BUKTI KORESPONDENSI ARTIKEL
JURNAL NASIONAL TERAKREDITASI SINTA 2

Judul Artikel	:	From Thinking to Designing: How Habits of Mind and Perceived Teacher ESD Competence Shape Pre-service Teachers' ESD Instructional Materials
Jurnal	:	Biodidaktika: Jurnal Biologi dan Pembelajarannya Volume 21 Nomor 2 (2026) Halaman 138-156

No.	Perihal	Tanggal
1.	Bukti Konfirmasi Submit Manuskrip	28 Februari 2026
2.	Bukti Konfirmasi Revisi	27 April 2026
3.	Bukti *Accepted*	12 Mei 2026
4.	Bukti *Publish*	26 Juli 2026

1. Proses Submit Manuskrip

[biodidaktika] Submission Acknowledgement External

Asst. Prof. Indah Juwita Sari, Ph.D. <jurnaluntirta2025@gmail.com>
to me
Sat, Feb 28, 10:35 PM

Mr. Bambang Ekanara:

Thank you for submitting the manuscript, "From Thinking to Designing: How Habits of Mind and Perceived Teacher ESD Competence Shape Pre-service Teachers' ESD Instructional Materials" to Biodidaktika : Jurnal Biologi dan Pembelajarannya. With the online journal management system that we are using, you will be able to track its progress through the editorial process by logging in to the journal web site:

Manuscript URL: https://jurnal.untirta.ac.id/index.php/biodidaktika/author/submission/39243
Username: ekanarabambang

If you have any questions, please contact me. Thank you for considering this journal as a venue for your work.

Asst. Prof. Indah Juwita Sari, Ph.D.
Biodidaktika : Jurnal Biologi dan Pembelajarannya

Biodidaktika: Jurnal Biologi dan Pembelajarannya
http://jurnal.untirta.ac.id/index.php/biodidaktika

2. Bukti Revisi

[Biodidaktika] Editor Decision External Kotak Masuk ×

Indah Juwita Sari <indah.juwitasari@untirta.ac.id>
kepada ekanara, saya, isfianiilma
Sen, 27 Apr, 17.20

Dear Mr. Bambang Ekanara.

We have reached a decision regarding your submission to Biodidaktika : Jurnal Biologi dan Pembelajarannya, "From Thinking to Designing: How Habits of Mind and Perceived Teacher ESD Competence Shape Pre-service Teachers' ESD Instructional Materials".

Our decision is: revision required, please check OJS of Biodidaktika: Jurnal Biologi dan Pembelajarannya

Please send your revision by 11 May 2026 through this email and OJS

Assoc. Prof. Indah Juwita Sari, Ph.D
(Web of Science Researcher ID: AAE-6742-2019, h-index =2)(Scopus ID: 57208302163, h-index: 6) Department of Biology Education, Faculty of Teacher Training and Education, Universitas Sultan Ageng Tirtayasa

REVIEW PAPER

TITTLE: From Thinking to Designing: How Habits of Mind and Perceived Teacher ESD Competence Shape Pre-service Teachers' ESD Instructional Materials

1) Does the paper contribute to the body of knowledge?

Yes, the paper has a meaningful potential contribution to the fields of science education, biology teacher education, and Education for Sustainable Development (ESD). Its main strength lies in connecting internal teacher-related factors, namely Habits of Mind and perceived ESD competence, with the quality of actual instructional design products rather than relying only on perceptions or attitudes. This gives the study practical relevance for curriculum and instruction, especially in the preparation of pre-service biology teachers. The mixed-methods design also adds value by attempting to explain not only whether these factors are associated with instructional design quality, but also how they may shape pedagogical decision-making.

However, the contribution would be stronger if the manuscript more clearly articulated its novelty in relation to previous ESD, teacher competence, and instructional design studies, and if the broader theoretical claims were presented with slightly more restraint.

2) Is the paper technically sound?

The study is built on an appropriate overall design. The explanatory sequential mixed-methods approach is well aligned with the research questions, and the attempt to combine regression analysis with qualitative explanation is commendable. The study also uses a product-based assessment of instructional modules, which is a strength in educational research because it moves beyond self-report data.

