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Epistemic Goals and Practices in Biology Curriculum—the Philippines and Japan

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Abstract

Despite cultural differences, the Philippines–Japan partnership is developing an intentional teaching curriculum with parallel standards. However, disparities among their respective educational systems have prompted inequalities. As education plays a critical role in collaboration, we explored the Epistemic Goals (EGs) and Epistemic Practices (EPs) in the biology curriculum, with the research question: How do the epistemic goals and practices of the biology curriculum transmit knowledge and skills in the Philippines and Japan? Using an ethnographic design, we conducted two iterative explorations of EGs and EPs. First, we examined the curriculum policy to determine its EGs. Using the A-B-C-D protocol, we employed discourse analysis to evaluate knowledge and skills in the biology grade-level standards. Second, we examined the articulation of goals in classroom teaching practices. We conducted classroom immersion and observed classes to determine EPs and supported our observations through interviews, synthesizing the data using inductive content analysis. Our findings revealed that the Philippines' EGs were to transmit factual knowledge enhanced by basic science skills, and their EPs were audio-visual materials, gamified instructions, guided inquiry, posing questions, and learning-by-doing. In comparison, Japan's EGs were to provide a solid foundation of theoretical and metacognitive knowledge, integrated science skills, and positive attitudes. Its EPs involved cultivating lasting learning, observation, investigation, experimentation, collaborative discussion, and reflective thinking. Our study makes a meaningful contribution by shedding light on crucial ideologies and cultural identities embedded in Biology curricula and teaching traditions.

Keywords Biology curriculum · Epistemic goals · Epistemic practices · Science education

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Introduction

The cultural and educational connections within the Philippines-Japan collaboration establish the basis for developing long-lasting relationships between individuals. Despite cultural differences, both countries continue to develop an intentional teaching curriculum with parallel standards. According to Joseph (2010), the most effective way to demonstrate cultural ideology is through school curriculum. The term "curriculum" refers to different areas of education, such as the content taught in schools, learning methods, teacher approaches, and student progress assessment (Schiro, 2013). Understanding the basic components of an effective curriculum is critical to academic achievement.

Improving the Philippines' curriculum is a significant and urgent matter given the considerable challenges they face in academic achievement. According to the Program for International Student Assessment (Organization for Economic Co-operation and Development, 2023), Filipino students exhibit relatively lower levels of achievement in critical academic domains such as science, mathematics, and reading (OECD, 2023). In contrast, the educational system in Japan is highly regarded for its exceptional quality and performance, consistently achieving top ranks among global academic systems. The 2022 PISA assessment shows that Japanese students consistently demonstrate superior performance compared with the average in their respective subject areas (OECD, 2023).

The disparities in outcomes and rankings between the education systems in Japan and the Philippines prompt an intriguing inquiry: what distinguishes Japanese education and how can we draw insights from its curricular practices to enhance the quality of education in the Philippines? This inquiry is of utmost importance as we aim to improve the educational outcomes and opportunities for Filipino students through an effective, quality curriculum. Moreover, it is essential to acknowledge the substantial research gap in curriculum studies regarding curricular benchmarks. This gap provides a valuable opportunity to gain insight into the unique educational system strategies.

Background of the Study

Examining the Epistemic Goals (EGs) and Epistemic Practices (EPs) of the biology curricula requires fundamental inquiries regarding the Nature of Science (NoS), the methodologies scientists employ in knowledge acquisition, and the scientific frameworks of understanding. Brock and Park (2022) argue that there has been a longstanding emphasis in science education on comprehending the NoS and the processes and undertakings of knowledge production. These essential elements are integrated as important learning goals in global science education curricula and policy documents (Leden & Hansson, 2019; Olson, 2018; Park et al., 2020).

EGs play a crucial role in establishing the fundamental and structural knowledge framework, including the required skills and attitudes. It encompasses the essential cognitive abilities that are pivotal for comprehension, academic engagement, and learning. It represents knowledge seeking, comprehension, and construction, particularly within the framework of the NoS (Chinn et al., 2011). Similarly, EGs enable individuals to explore their own beliefs about knowledge, as emphasized by Cho et al. (2011), with a significant influence on how individuals develop epistemic values and academic achievement. This includes improving advanced literacy skills, making informed decisions, and promoting a lifelong dedication to continuous learning.

Similarly, McDevitt et al. (1994) discuss how EPs involve various personal inquiry methods. The practices discussed by Hofer (2001) relate to the personal justification of knowledge acquisition. Personal justification of epistemic beliefs occurs through reliable processes when individual and social practices are considered within the epistemological framework (Chinn et al., 2011). According to Goldman (1999), considerable research has been dedicated to studying reliable belief formation processes, particularly concerning specific practices within scientific inquiry, arguing that practices, as opposed to errors and ignorance, have a relatively positive effect on knowledge. Furthermore, utilizing EPs include exploring external sources of information and engaging in active cognitive construction processes, as elucidated by Muis and Franco (2009). Hence, scientific inquiry is developed as a core emphasis to raise awareness, cultivate independent thinking skills, question assumptions, and make informed judgments.

