3 (Count)	Step 3 (%)
<i>a</i>	forms	3	0.4
<i>d</i>	energy	11	1.6
<i>f</i>	molecules	4	0.6
<i>b</i>	celestial bodies	3	0.4
<i>i</i>	rocks	1	0.1
<i>j</i>	land	29	4.2
<i>m</i>	organisms	48	7.1
<i>n</i>	populations	27	3.9
<i>o</i>	instincts	1	0.1
<i>p</i>	consciousness	8	1.2
<i>q</i>	language	21	2.7
<i>r</i>	rituals	16	2.4
<i>s</i>	communities	123	18.6
<i>t</i>	polities	62	9.2
<i>u</i>	enterprises	92	12
<i>v</i>	technologies	83	12.5
<i>w</i>	artifacts	54	7.9
<i>x</i>	artworks	45	6.7
<i>y</i>	knowledge	54	8.3
Total		685	100

Table 10. Step 3 Classification Results of K-KOS by ILC2 Main Classes (Including Multiple Assignments).

The multidimensionality of KOSs, as revealed through ILC, can be illustrated by cases in which multiple classification codes were assigned. In these cases, two to four ILC classes were used, reflecting the choice not to synthesize facet elements into a single notation. Rather than combining classes into compound codes using facet indicators, distinct ILC classes were enumerated as needed. The following examples present KOS entries with multiple assigned classes.

Two-Class Assignments

Korean folk religion, rites (한국의 민속신앙)

- *ral* “rites” + *sykk* “Korean civilization”;
- Assigned to 11 entries, including *Folk religion of villages in Korea* (한국의 마을신앙), *Encyclopedia of Korean Folk Beliefs* (한국민속신앙사전).

Military supplies (군수품), *force support* (전력 지원)

- *tat* “military” + *uag* “goods distribution”;
- assigned to 6 entries, including *Classification of military supplies* (군수품의 분류), *Types of Force Support Systems* (전력지원체계 분류).

Social insurance (사회보험)

- *spas* “social insurance” + *spl* “welfare; social services”;
- assigned to 5 entries, including *National Pension Terms* (국민연금 용어사전), *Long-term Care Insurance Terms* (장기요양보험 용어사전).

Three-Class Assignments*Electronic components tariff*(전자부품 관세)

- *vtr* “electrical manufacturing” + *uaqst* “tariffs” + *uak* “trade; commerce”;
- assigned to 3 entries, including *Semiconductor Guide* (반도체 가이드), *Mobile Phone Parts Guide* (휴대전화부품 가이드).

Artists, Groups (예술인 단체)

- *x* “artworks” + *px98x* “artists” + *uo* “corporations; companies”;
- assigned to 3 entries, including *Seoul Art Guide Name Authority List* (서울아트가이드 인명사전), *Professional Art Organization List* (전문 예술법인·단체 리스트).

Four-Class Assignment*Aviation* (항공)

- *vx926y* “aviation” + *vxc* “cargo; freight transportation” + *wvr* “aircrafts” + *wux* “airports”;
- assigned to 4 entries, including *Terms of Aviation* (항공용어 사전), *Korea Institute of Aviation Safety Technology Glossary* (KIAST 용어사전).

4.3.2. Addressing Gaps in Cultural and Topical Coverage

During the classification process, several KOS entries lacked clear counterparts within existing ILC2 classes or could only be matched at a very general level. This was particularly evident for topics reflecting recent technological developments or contemporary social trends. Although these topics are inherently phenomenon-based, they could not be precisely aligned with existing ILC categories due to limitations in specificity and coverage. For instance, KOSs related to renewable energy, secondary batteries, and green taxonomy were difficult to place due to insufficiently granular entries. Similarly, digital innovation domains such as blockchain, big data, and the Internet of Things had to be mapped to the most proximate existing classes, thereby limiting classification precision. Representative KOS examples falling into this category were classified under the following ILC2 classes.

- *Classification of IoT* (사물인터넷 분류체계) - *wnw* “Internet”;
- *Korea New and Renewable Energy Center Terms* (신·재생에너지센터 용어사전) - *dam* “energy form”;
- *E-learning Industry Classification*(이러닝산업분류) - *spe* “education services; schools”;

- *e-sports classification*(이 스포츠 등급분류) - *xw* “sport; games” *xy9ytm* “videogames”.

In addition, the cultural specificity of many Korean KOSs revealed underdeveloped domains in ILC. Certain entries contain culturally bound concepts—such as regional proper names (e.g., Jeju Island), indigenous religious movements (e.g., Donghak), or traditional knowledge systems—that are not easily rendered into a single English expression. In such cases, classification fidelity may be improved by incorporating Romanized Korean labels or introducing culturally specific entries.