However, the manuscript would benefit from clearer methodological reporting in several important areas. It would be helpful to provide more explicit information about the development and validation of the instruments, the construction and scoring of the instructional design rubric, the number and role of expert raters, and any evidence of scoring consistency. In addition, the manuscript mentions classical assumption testing for regression, but these results are not reported in sufficient detail. These points do not necessarily invalidate the study, but addressing them would significantly improve the transparency and trustworthiness of the findings.

A second point concerns the interpretive tone. Some parts of the discussion and integrated findings are conceptually interesting, but the language occasionally becomes more assertive or metaphorical than the available evidence seems to support. A slightly more cautious presentation would strengthen the manuscript technically and academically.

3) Is the subject matter presented in a comprehensive manner?

Overall, the topic is presented in a reasonably comprehensive manner. The manuscript provides a clear contextual background on ESD, biology teacher education, Habits of Mind, and perceived teacher competence. It also attempts to integrate the quantitative and qualitative findings in a way that is pedagogically meaningful, especially for teacher preparation and curriculum development. The identification of the “content integration barrier” is particularly valuable and deserves emphasis, as it points to a concrete instructional issue in ESD-oriented biology education.

That said, the manuscript could be strengthened by improving its internal organization. There is some repetition across the Results and Discussion, qualitative interpretation, integrated findings, and Conclusion sections. A more concise structure would make the manuscript easier to follow and would help the strongest insights stand out more clearly.

4) Are the references provided applicable and sufficient? Please note that suggesting one's own references as a reviewer if not relevant to the article, or at an excessive level, is unethical and is not permitted.

Overall, the references are relevant and generally sufficient for the topic. The manuscript draws from literature on ESD, biology education, teacher competence, Habits of Mind, self-efficacy, and mixed methods, and many of the cited works are recent. This provides a reasonably solid conceptual basis for the study.

Still, I would encourage the authors to review the reference list carefully for completeness, consistency, and precision. A few entries appear incomplete or need closer alignment with the claims being made in the manuscript. For example, the Bandura entry is not fully presented in standard reference form. Strengthening this aspect would improve the scholarly presentation of the paper.

5) Are there references that are not appropriate for the topic being discussed? If yes, then please indicate which references should be removed.

I did not identify any references that are clearly inappropriate and should definitely be removed. In general, the cited sources are thematically related to ESD, teacher education, or relevant educational constructs. However, I encourage the authors to review whether each reference directly supports the specific claim being made in its immediate context, particularly in sections where broader conceptual arguments are advanced. The issue seems to be more about precision and alignment than clear inappropriateness.

BIODIDAKTIKA: Jurnal Biologi dan Pembelajarannya, Vol.X, No.X, 20XX, pp. X-X
e-ISSN XXXX-XXXX. DOI. 11.11111/X.vXiX.X

From Thinking to Designing: How Habits of Mind and Perceived Teacher ESD Competence Shape Pre-service Teachers' ESD Instructional Materials

Submitted Date Month Year, Revised Date Month Year Accepted Date Month Year

Abstract

Designing instructional materials for Education for Sustainable Development (ESD) presents an ill-structured problem that requires pre-service teachers to navigate complex intersections between biological science and sustainability values. This study investigates the extent to which Habits of Mind (HoM) and Perceived Teacher ESD Competency contribute to the instructional design skills of pre-service biology teachers. Employing an explanatory sequential mixed methods design, quantitative data were collected from 49 pre-service teachers at a state university in Indonesia. This was followed by a qualitative phase involving semi-structured interviews, reflective journals, and document analysis of instructional modules from nine purposively selected participants. Multiple regression analysis revealed that HoM and Perceived Teacher ESD Competence simultaneously predicted 64.3% of the variance in instructional design quality ($R^2 = 0.643$, $p < .001$), with Perceived Competence ($\beta = 0.514$) emerging as a stronger predictor than HoM ($\beta = 0.445$). Notably, the quantitative data revealed a critical content deficit, as *Instructional Content* scored the lowest among all module design components ($M = 2.80$). Qualitative findings elucidated this mechanism: while HoM functioned as the cognitive architect for instructional planning, Perceived teacher ESD competence acted as the professional agency required to execute transformative pedagogies. Furthermore, the integrated data highlighted an interdisciplinary literacy gap, where participants suffered from pedagogical doubt and profoundly struggled to seamlessly synthesize normative sustainability goals with objective biological facts. The study concludes that bridging the knowing-doing gap in ESD necessitates a synergistic approach in teacher education that cultivates intellectual dispositions, resilient self-efficacy, and targeted interdisciplinary content mapping.