Theoretical Framework

This study anchors its theoretical framework in the earlier work of Berland et al. (2016) on Epistemologies in Practice (EIP). Two epistemic folds define this framework.

First, the EIP defines epistemic goals for student knowledge acquisition, referring to the NoS as a means of understanding scientific development (Lederman, 2002). It entails an epistemological investigation of the fundamental features of reality such as the essence of truth, the process of justification, and the distinction between knowledge as a manifestation of capabilities and as a collection of factual information (Knight et al., 2014).

Moreover, defining goals is intimately connected to the epistemic dimensions; hence, this study examines how students use epistemic considerations when constructing scientific knowledge. This approach offers an analytical lens for understanding student involvement in scientific practices, which is vital to classroom and learning engagement. Berland et al. (2016) conducted a study identifying four noteworthy epistemic considerations: *nature*, *generality*, *justification*, and *audience*.

Nature explores an extensive range of knowledge. Fundamental to this consideration is the nature of knowledge (knowledge is) and that of knowing (knowledge acquisition) (Lederman, 2007; Schiefer et al., 2022). *Generality* delves into complex interconnections, forming an understanding using scientific concepts and facts. For instance, a phenomenon of interest can be comprehensively understood and explained within the scientific community by examining specific contexts and conditions utilizing scientific theories (Lewis & Belanger, 2015). Hence, this act of knowledge generation is crucial to thoroughly comprehending observed events and phenomena (Beeth & Hewson, 1999).

Next, *justification* underscores the necessity for logical reasoning to substantiate our conceptual comprehension. It is the systematic process that employs factual information and evidence, particularly that obtained from experiments, to substantiate assertions (Peffer & Ramezani, 2019). This practice links evidence with knowledge to assess essential claims and facilitates meaningful discussion (McNeill et al., 2006; Osborne et al., 2004). Finally, the *audience* dimension orients students' knowledge and the usefulness of their understanding (Berland et al., 2016). It is also relevant regarding how students perceive and derive meaning from the material, and how they develop a comprehensive understanding of it (Berland & Reiser, 2009; Paretti, 2009). The combined impact of these epistemic factors intricately shapes and defines the goals that guide the pursuit of epistemic knowledge.

Second, EIP includes essential practices in the classroom and learning community. In addition to acquiring discipline-specific knowledge, Peffer and Ramezani (2019) argue that demonstrating proficiency in scientific methodologies leads to developing a sophisticated epistemological understanding of concepts relevant to the NoS and scientific knowledge. Since the NoS is an essential element of inquiry in practice, epistemology and the NoS are inextricably linked (Deng et al., 2011). By exploring the NoS, we can gain insight into the fundamental elements that define scientific investigation, including its fundamental principles, underlying assumptions, and the methodologies of scientific pursuit.

According to Greene et al. (2016), NoS can be used interchangeably with concepts such as personal epistemology and epistemic cognition, which explore how individuals conceptualize knowledge. Personal epistemology reflects epistemological beliefs, reflective judgments, ways of knowing, and reflection (Hofer, 2001), whereas epistemic cognition is the examination of knowledge, particularly the evaluation of the essential components of justification and related concepts of objectivity, subjectivity, rationality, and truth (Moshman, 2014).

Furthermore, Lederman et al. (2002), referred NoS to the epistemology and sociology of science – understanding science as a way of knowing, and the values and beliefs inherent in scientific knowledge and its development. It encompasses various philosophical presuppositions, including values, development, conceptual inventions, consensus-building in the scientific community, and distinguishing scientific knowledge (Lederman, 1992; Smith & Wenk, 2006; Tsai, 2007). The close connection between an individual's cognitive framework and the philosophical foundations of the NoS becomes evident when we recognize that these concepts have a shared identity.

Research Question

In this study we analyzed the EGs and EPs in the Biology curriculum. Specifically, we address the question: How do the epistemic goals and practices of the Biology curriculum transmit knowledge and skills in the Philippines and Japan?

Methods

Research Design

We employed an ethnography design to examine the EGs and EPs of the biology curricula. Ethnography comprehensively explores the historical, cultural, and political aspects of knowledge evident in the educational traditions and practices of the countries under study (Hout, 2004). It involves systematically observing individuals, locations, concepts, written records, and behaviors (Savage, 2000) to document routine occurrences and identify opportunities for improvement (Dixon-Woods et al., 2019).

Research Strategies

We investigated two iterative cases of EGs and EPs. First, to determine the framework guiding the scope and implementation of EGs, we examined the Biology Grade Level Standards (BGLSs). In this context, EGs refer to the instructions' specific statements and purposes that outline what students are expected to learn as they interact with the curriculum (Orr et al., 2022; Print, 1993).

According to Plowright (2011), the standards within a curriculum serve as its policies. A curriculum is inherently governed by the power and knowledge structures that stem from and circulate within sociocultural and political domains (Ball et al., 2012). As an artifact, it embodies culture, design, and learning (Hodder, 2000) and is associated with socio-material factors, discursive frameworks, policies, and performativity frameworks (Horan et al., 2014; Kalantzis & Cope, 2020; Maguire et al., 2011).

