# Cross-National Variations in Students' Diagrammatic Representations of Biological Taxonomy

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**Abstract.** This study investigates cross-national variations in college students' diagrammatic representations of biological taxonomy, focusing on how learners from different sociocultural backgrounds construct visual structures to convey hierarchical relationships. A total of 121 college students from Taiwan (n = 60) and Indonesia (n = 61) participated in a diagrammatic task in which they were asked to design an instructional representation of the five biological kingdoms for Grade 7 students. The collected drawings were coded into six structural types—Pictorial, List, Ring, Interaction, Evolution, and Tree—and further categorized as hierarchical or non-hierarchical representations. Quantitative analysis revealed significant differences between the two groups. Indonesian students demonstrated a strong preference for hierarchical tree structures, whereas Taiwanese students predominantly adopted non-hierarchical forms. A chi-square test confirmed that nationality was a significant factor influencing representational structure, while academic major showed no significant effect. These findings suggest that diagrammatic representations are shaped not only by disciplinary knowledge but also by sociocultural factors, including prior exposure to textbook conventions. The study highlights the role of representational familiarity in guiding students' design choices and suggests that visual representations in science are culturally situated rather than universally constructed. Implications are discussed for science education and teacher preparation, particularly in raising awareness of how instructional representations may reflect implicit cultural norms and influence students' understanding of scientific concepts.

**Keywords:** biological taxonomy, diagrammatic representation, cross-national study


S. E. Atmojo (ed.), *Proceedings of the 2026 International Conference on Primary Education (ICOPE 2026)*, Advances in Social Science, Education and Humanities Research 1027,
https://doi.org/10.2991/978-2-38476-605-5_2

## 1. Introduction

Visual representations play a central role in science education by supporting the visualization of abstract concepts, facilitating information processing, and enhancing learning [2] [6]. In biology, taxonomy is a foundational concept that relies heavily on diagrammatic representation to communicate hierarchical relationships among living organisms.

However, representations are not neutral carriers of knowledge. Prior research has shown that instructional images are shaped not only by cognitive considerations but also by sociocultural conventions embedded in textbooks and learning environments. In particular, comparative studies of biology textbooks have revealed systematic differences in how taxonomic relationships are visually represented across countries. For example, Taiwanese textbooks tend to adopt non-hierarchical layouts, whereas Indonesian and Australian textbooks more frequently use hierarchical tree structures to explicitly represent classification levels.

Despite these findings, it remains unclear whether such textbook conventions persist in learners' own representational practices. If students reproduce similar visual structures, this would suggest that representational conventions learned during schooling continue to influence instructional design decisions into adulthood.

This study aims to examine whether college students from different sociocultural backgrounds produce different diagrammatic representations of biological taxonomy and to identify the factors influencing these variations.

## 2. Theoretical Background

This study draws on both cognitive and social semiotic perspectives to understand how representations are constructed. From a cognitive perspective, generating a visual representation involves retrieving and organising knowledge from memory, influenced by prior learning experiences and pedagogical considerations [3] [5]. In this study, pedagogical content knowledge (PCK), which integrates content knowledge and pedagogical knowledge, is considered as a potential factor influencing representation design.

From a social semiotic perspective, representations are viewed as culturally situated meaning-making practices. Visual designs are not arbitrary but are shaped by socially shared conventions and values [4]. Textbook images, as authoritative semiotic resources, provide canonical forms that may guide learners' representational choices.

A key concept in this study is representational familiarity, which suggests that learners tend to reproduce familiar visual formats encountered in prior learning experiences [1]. These formats function as a "semiotic toolbox" from which individuals select representations appropriate to a given context.

Based on these perspectives, this study examines the relative influence of socioculture and PCK on students' diagrammatic representations.

## 3. Method

### *3.1 Participants*

A total of 121 college students from a Taiwanese public university participated in the study, including 61 Indonesian and 60 Taiwanese students.

### *3.2 Task*

Participants were asked to assume the role of a textbook editor and design a diagram representing the five biological kingdoms for Grade 7 students. A short explanatory text was provided to support recall of relevant concepts.

### *3.3 Data Collection*

Data included student-generated drawings and semi-structured interviews. The interviews were used to elicit participants' interpretations of their diagrams and to identify possible sources of influence.

### *3.4 Data Analysis*

Drawings were coded into six structural types: Pictorial, List, Ring, Interaction, Evolution, and Tree structure (see coding scheme on p. 3).