Commented [FU1]: This study is well-designed and provides meaningful insights, with an appropriate use of an explanatory sequential mixed-methods approach. However, the abstract could be improved by simplifying dense phrasing and clarifying key terms to enhance readability for a broader audience.

Keywords: *Education for Sustainable Development, Habits of Mind, Teacher ESD Competence, Instructional Design Skills, Pre-service Biology Teachers, Mixed Methods.*

INTRODUCTION

In the face of escalating earth crises, ranging from biodiversity loss and climate change to widening social inequalities, education has been mandated by the United Nations as a primary vehicle for societal transformation. Sustainable Development Goal Target 4.7 explicitly calls for all learners to acquire the knowledge and skills needed to promote sustainable development (UNESCO, 2017, 2019, 2020). Within this global agenda, Higher Education Institutions, particularly Teacher Education Programs, bear the critical responsibility of producing change agents capable of translating sustainability principles into concrete classroom practices (Beasy, Richey, Brandsema, & To, 2024; Dittrich, 2024; Fischer et al., 2022; Franco et al., 2019; Wals & Benavot, 2017).

Commented [FU2]: improve citation writing using APA style

Biology education occupies a strategic position in this endeavour, as the core of biological science is directly linked to understanding ecological systems and the interdependence between humans and nature (Abdildauly, Bakhtaulova, Mukasheva, & Haas, 2025; Biletska, Mironova, Yefremova, Barna, & Bloshchynskyi, 2021; Hogan & O'Flaherty, 2021; Wibowo & Sadikin, 2019). Biology teachers are no longer required merely to teach the facts of life; they are now demanded to facilitate a systemic understanding of how human activities impact the biosphere. However, preparing pre-service biology teachers who are effective in teaching Education for

e-ISSN XXXX-XXXX. DOI. 11.11111/X.vXiX.X
Sustainable Development (ESD) remains a complex and multidimensional challenge (Ardoin, Bowers, & Gaillard, 2020; Bulut & Elci Oksuzoglu, 2025).

Unlike traditional biology instruction, which often focuses on established facts and linear procedures, ESD requires a pedagogical approach that is interdisciplinary, values-driven, and action-oriented (Ekanara, Riandi, Rahman, Solihat, & Rusyati, 2026; Rieckmann, 2018; Sinakou, Donche, & Van Petegem, 2022; UNESCO, 2017). Designing instructional materials for ESD is not simply a technical task of lesson planning; it is, fundamentally, an ill-structured problem (Salsabila, Suyono, & Supardi, 2025; Spiro, Coulson, Feltovich, & Anderson, 1988). In this domain, there is no single correct solution, and teachers must navigate conflicting values, future uncertainties, and the complexity of social-ecological systems (Redman & Wiek, 2021). Due to this complexity, many pre-service teachers experience a knowing-doing gap. They may possess adequate theoretical knowledge of environmental issues but fail to synthesize this knowledge into coherent and transformative lesson plans (Malandrakis, Papadopoulou, Gavrilakis, & Mogias, 2018; Saraswati et al., 2023). This phenomenon often results in superficial biology instruction, where sustainability issues are merely bolted on without altering the fundamental pedagogical structure. This superficial integration often stems from a profound interdisciplinary literacy gap; pre-service teachers find it conceptually daunting to synthesize normative sustainability values with objective science content without feeling like they are compromising the biological core (Bürgener & Barth, 2018; Cebrián, Junyent, & Mulà, 2020; Khairati, Lufri, Festiyed, Mawardi, & Usmeldi, 2025; Purwianingsih, Novidsa, & Riandi, 2022).

Literature suggests that the inability to design effective ESD instruction is often caused not by a lack of content knowledge, but by cognitive and psychological barriers in dealing with uncertainty. Pre-service teachers frequently feel overwhelmed by cognitive load when attempting to integrate various dimensions of sustainability into a crowded curriculum (Ahmad et al., 2023; de Jong, 2010; Munasi, 2024). Therefore, the capacity to navigate this pedagogical complexity relies heavily on the teacher's internal dispositions. This underscores the urgency of investigating the internal factors that shape the *instructional design skills* of pre-service teachers. Two constructs that are theoretically promising but rarely examined together in the context of instructional design are Habits of Mind (HoM) and Perceived Teacher ESD Competency. These two variables represent two sides of the same coin: the ability to think and the belief to act.