- *Korean Sign Language Dictionaries*(한국수어사전) - *qvh* “Korean language”;
- *Folk religion of villages in Korea:Jeju-do*(한국의 마을신앙:제주특별자치도) - *ral* “rites; practices; worship; uses; habits; ceremonies; liturgies; divine service” *sykk* “Korean civilization”;
- *Encyclopedia of Korean Folk Arts:Nongak* (한국민속예술사전:농악) - *xmavd* “traditional; root; ethnic” *sykk* “Korean civilization”.

These observations suggest that future versions of ILC, including the upcoming ILC3, would benefit from more flexible inclusion of regionally specific and topically emergent categories, enabling improved applicability to diverse national contexts. The following examples illustrate KOS entries that reflect such needs.

4.3.3. Assessing the Role of Generative AI in Faceted Classification

In this study, generative AI – specifically ChatGPT-4o – was used as a support tool during the second phase of the classification process. The AI was tasked with suggesting one or more ILC2 class codes for each KOS entry, based on contextual descriptions, and provided brief justifications for its choices. This allowed the human classifier to explore alternative perspectives, particularly for entries involving semantic ambiguity or interpretive disagreement between experts. In cases involving complex or multidimensional topics, AI-assisted suggestions often included multiple codes, thereby contributing to broader conceptual coverage.

Example1: Classification of *List of Wooden Tablets by Historical Site* (고대 목간: 유적별 목간목록)

Recommended ILC2 Classmarks by Generative A

Based on the description of the KOS, the generative AI (ChatGPT-4o) proposed the following classmarks:

- *yt* – writing → The primary function of wooden tablets is written communication; therefore, this class is appropriate;

- *mpat* – wooden materials → Since the items are wooden artifacts, this class represents the material aspect accurately;
- *sykk* – Korean civilization → As the KOS focuses on archaeological finds within Korea, this class reflects the cultural and geographic scope.

Corresponding ILC2 Classmarks and Captions

The suggested codes correspond to the following official ILC2 classmarks:

- *yt* “documents; instantiations; knowledge items”;
- *mpat* “trees; arboreous; arboreal plants”;
- *sykk* “Korean civilization”.

Final Classmarks Assigned by Expert Review

After evaluating the material, function, and cultural context of the KOS, the following two classmarks were selected:

- *yt* “documents; instantiations; knowledge items”;
- *sykk* “Korean civilization”.

The classmark *mpat* was excluded, as the material aspect was deemed less central than the functional and cultural dimensions in this case. However, the limitations of generative AI were also apparent. In some instances, the AI produced hallucinated codes that did not exist in ILC2 or made structurally inconsistent recommendations. As a result, every AI-generated suggestion required expert verification, and final decisions rested entirely with human experts. While the tool proved useful in generating ideas and highlighting cross-category linkages, its outputs could not be used uncritically. Future use of generative AI in classification will require improved training on structured vocabularies and controlled integration into expert workflows.

In another case, for the KOS entry *Disaster and Safety Industry Classification*, the combined use of *spr* “emergency services” and *tas* “social safety” was proposed to better capture its complex thematic scope. However, the additional suggestion of *uaq* – interpreted by the AI as representing “industrial sectors” – was in fact inaccurate, as *uaq* in ILC2 denotes “taxes; levies.” This reflects a case of hallucination in generative AI, underscoring the need for expert validation of AI-generated classification results.

Example2: Disaster and Safety Industry Classification (재난안전산업 분류)

Recommended ILC2 Classmarks by Generative AI

- *spr* – emergency services → Relevant to disaster response, recovery, and preparedness functions described in the KOS;
- *tas* – social safety → Captures the broader societal goal of disaster and safety-related classifications;

- *uaq* – industrial sectors → Since the KOS itself defines sectors within an industry, this high-level class contextualizes the classification’s scope.

Corresponding ILC2 Classmarks and Captions

- *spr* “emergency services; rescue services”;
- *tas* “police; constabulary; civil guard; protective services; cops”;
- *uaq* “taxes; levies”.

Final Classmarks Assigned by Expert Review

After evaluating the material, function, and cultural context of the KOS, the following two classmarks were selected:

- *spr* “emergency services; rescue services”;
- *tas* “police; constabulary; civil guard; protective services; cops”.

After identifying *uaq* “taxes; levies” as a hallucinated recommendation, the case was re-submitted to the ChatGPT prompt with a clarification. The AI subsequently returned a revised set of ILC2 classmarks, none of which involved non-existent or misinterpreted codes. This illustrates the importance of not only assessing the relevance of AI-generated suggestions, but also verifying that the proposed classmarks correspond to actual entries in the classification system.