Second, we engaged in classroom immersion for observational (teaching) research (Sheal, 1989) to investigate the EPs. Teaching observation is an unbiased measure that allows us to gain a thorough, firsthand understanding of teaching practice (Desimone, 2009). Being physically present in the learning environment provides a unique opportunity to directly observe the teaching methods and strategies in real-time, including their application and usefulness (Granström et al., 2023). In addition to helping us identify opportunities for unique learning practices and ways to improve education (Sullivan et al., 2012), it provided a better understanding and appreciation of each country's cultural and pedagogical intricacies.

Data Collection and Gathering Procedures

This longitudinal study is part of an ongoing two-year community inquiry project. Our ongoing immersion began in the last quarter of 2022. The first iteration of the case focuses on the documented policies based on the BGLS. Policy materials were obtained from the websites of the Philippines Department of Education (DepEd) and the Ministry of Education, Culture, Sports, Science, and Technology (MEXT) (2006) in Japan. In the Philippines, science education goals are carefully designed with each grade level having its own standards that differentiate biology from other specialized areas of science, such as earth science, chemistry, and physics. The curriculum goals are divided into objectives customized for each grade level, thus ensuring a smooth and logical learning progression.

In contrast, science education in Japan follows a standardized set of overarching objectives that cover essential scientific concepts such as energy, particles (matter), life, and the earth. These objectives are outlined in the study course and provide a comprehensive framework that includes a range of knowledge, skills, and attitudes. The framework clearly outlines the overall objectives, making it possible to identify those specific to different scientific concepts.

The collected BGLSs were analyzed in the subsequent stages below.

Curriculum Matching and Mapping

Table 1 shows the curriculum matching results for both countries. DepEd and MEXT developed, implemented, and monitored the goals of the biology curriculum at the

Table 1 Curriculum matching

Country	System	Focus of standards	Level			
Philippines	DepEd	Objectives	Elementary	G3-G6	Junior high	G7-G9
Japan	MEXT	Objectives	Elementary	G3-G6	Lower secondary	G7-G9

Note: Authors' elaboration

elementary (grades (G) 3–6), junior high (G7–G10), and lower secondary (G7–G9) levels. Employing Hale's (2007) curriculum mapping protocol, to map EGs in the BGLS. Essential mapping was used to ascertain specific competencies, including detailed knowledge and abilities that students are expected to acquire.

Syntactic Analysis and Transformation

We expound upon these goals by examining their syntax. Syntax is a methodological analysis of the structure of sentences or statements (Foorman et al., 2016), including aspects such as word order, and structure. First, we investigated the verb-content-context and transformed it into Anderson and Krathwohl's (2001) A-B-C-D protocol. As shown in Table 2, a sample goal is divided into four distinct components.

Component A pertains to the intended *audience*, typically comprising students; component B relates to expected *behavior* or cognitive faculties component C pertains to the *conditions* necessary to demonstrate capabilities, and component D relates to the *degree* to which a behavior must be performed.

Classroom Immersion and Teaching Observation

We coordinated the immersion and teaching observation (IATO) with Philippine and Japanese school administrators. We were granted permission to conduct observations at three schools in Japan and two in the Philippines between January and December 2023. In August 2023, we conducted teaching observations in three classrooms in the Philippines. We further observed ten classrooms, which were predominantly held between November and December in Japan. Our observations encompass various aspects such as imparting subject knowledge, fostering skills, critical thinking abilities, and instilling specific values. Inside the classrooms, we were able to capture photographs and take detailed field notes, which allowed us to thoroughly document the interactions within each dynamic learning environment. By engaging in visual and observational documentation, we created a thorough record of the EPs. For ethical considerations, we deliberately chose not to incorporate any photographs of the students in this manuscript.

Interviews and Focus Group Discussions

After completing IATO, we conducted interviews with the educators to clarify the EPs. This dialogue dramatically improved our understanding of the factors influencing pedagogical decision-making by facilitating the exchange of ideas and perspectives. It also

Table 2 Syntactic transformation

Audience	Behavior *(verb)*	Condition *(content)*	Degree *(context)*
Students will	develop	the ability to generate questions based on differences and similarities of objects and phenomena	by investigating familiar living things and the sun and the ground

Note: Authors' elaboration

provided valuable context, enhancing our observations and enriching the quality of the observational data collected.

Data Analysis

Using discourse analysis (DA) and curriculum coding, we examined the explicit words that indicate EGs (knowledge and skills), which go beyond signs and signifiers by becoming "practices that methodically produce the objects of which they speak" (Foucault, 1972, p. 49) at the expense of meaning formation (Khan & MacEachen, 2021).