Habits of Mind as defined by Costa and Kallick (2000, 2009), are dispositions displayed by intelligent people when they are confronted with problems for which the answers are not immediately known. In the context of designing ESD modules, which are fraught with

e-ISSN XXXX-XXXX. DOI. 11.11111/X.vXiX.X
uncertainty, thinking habits such as *Thinking Flexibly* allow teachers to shift perspectives between biological facts and socio-economic impacts. This disposition prevents teachers from falling into reductionist, linear thinking. Furthermore, the *Metacognition* aspect of HoM plays a vital role in enabling teachers to reflect on and regulate their own design decisions (Marzano, Pickering, & Pollock, 2001; Moon, 2013). Metacognitive teachers are aware of the limitations of their understanding and actively seek new strategies to present complex material. Without strong HoM, pre-service teachers tend to revert to conventional methods when facing the challenging demands of the ESD curriculum (Isfiani & Ekanara, 2024; Wiyarsi, Çalık, Priyambodo, & Dina, 2023). However, possessing an intelligent brain is not enough. A psychological driver is also needed to translate thinking into tangible products. This is where Perceived Teacher ESD Competency plays a critical role. Rooted in Bandura (1977) self-efficacy theory and operationalized through the Asia-Pacific ESD Teacher Competency Framework , this construct refers to a teacher's belief in their capability to facilitate learning, create new ideas, and shape a sustainable future (Okayama University, 2020).

Research indicates that teachers with low self-efficacy in ESD tend to avoid innovative pedagogies, perceiving them as too risky or difficult (Malandrakis et al., 2018; Rauch & Steiner, 2013). Conversely, high perceived competence is hypothesized to drive pre-service teachers to *persist* in the task of designing transformative modules, despite conceptual hurdles. ESD competence is not just about being able, but about being confident to enact transformation. Despite the strong theoretical relevance of these two factors, there is a significant empirical gap in the current literature. The majority of previous studies on Habits of Mind in Indonesia have focused primarily on their impact on student academic achievement or critical thinking skills (Isfiani & Ekanara, 2022; Rikizaputra, Lufri, Andromeda, & Mufit, 2021). Very few studies have positioned HoM as a professional prerequisite for *teachers* in performing instructional design tasks. On the other hand, research on ESD competence often stops at self-reported surveys or macro-level curriculum analysis (Hallinger & Chatpinyakoop, 2019; Vaughter, McKenzie, Lidstone, & Wright, 2016). There is a scarcity of studies that directly link competence profiles and HoM to the quality of instructional products produced by pre-service teachers. The mechanism of how thinking dispositions interact with self-beliefs to produce quality instructional design remains a "black box" in teacher education research.

This gap is even more pronounced when viewing the broader context of biology teacher education in Indonesia, where curricula are increasingly demanded to integrate character values and sustainability. Here, the challenge is doubled: integrating science, sustainability, and ethical values. Studies exploring how students navigate this integration through the lens of HoM and ESD Competency are extremely rare. Therefore, this study aims to fill this void by offering an analysis that delves into the micro-pedagogical level. We argue that the skill of designing ESD instruction is not merely a technical skill, but a manifestation of intellectual maturity and professional agency.

This study aims specifically to analyse the contribution of *Habits of Mind* and *Perceived Teacher ESD Competency* to the instructional design skills of pre-service biology teachers. The complexity of this research lies in its use of an *Explanatory Sequential Mixed Methods* design. This approach does not simply measure the magnitude of statistical influence, but also digs deep through qualitative data to explain *why* and *how* these relationship patterns form. We ask not only "is there a relationship?" but "how are thinking dispositions translated into pedagogical design decisions?" Another unique feature of this research lies in the use of a product assessment instrument based on UNESCO (2017) *ESD Learning Objectives*, providing an objective measure of design quality that goes beyond students' subjective perceptions. In this way, this research provides more *rigorous* empirical evidence regarding the determinants of future teacher quality. The findings of this study are expected to provide theoretical implications for the development of a more holistic teacher competency model, one that emphasizes not only Content Knowledge or Pedagogical Knowledge, but also dispositional and psychological dimensions. Practically, these results will serve as a foundation for Teacher Education Program's to redesign teacher education curricula that foster intelligent thinking habits and strengthen student self-efficacy.