These were further grouped into:

- **Non-hierarchical representations** (five types)
- **Hierarchical representations** (Tree structure)

Chi-square tests were conducted to examine the effects of nationality and academic major on representation type.

## 4. Results

The results revealed both similarities and differences between the two groups. All six structural types were identified across the dataset, although the Evolution design appeared only among Taiwanese students.

A clear contrast emerged in the distribution of hierarchical and non-hierarchical representations. Indonesian students showed a strong preference for hierarchical tree structures (46%), whereas Taiwanese students predominantly used non-hierarchical designs (82%) (see Table 3 on p. 4).

Statistical analysis confirmed that nationality was significantly associated with representation type ($\chi^2 = 30.423$, $p < .001$), while academic major and gender were not significant factors.

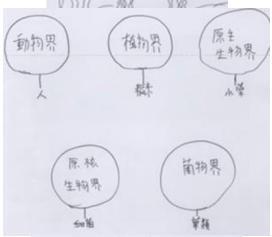
Interview data further indicated that Taiwanese students often reproduced representations from memory, particularly textbook images depicting evolutionary sequences. In contrast, Indonesian students' designs aligned with hierarchical textbook conventions but were less frequently described as direct recall.

## 5. Discussion

The findings indicate that diagrammatic representations are shaped by sociocultural influences rather than solely by disciplinary knowledge. The strong alignment between students' representations and textbook designs suggests that representational familiarity plays a critical role in shaping visual meaning-making.

Taiwanese students' preference for non-hierarchical designs reflects the implicit representation style commonly found in their textbooks, while Indonesian students' preference for hierarchical tree structures corresponds to the explicit representation of taxonomic relationships in their learning materials.

**Table 1.** Coding scheme for the visual structure of the five-kingdom representation

| Code | Definition | Example |
|---|---|---|
| Pictorial | Drawing living things, each one representing one kingdom, in a realistic setting; no frame or line to separate different kingdoms. |  |
| List | Representing each kingdom by either words or realistic examples that are arranged in separate spaces; kingdoms are separated with no connection among them. |   |
| Ring | Five kingdoms connecting each like a ring or a pie chart; the superordinate class 'all living things' is not denoted. |  |

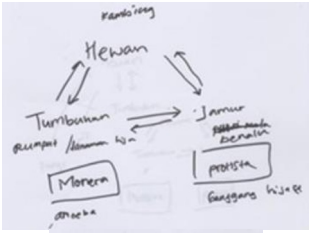
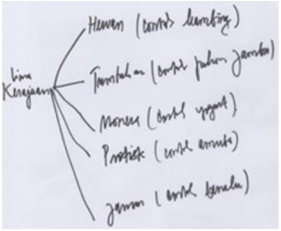
| | | |
|---|---|---|
| Interaction | Using bidirectional arrows to show the feeding relationships (mode of nutrition) between/among kingdoms. |  |
| Evolution | A process-based arrangement to show how the modern five kingdoms evolved from the unicellular kingdom Monera to Protista and developed into multicellular kingdoms (Plantae, Fungi, and Animalia). |  |
| Tree structure | Using a hierarchical structure to differentiate superordinate and subordinate classes, 'all living things' is usually given as the superordinate class; kingdoms are the subordinate class. |  |

**Table 2.** Distribution of design variations between Indonesian and Taiwanese participants.

| | Non-hierarchical | | | |
|---|---|---|---|---|
| Culture group | Independent taxa | Interrelated taxa | Sequential taxa | Hierarchical tree structure |
| Indonesian | 20 (33%) | 13 (21%) | 0 (0%) | 28 (46%) |
| Taiwanese | 32 (54%) | 3 (5%) | 14 (23%) | 11 (18%) |

Note: Percentage represents the ratio in each culture group.

Importantly, the lack of significant effects from academic major suggests that short-term disciplinary training does not override long-term exposure to representational conventions. Instead, socioculture appears to function as a more powerful and enduring influence.

These results support the view that scientific representations are not universal but are culturally mediated artefacts shaped by shared practices and epistemological orientations.

## 6. Conclusion

This study provides evidence that college students from different sociocultural backgrounds produce systematically different diagrammatic representations of biological taxonomy. The findings highlight the enduring influence of textbook representations and the role of sociocultural context in shaping instructional design.

For science education, the results suggest the need to develop greater awareness of the cultural assumptions embedded in visual representations. Teacher education programs should emphasize critical evaluation of instructional images and support the development of visual literacy in designing effective representations.

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