We analyzed EGs based on the explicit BGLSs in the form of knowledge-using *behavior* and *condition*. *Behavior* referred to the knowledge dimension, and *condition* referred to content (scope of knowledge). To establish a connection between behavior and the cognitive domain, it is imperative to systematically categorize and classify individual cognitive verbs or processes based on their unique characteristics and underlying theoretical frameworks. This allows the development of personalized knowledge about cognitive tasks while contributing to a more organized understanding of cognitive functioning. Using Bloom's Taxonomy of Objectives as revised by Anderson and Krathwohl (2001), we coded each behavior against the cognitive domains. Each cognitive domain uses active verbs arranged hierarchically. The first aspect is *remembering*, which facilitates quick recall (i.e., recognition). The second aspect is *understanding*, which allows one to make sense of knowledge/information (i.e., description). The third aspect is *applying*, which is a demonstration method/procedure (i.e., classification). The fourth aspect is *analyzing*, which enables breaking down the structure of one's understanding into parts and pieces of information (i.e., differentiation). The fifth aspect is *evaluating*, which entails making use of one's judgment based on parameters such as conditions (i.e., conclusion). Finally, the sixth aspect is *creating*, which involves putting together pieces of information to create cohesive and holistic knowledge (i.e., development).

Table 3 presents the coding of EGs using knowledge types. First, with the verb *describe*, we classified a wide range of behaviors from focus and recall to perception and processing to problem-solving and decision-making and compared and categorized the respective verbs based on characteristics derived from cognitive traits. In this context, the term *be* describes the understanding of information by employing the knowledge of principles. After determining behaviors using verbs, we further classified them into Anderson and Krathwohl's (2001) *types of knowledge* (ToK). Each behavior is determined using the following: (1) familiarity with concepts, which necessitates acquiring *factual knowledge (fk)*, specifically knowledge of revealed facts; (2) *conceptual knowledge (ck)* encompassing the comprehension of ideas, associations, and operations; (3) *procedural knowledge (pk),* pertaining to the investigation methodology and knowledge acquisition within scientific inquiry; and (4) *meta-cognitive knowledge (mck)*, which denotes a more advanced level of comprehension pertaining

Table 3 Coding for ToK

Level	Behavior + Condition	Domain	Types of knowledge	
G3	Describe + Functions of the different parts of the body and things…	Remembering	Factual	Knowledge of details/ elements

Note: Authors' elaboration

to an individual's understanding of cognition, self-awareness, and self-regulation. In Table 3, *remembering* falls under *fk*, illustrating the *knowledge of details/elements*.

Similarly, we assessed EGs based on explicit standards in the form of *practical skills (PSs)* using *condition* and *degree* categories. *Condition* revealed the scope of knowledge and the *degree* of skill development. We examined the degree by selecting skills based on Gott and Duggan's (1995) classification. These *PSs* were classified according to Finley (1983) *Science skills*. The first is *Basic Science skills (BSs)*, which cover fundamental scientific processes, including observation, classification, measurement, prediction, inference-making, and communication. Second, *Integrated Science skills (ISs)* are composites (two or more BSs) with fundamental scientific process competencies. Integrated science skills are uniformly identified as a control variable combined with interpreting, hypothesizing, and experimenting to form a cohesive approach.

Table 4 presents the coding of conditions and degrees. We underlined *PSs* (i.e., investigating) for ease of identification. Each skill is coded according to its degree of development. Finally, we classified the underlying skills as *ISs*.

Furthermore, we analyzed IATO data using inductive content analysis (ICA). ICA is a social inquiry method grounded in epistemology that depicts the reality of practice. For example, by examining learning delivery, one can identify replicable and valid strategies that can be used to draw inferences from the data (Krippendorff, 2019). We utilized Marying's (2000) *ICA* protocol to effectively organize, refine, and establish significant categories in teaching practice, ensuring that our observations and field notes were aligned.

Results

Epistemic Goals and Practices – the Philippines

Table 5 presents the EGs and ToK in the Philippines context, utilizing *behavior* and *condition*. Regarding *behavior*, the data revealed a wide range of knowledge, primarily encompassing the domains of remembering and understanding. This trend indicates that the EGs emphasize acquiring crucial and foundational knowledge to develop *fk*, namely the specific details, elements, and principles of biology. Furthermore, this trend was consistently evident in G3, G4, G7, G8, and G9. However, we found variations in knowledge offerings for G5, G6, and G9. Higher order behavior incorporates *mck* in G5. This approach involves generating and cultivating strategic knowledge about health-promotion and hygienic practices. During G6, *ck* was presented to deliver life science principles, whereas during G9, more profound *pk* was presented. During G9, students were involved in the knowledge acquisition of scientific inquiry.