Re-recommended ILC2 Classmarks by Generative AI

- *spr* – emergency services → Relevant to disaster response, recovery, and preparedness functions described in the KOS;
- *sprf* – fire and rescue services → Specifically captures firefighting and rescue operations, which are key components of the industry;
- *uaqi* – social-security contributions → Reflects the institutional and policy-related dimension of disaster safety support, though its relevance may be secondary.

When appropriate classmarks were not available, it was also possible to prompt the AI to suggest new classmarks that could potentially be added to ILC2. For example, in the case of the *Classification of Blockchain* KOS, the AI not only recommended two existing ILC2 codes, but also proposed additional classmarks along with justifications for their inclusion in future updates of the classification system.

- KOS title - *Classification of Blockchain* (블록체인 분류체계);
- KOS description - Classification of Blockchain is one of the new software domain classification schemes used in the *Software Industry Survey* published by the Software Policy & Research Institute. The classification system is described in the December 2018 report titled *2018 Software Industry Survey*, issued by the same institute. This new set of software classifications includes schemes for cloud services, big data,

Internet of Things (IoT), artificial intelligence, VR/AR/MR, software-convergent services, and blockchain (*translated from Korean*).

The classmarks suggested by the generative AI are as follows. As shown below, both of the recommended classmarks currently listed in the ILC2 schedule were found to be valid and supported by reasonable justification. The newly proposed classmarks, on the other hand, were not part of the existing ILC2 scheme and appear to be conceptual extensions of *wmv* “computer networks.”

Suitable ILC2 Classmarks

- *wmv* – computer networks [telematics] → Blockchain is fundamentally a decentralized network technology, which can be categorized under computer networks;
- *wnuas* – software → As blockchain is classified as part of the software industry, this classmark reflects its technological foundation.

Suggested New Classmarks Not in ILC2

- *wmvbx* – distributed ledger technology → A proposed subclass under computer networks to represent the distinctive architecture of blockchain systems;
- *wmvas* – crypto-assets or smart contracts → Reflects emerging applications of blockchain beyond infrastructure, including digital asset exchange and contract automation.

Notably, the *ILC developing version* (ISKO Italia 2026), which is currently under development as the successor to ILC2, includes a specific entry for “blockchain.” In this version, the previous *wmv* class for “computer networks” has been updated to *suw*, under which *suwvl* refers to “blockchains,” categorized as a subclass of “distributed ledgers; shared ledgers.” This comparison suggests that the generative AI’s proposed extensions – although not present in ILC2 – are aligned with the direction of ongoing classification development and may offer meaningful guidance.

Blockchain in ILC developing version

<i>suw</i>	computer networks [telematics]
<i>suwv</i>	distributed ledgers; shared ledgers
<i>suwvl</i>	blockchains

5. Conclusions

This study explored the applicability of the Integrative Levels Classification, second edition (ILC2), to the classification of Korean Knowledge Organization Systems (K-KOS), as well as the role of generative AI in supporting

the classification process. By applying ILC2 to 458 KOS entries and integrating AI-assisted suggestions, the research yielded several key insights.

First, the phenomenon-based structure of ILC2 proved conceptually well-suited to the classification of KOSs, which often reflect applied, interdisciplinary, and real-world domains. The flexibility of ILC2 allowed for multidimensional representations through multiple class assignments, especially in domains such as technology, governance, and communities. Second, the classification process revealed topical and cultural gaps in the current ILC2 schedules. Specific challenges were encountered when classifying KOSs related to emerging technologies and culturally specific content. These findings suggest the need for more granular and localized categories in future updates of ILC. Third, the use of generative AI, particularly ChatGPT-4o, demonstrated both potential and limitations. While AI provided valuable classification suggestions and alternative perspectives, some AI-generated suggestions exhibited hallucinations, requiring expert validation before final adoption. AI was most effective when used as a complementary tool rather than as a substitute for expert judgment.

Overall, the study contributes a practical model for applying ILC2 to a national KOS registry and demonstrates how AI can enhance classification workflows. It also identifies future directions for improving classification systems through iterative updates, culturally responsive expansions, and enhanced human–AI collaboration.

Acknowledgments

This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2023S1A5A2A03085177).

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AID Ainformazioni

Rivista semestrale di Scienze dell'Informazione

Anno 43

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In copertina

Disegno di Paul Otlet, Collections Mundaneum, centre d'Archives, Mons (Belgique).

ISBN 979-12-5965-639-1

ISSN 1121-0095



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