Ultimately, this study asserts that to produce teachers capable of saving the earth's future, we must first address how they think and what they believe about themselves. Without intervention at the level of *Habits of Mind* and *Perceived Competence*, efforts to integrate ESD into the curriculum will remain mere rhetoric on paper, never touching the essence of transformation in the classroom. Specifically, this study is guided by two research questions: (1) To what extent do Habits of Mind and Perceived Teacher ESD Competency predict the instructional design skills of pre-service biology teachers? (2) How do these cognitive and psychological determinants interact to influence their pedagogical decision-making and content integration processes?

METHODS

This study employed an explanatory sequential mixed methods design. This design consists of two distinct phases: a quantitative phase followed by a qualitative phase (Creswell, 2022). The rationale for choosing this design was to first identify the predictive relationship between internal factors and instructional design skills through statistical trends, and subsequently use qualitative data to explain the *mechanism* of how these factors influence the decision-making

e-ISSN XXXX-XXXX. DOI. 11.11111/X.vXiX.X
process during the design of ESD modules. The mixing of data occurred at the intermediate stage (sampling selection) and the interpretation stage. The research was conducted at the Department of Biology Education at a state university in Indonesia, an institution that emphasizes the integration of science and sustainability within its curriculum. The context of the study was the "Conservation Biology" course, a compulsory subject specifically designed to integrate sustainability issues with biological content.

The population comprised all fifth-semester pre-service biology teachers enrolled in the course. Using a total sampling technique, 49 students (N=49) participated in the quantitative phase. For the qualitative phase, a purposive sampling technique was used to select nine participants (n=9) based on the results of the quantitative analysis. These participants were stratified into three groups based on their aggregate scores of Habits of Mind and Perceived Teacher ESD Competence: High Achievers (n=3), Middle Achievers (n=3), and Low Achievers (n=3). This maximum variation sampling strategy allowed for a detailed comparison of cognitive and psychological mechanisms across different performance levels (Miles, Huberman, & Saldaña, 2014).

Data were collected using three rigorously validated instruments. First, the Habits of Mind Inventory, adapted from Costa and Kallick (2000, 2009), measured 16 intelligent behaviours using a 4-point Likert scale to avoid central tendency bias, demonstrating empirical validity and good internal consistency. Second, pre-service teachers' self-efficacy in ESD was assessed using the Perceived Teacher ESD Competency Scale. Adapted from the Asia-Pacific ESD Teacher Competency Framework (Okayama University, 2020), this scale covers three core domains: Facilitate Learning; Continue to Learn and Create; and Connect, Collaborate and Engage. Finally, to measure the dependent variable (Y), participants designed an ESD-integrated biology teaching module. These resulting products were evaluated by expert raters using an Instructional Design Assessment Rubric grounded in the ESD Learning Objectives (UNESCO, 2017) to assess six core pedagogical components.

Quantitative data were analysed using Multiple Linear Regression to test the predictive power of Habits of Mind (X1) and Perceived Competence (X2) on Instructional Design Skills (Y). Prior to hypothesis testing, classical assumption tests were conducted to ensure the data met the requirements for parametric statistics. The analysis focused on the Coefficient of Determination (R^2) to measure the effect size and the standardized beta coefficients to determine the relative contribution of each predictor. Qualitative data from semi-structured interviews and reflective journals were analysed using the interactive model by Miles et al. (2014). This process involved three concurrent flows of activity: (1) *Data Condensation*; (2) *Data Display*; and (3) *Conclusion Drawing/Verification*. The qualitative findings were integrated to construct a narrative that

e-ISSN XXXX-XXXX. DOI. 11.11111/X.v.XiX.X
explains the statistical trends observed in the first phase. All participants provided informed consent prior to data collection, and their identities were anonymized (e.g., HPG-1, LPG-2) to ensure confidentiality during the qualitative analysis.