The *condition* suggests a progression of goals from elementary to junior high school. Fundamental principles of biology, such as the components and functions of living organisms, are systematically introduced in the early stages of education. For instance, as

Table 4 Coding for PSs

Level	Condition + Degree	Practical skills	
G 3	Ability to generate… + <u>Investigating</u> familiar living things…	Investigating	Integrated skills

Note: Authors' elaboration

Table 5 The EGs and ToK in the Philippines

Level	Behavior + Condition	Domain	Type of knowledge	
G3	Describe + Functions of the different parts of the body and things…	Remembering	Factual	Knowledge of details/elements
G4	Describe + Functions of the different internal parts of the body…	Remembering	Factual	Knowledge of details/elements
G5	Develop + Healthful and hygienic practices …	Creating	Metacognitive	Strategic knowledge
G6	Understand + How the different organ systems of the human body…	Understanding	Conceptual	Knowledge of principles
G7	Recognize + Living things are organized into different levels…	Remembering	Factual	Knowledge of details/elements
G8	Recognize + Reproduction as the process of cell division	Remembering	Factual	Knowledge of details/elements
G9	Gain + Deeper understanding of the digestive, respiratory, and circulatory systems to…	Applying	Procedural	Knowledge acquisition of scientific inquiry
	Familiar + With some technologies that introduce desired traits in economically …	Remembering	Factual	Knowledge of details/elements

Source: K–12 Curriculum Guide (Science) DepEd (n.d.); Department of Education website open repository (public domain) students progressed to higher grades, they were presented with more advanced concepts related to the organization and functioning of the human body.

Table 6 shows the degree-related goals and *PSs* in the Philippines. The data indicates that most elementary-level skills (G3–G6) involved classification, investigation, and communication. The acquisition of proficiency in classification and communication skills are imperative for developing a solid foundation for scientific literacy, commonly known as *BSs*. This investigation enabled a comprehensive scientific inquiry encompassing extensive processes. Investigative skills in G5 and advancements in classification improve the exploration and comprehension of biological phenomena, a combination of skills commonly referred to as *ISs*.

Additionally, we acknowledge the skills alignment with the proficiencies exhibited in junior high school. Where the use of *condition* and *degree* in the syntax did not effectively express practical skills, we resorted to observing behavior as an indicator of the skill dimension. Both the G7 and G8 levels of the curriculum employed the term *recognize*. In contrast, at the G9 level, the term *familiar* was used, implying the incorporation of students' sensory abilities, such as sight or visual perception. These *BSs* enable students to cultivate their power of observation.

During our IATO, we identified recurring themes to indicate the EPs in the Philippines.

Audio-Visual Materials

We frequently noticed how adept educators were in using audio-visual materials (AVM) to leverage their instruction. Strategically integrating AVM materials led to more engaging and interactive multimedia content for students while stimulating their auditory and visual faculties. Interestingly, we found that the use of AVM also encourages inclusivity within the classroom. By supporting diverse learning preferences, AVM fostered wider understanding, retention, and promoted significant learning experiences.

Gamified Instruction

Several students actively participated in thrilling learning experiences. We observed a gamified strategy that effectively utilized game elements to optimize student engagement. Teachers incorporated gamified experiences, including quick recall sessions, critical thinking exercises, and formative assessments. The interactive nature of gamified experiences captured students' attention, transforming ordinary learning activities into intellectually stimulating tasks. Therefore, sparked greater motivation, and consistent engagement.

Guided Inquiry

Students demonstrated scientific exploration consistent along with the structured guidance by their teachers. Curiosity prompted students to ask scientific questions and uncover practical solutions. This increased their interest and understanding to learning, while honing important abilities such as inquiry, critical thinking, and decision-making.

Posing Questions

We observed the art of posing thought-provoking questions. Posing questions tapped into students' inherent curiosity while stimulating their interest and motivation. Teachers often asked questions to probe student understanding and ask critical questions. Students learned

Table 6 The EGs and PSs in the Philippines

Level	Condition + Degree	Practical skills	
G3	(Describe) Functions of the different… + Plants and animals…	Communication	Basic science skills
G4	Functions of the different internal parts… + They can classify plants and animals… They can infer that …	Classification/Inference-making	Basic science skills
G5	Healthful and hygienic… + They compare different modes of … and conduct an investigation on pollination…	Classification/Investigation	Integrated science skills
G6	How the different systems work… + They classify plants …and animals on… They design and conduct an investigation on plant propagation. They describe larger ecosystems…	Classification/Investigation communication	Integrated science skills
G7	(Recognize) Living things are organized into different levels…	Observation	Basic science skills
G8	(Recognize) Reproduction as the process of cell division	Observation	Basic science skills
G9	(Familiar)… with some technologies that introduce desired traits in economically…	Observation	Basic science skills

Source: K–12 Curriculum Guide (Science) DepEd (n.d.); Department of Education website open repository (public domain) self-regulation, critical inquiry, and advanced learning while providing relevant, accurate, and thorough knowledge through this guided process.

Learning-By-Doing

We witnessed a learning experience in which the students were active participants. They were engaged in dynamic discussions that provided them with first-hand encounters toward understanding. During this period, students actively engaged in observing phenomena and scientific processes. Through hands-on experiences, engaged learners assume responsibility for their own understanding. They skillfully implement acquired knowledge while effectively connecting theoretical ideas to real-life situations.

Epistemic Goals and Practices – Japan

Table 7 presents the EGs and ToK by incorporating *behavior* and *condition*. Japan has a standardized *overall objective* (goals) from elementary to lower secondary/junior high schools. The objective is to construct a layer: in elementary school science, each grade's objectives fall under the subject's overall objectives and that of lower secondary school science. Under the "objectives of science as a subject," the first (energy and particles) and second (life and earth) fields have their own objectives, and each unit of the two fields has objectives based on the upper levels. This classification includes knowledge, abilities, and attitudes. We observed a comparable classification between the elementary and lower secondary levels. Within this categorization, there is remarkable uniformity in behavior, which illustrates the knowledge pattern. Students acquire knowledge, abilities, and attributes through higher cognitive learning, specifically in the form of creation. Each form of *mck* then contributes to the development of strategic knowledge, knowledge of cognitive tasks, and self-knowledge from G3–G9.

This condition entails a deeper understanding of living things, the structure of movement, the continuity of life, and the structure and function of the body. Various biology concepts facilitate scientific inquiry with the objective of advancing the understanding and acquisition of metacognitive knowledge. These objectives were designed to enhance proficiency in employing scientific methods, specifically in conducting scientific inquiry into natural objects, experiencing objects, and understanding phenomena. Furthermore, the process of developing student understanding is facilitated by their direct engagement with objects and phenomena, while honing their attitudes toward scientific inquiry.

Table 8 shows the degree-related EGs and *PSs* in Japan. The goals consist of knowledge, abilities, and attitude, and demonstrate the consistency of learning development across the elementary and lower secondary school levels. Irrespective of the concept being considered, skill development follows a standardized approach from G3 to G9. *PSs* are uniform across various learning domains, like all knowledge derived from active demonstration, including observations, experiments, and other scientific activities. Similarly, we noted that student abilities were centered around a repetitive mode of inquiry. The students employ and hone their skills to enhance their comprehension of biological principles. Furthermore, cultivating a positive attitude toward nature, life, and the environment requires consistent practice and refining one's abilities. By employing observation, experimentation, and other practical work, students cultivate a positive disposition toward scientific inquiry and conducting scientific inquiries.

Table 7 The EGs and ToK in Japan

Level	Behavior + Condition	Domain	Type of knowledge	
G3	Develop + Knowledge and understanding of familiar living things and the sun…	Creating	Strategic knowledge	Metacognitive
	Develop + Ability to generate questions based on differences and similarities …	Creating	Knowledge of cognitive tasks	
	Develop + Attitude to love and care for living things/toward active …	Creating	Self-knowledge	
G4	Develop + Knowledge and understanding of structure and movement of …	Creating	Strategic knowledge	Metacognitive
	Develop + Ability to generate evidence-based predictions and hypotheses …	Creating	Knowledge of cognitive tasks	
	Develop + Attitude to love and care for living things/toward active…	Creating	Self-knowledge	
G5	Develop + Knowledge and understanding of the continuity of life…	Creating	Strategic knowledge	Metacognitive
	Develop + Ability to generate solutions based on predictions …	Creating	Knowledge of cognitive tasks	
	Develop + Attitude to respect life/engage in active scientific problem-solving	Creating	Self-knowledge	
G6	Develop + Knowledge and understanding of the bodily structure and functions of …	Creating	Strategic knowledge	Metacognitive
	Develop + Ability to produce more valid ideas about functions…	Creating	Knowledge of cognitive tasks	
	Develop + Attitude to respect life/engage in active scientific problem-solving…	Creating	Self-knowledge	
G7-G9	Develop + …conduct a scientific inquiry into natural objects through…	Creating	Strategic knowledge	Metacognitive
	Develop + experience objects and phenomena related to …	Creating	Knowledge of cognitive tasks	
	Develop + Attitude toward conducting scientific inquiry…	Creating	Self-knowledge	

Source: Course study (science); MEXT (n.d.); *MEXT website open repository (public domain)*

Table 8 The EGs and PSs in Japan

Level	Condition + Degree	Practical skills	
G3	Knowledge and understanding… + Acquire fundamental skills for observations, experiments, and other scientific activities	Observations, experiments, and other scientific activities	Integrated science skills
	Ability to generate… + Investigating familiar living things and …	Investigating	
	Attitude to love and care for living things/engage in active … + Investigating familiar living …	Investigating	
G4	Knowledge and understanding… + Acquire fundamental skills for observations, experiments, and other scientific activities	Observations, experiments, and other scientific activities	Integrated science skills
	Ability to generate evidence-based… + Investigating the structure and movement of the human body…	Investigating	
	Attitude to love and care for living things/engage in active… + Investigating the structure of the human body…	Investigating	
G5	Knowledge and understanding… + Acquire skills for observations, experiments, and other scientific activities	Observations, experiments, and other scientific activities	Integrated science skills
	Ability to generate solutions… + Investigating the continuity of life, …	Investigating	
	Attitude to respect life/toward… + Investigating the continuity of life…	Investigating	
G6	Knowledge and understanding… + Acquire basic skills for observations, experiments, and other scientific activities	Observations, experiments, and other scientific activities	Integrated science skills
	Ability to produce… + Investigating bodily structures and the functions of living things…	Investigating	
	Attitude to respect life/toward… + Investigating bodily structures and the functions of …	Investigating	
G7-G9	…conduct scientific inquiry… + Through conducting observations, experiments, and other scientific activities…	Observations/experiments, and other scientific activities	Integrated science skills
	Experiencing objects and phenomena… + Conducting scientific inquiry activities that include generating questions, conducting observations, experiments, and other scientific activities with… analyzing and interpreting the results, and expressing…	Observations, experiments, and other scientific activities	
	Attitude toward conducting scientific inquiry… + Conducting integrated skills actively into …	Investigating	

Source: Course study (science); MEXT (n.d.); *MEXT website open repository (public domain)*

Our IATO in different schools, helped us determine recurring themes to indicate the EPs in Japan.

Cultivating Lasting Learning

Japanese teachers cultivate lasting learning. They began their lessons by writing the learning goals which are grounded on shared responsibility, to develop a sense of direction and purpose. They introduce real-world problems that allow students to connect their prior understanding. During active learning activities, the teachers gathered students' observations and methodically arranged them on classroom boards. Such visual representations served as a valuable reference for ongoing discussions, reflection, and knowledge construction. It depicted patterns and variation that can elicit further scientific inquiries. Similarly, it promotes data-driven practice towards generating conclusions and generalizations. This approach bolstered students' capacity for analysis and cultivated a more profound comprehension of biology.

Observation, Investigation, and Experimentation

We observed learners utilizing their senses to examine organisms. They engaged in direct interactions under meticulously replicated conditions in the classroom or laboratory. They participated in a wide range of scientific activities and performed experiments. They diligently adhered to scientific methodologies and precisely recorded their discoveries to enhance understanding of diverse scientific phenomena and processes through practical activities.

Collaborative Discussion

All classes were encouraged to participate in micro-discussions. This allowed the students to ask questions, seek clarification, and enhance their understanding in a smaller and supportive environment. It was crucial for students with advanced understanding to take the lead and facilitate the discussion. Collaborative discussions were instrumental to learning from peers and affirming understanding, while expressing their thoughts and beliefs leading to collective empowerment and collaborative learning.

Reflective Thinking

The classes were adept in reflective thinking. This method encouraged students to carefully review what they had learned and evaluate if their present experiences met the learning objectives. Teachers designed purposeful queries to prompt reflection. While the students were provided ample time to ponder and participate in creating a tranquil environment for introspection.

Discussion

Epistemic Goals – the Philippines and Japan

In the Philippines, EGs focus on transmitting *fk*. Both *fk* and *ck* are crucial for cognitive proficiency advancement (Schraw, 2006) and for helping students perform better in school

(Idrus et al., 2022). Having a solid foundation of *fk* is essential for comprehending biological concepts. Thus, these goals aid in the development of critical thinking skills and enhancing students' self-confidence. Moreover, this knowledge helps individuals navigate their surroundings, make informed choices, and contribute to a knowledgeable and enlightened society. *Fk* leverages *ck*, in contrast to the mere acquisition of information; fostering critical thinking skills and facilitating the transfer of learning, adaptability, and effective problem-solving.

The Philippines' EGs mainly involve transmitting scientific skills essential for establishing scientific literacy and active participation in scientific investigations. Individuals with such skills can confidently observe, communicate, measure, hypothesize, analyze data, solve issues, and navigate the life sciences. Improving and refining these skills increases scientific comprehension and builds crucial life skills such as critical thinking, problem-solving, and communication.

In contrast, EGs in Japan center on transmitting *mck*, which is critical for cognitive development and learning. This knowledge can govern and regulate all aspects of knowledge or processes and can be applied to any cognitive pursuit, including learning (Flavell, 1979). This enables individuals to control their learning, adjust their strategies, participate in metacognitive processes, and apply their knowledge to new situations.

Japan's EGs transmit highly integrated skills that provide a comprehensive and interdisciplinary approach to scientific inquiry. Such skills foster a holistic comprehension of broader issues and the cultivation of analytical and reasoning abilities, ideation, and advanced learning. Padilla (1990) posits that acquiring expertise is imperative for the development, experimentation, and execution of scientific research. Acquiring integrated scientific processing skills enables individuals to proficiently address complex challenges, contribute meaningfully to scientific advancement, and have a considerable impact on their understanding of biology.

Epistemic Practices – the Philippines and Japan

Epistemic practices in the Philippines capitalize on timely and relevant learner-centered pedagogy. The strategic integration of AVM resulted in an engaging and interactive classroom. AVM are designed to cater to diverse learning styles and stimulate learners' auditory and visual faculties. AVM or multimedia inside the classroom consists of more than one medium aided by technology (Kapi et al., 2017; Abdulrahaman et al., 2020) and is used to improve understanding (Guan et al., 2018). Shaojie et al. (2022) found that AVM input can enrich learners' understanding of the content and motivate them to actively participate in listening comprehension activities by providing more authentic language input that is richer in multimodal cultural and situational contexts. Moreover, AVM promotes inclusivity by accommodating diverse learning preferences and enhancing comprehension and retention. This drives students' eagerness to learn, while simplifying and adding excitement to the learning process (Rasul et al., 2011). AVM found to enhance student motivation and engagement (Dichev & Dicheva, 2017), as well as improve positive learning outcomes (Zainuddin, 2023), thus positively impacting student focus and concentration. Integrating gamified elements proved effective in capturing students' attention and foster a higher level of engagement.

It was also evident that the students exhibited a proactive and experiential approach toward scientific exploration. According to Kong (2021), this educational phenomenon promotes engagement and eventually leads to classroom success. The students demonstrated genuine and inherent curiosity and displayed a sincere interest in biology. Wang et al. (2022) argue that inquiries and epistemological beliefs form the foundation of scientific literacy. The teachers' adept organization and support effectively nurtured this curiosity. Students' inherent inquisitiveness, under the guidance of the teacher's intentional mentorship, fostered an atmosphere conducive to purposeful inquiry and thus a heightened comprehension of biology. Based on Lin et al. (2011) and Jack et al. (2014), advancing toward scientific understanding and the application of scientific knowledge promotes interest in learning science.

Finally, educators' ability to pose thought-provoking questions has become important in the classroom. Each teacher's inquiries shaped classroom dynamics and fostered students' curiosity, critical thinking, and academic growth (Salmon & Barrera, 2021). Hilsdon (2010) states that insightful inquiries can lead to critical thinking by efficiently probing comprehension. Students actively participate in dynamic discussions and take responsibility for their learning.

Conversely, EPs in Japan use advanced methods to create a highly engaged and learning environment, outperforming traditional education. Teacher techniques included collaborative conversations, reflective thinking, and strategic use of thought-provoking questions throughout our classroom visits. This fostered active participation that encouraged students to critically engage and reflect on their learning. Higher-order thinking skills are essential for conceptual and disciplinary understanding (Heron & Palfreyman, 2023). These skills enable students to examine, synthesize, and evaluate information beyond fundamental knowledge.

Barlow et al. (2020) noted that in extensive research, empirical evidence is consistent, indicating that students who actively engage with learning materials and participate in the educational process demonstrate increased levels of engagement and achieve significantly greater learning outcomes. Similarly, Wang et al. (2022) argue that metacognitive skills help students learn and perform better. Furthermore, metacognition, or higher learning, also prepares learners for higher education (Stanton et al., 2021).

Reflective breaks were thoughtfully included in classroom immersion. Teachers set aside times for students to reflect. It reflects Japan's educational philosophy, which emphasizes learning, internalizing, and synthesizing knowledge to improve metacognition (Hanya et al., 2014). Kolb (1984) successfully linked reflection to experiential learning. The Japanese way of active learning transfer incorporates collaborative discussion and reflective dialogue. Dewey (1993) argues that reflective thinking examines beliefs, requiring careful examination of reporting, relating, reasoning, and reconstructing knowledge (Ryan, 2013).

Conclusion

We conducted ethnographic research examining two iterative cases of EGs and EPs of biology curriculum in the Philippines and Japan. We analyzed how these curricula effectively transmit valuable knowledge and skills. We found that the EGs in the Philippines were primarily grounded in disseminating *factual knowledge* with a specific emphasis on enhancing health and environmental awareness. Knowledge acquisition transitions from factual to conceptual as students progress to junior high school. EGs emphasize the utilization of *basic science skills*, particularly for exploring and comprehending various biological concepts. Alternatively, EPs prioritize learner-centered approaches that are both timely and relevant. These EPs include using AVM, gamified instruction, guided inquiry, thought-provoking questions, and hands-on learning experience.

However, EGs in Japan differed, focusing on a reliable means of imparting *meta-cognitive knowledge*. Students are equipped with problem-solving abilities and empowered to acquire *integrated science skills* to effectively engage in scientific inquiry. Implementing EPs fosters a sustainable learning environment and cultivates lasting learning, observation, investigation, experimentation, collaborative discussion, and reflective thinking.

Our findings shed light on the distinct and prioritized elements of biology standards and its EGs and EPs, making it a valuable addition to the current body of literature. Examining the realm of curriculum can improve comprehension, spark significant conversations, and enable informed decisions across cultures and borders. This research invites educators, policymakers, and stakeholders to embrace varied educational approaches to build a global community exploring knowledge and skills across national lines.

Limitations and Implications

The scope of this study is limited to a *DA* of the EGs and an *ICA* of the EPs. Our study provides insights into the development of policies and interventions that can address gaps in EGs and Eps. They can be used as a foundation for improving the biology curriculum in line with educational objectives and societal needs. Educators can also derive advantages from the findings of this study by engaging in professional development programs specifically designed to equip them with the essential skills and knowledge required to effectively implement learner-centric methodologies and integrate innovative teaching practices seamlessly. In addition, this study's cross-cultural benchmarks provide the potential for collaborative initiatives among educational institutions. Gaining insight into both commonalities and distinctions in EGs and EPs can foster cooperative endeavors aimed at improving global educational benchmarks.

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Data Availability The data have been made accessible in the results.

Declarations

Ethical Standards This research conformed to the ethical standards approved by the institutional review board.

Conflict of Interest The authors declared no conflict of interest.

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