Building upon this integration, the final analytical step involved the formulation of meta-inferences. Meta-inferences were drawn by systematically synthesizing the quantitative determinants with the qualitative explanations. By explicitly connecting the "what" with the "how" and "why", this stage generated a comprehensive meta-narrative. This rigorous meta-inference process ultimately yielded the overarching theoretical construct of the study, providing a holistic understanding of how intellectual dispositions and professional self-beliefs collectively drive the quality of ESD instructional design, an insight that would be unattainable through a single methodological approach alone.

RESULTS AND DISCUSSION

The Determinants of Design Skills

The statistical analysis of this study reveals a compelling narrative about the prerequisites for effective ESD instructional design. The multiple regression model indicates that Habits of Mind (X1) and Perceived ESD Competency (X2) simultaneously predict 64.3% of the variance in pre-service teachers' instructional design skills ($R^2 = 0.643$, $F_{(2,46)} = 44.220$, $p < .001$). This high coefficient of determination suggests that the ability to design transformative biology modules is not merely a function of technical pedagogical knowledge, but is deeply rooted in the interplay between intellectual dispositions and professional self-beliefs. As argued by Sternberg and Grigorenko (2003), expertise is developed when potential abilities are catalysed by the motivation and self-regulation to act. In our context, HoM represents the cognitive potential, while Perceived Competence acts as the catalytic agency.

Breaking down the contributions, Perceived Teacher ESD Competency emerged as the stronger predictor ($\beta = 0.514$, $p < .001$) compared to Habits of Mind ($\beta = 0.445$, $p < .001$). This finding is pivotal. It implies that while "thinking intelligently" (HoM) is essential, the "belief in one's capability to act" plays a more decisive role in determining the quality of the final product. This aligns with Bandura (1977) assertion that self-efficacy is the major determinant of whether individuals will use the skills they possess. A pre-service teacher may have high cognitive flexibility (HoM), but without the specific efficacy to teach for sustainability, their design performance remains inhibited. A detailed breakdown of the multiple linear regression analysis, which illustrates the simultaneous and partial effects of these internal variables on instructional design skills, is provided in Table 1.

Table 1. Summary of Multiple Linear Regression Analysis for Variables Predicting Instructional Design Skills.

Predictor Variable	B	SE B	β	t	p
(Constant)	0.693	0.282		2.461	.018
Habits of Mind (X1)	0.461	0.099	.445	4.667	< .001
Perceived Competency (X2)	0.300	0.056	.514	5.387	< .001

To further conceptualize these statistical relationships, Figure 1 presents the structural model. This visual representation highlights the standardized beta coefficients, clearly illustrating that while both internal dispositions significantly contribute to design skills, Perceived Competence exerts a stronger direct effect than Habits of Mind.

Figure 1. Structural model illustrating the simultaneous and partial effects of Habits of Mind and Perceived Teacher ESD Competency on Instructional Design Skills.

The dominance of Perceived Competence as a predictor warrants a deeper examination of the descriptive data. As summarized in Table 2, the participants' Perceived Teacher ESD Competency score (M=2.86) was the lowest among all variables, falling primarily into the "Moderate" category.

Table 2. Descriptive Statistics and Categorization of Research Variables (N = 49)

Variables	Mean Score	Categories	Frequency (n)	Percentage (%)
Habits of Mind (HoM)	3.13	High	9	18.4%
		Moderate	29	59.2%
		Low	11	22.4%
Perceived Teacher ESD Competency	2.86	High	17	34.7%
		Moderate	28	57.1%
		Low	4	8.2%
Instructional Design Skills	2.99	High	5	10.2%
		Moderate	22	44.9%
		Low	22	44.9%

More revealingly, a breakdown of its sub-scales (Figure 2) shows that *Continue to Learn and Create* scored the lowest (M=2.75). This signals a phenomenon we identify as "Pedagogical Doubt." Pre-service teachers appear to feel insecure about their ability to *create* new, interdisciplinary learning architectures required by ESD. As noted by Malandrakis et al. (2018), ESD self-efficacy is often lower than general teaching efficacy because ESD demands a departure from comfortable, fact-based instruction toward value-laden and action-oriented pedagogies.

Commented [FU3]: The interpretation of the lowest sub-scale score as "Pedagogical Doubt" is interesting and potentially insightful; however, it would benefit from clearer conceptual grounding and justification. The authors may consider elaborating whether this construct is derived from established literature or introduced as a new interpretation, and how it is operationally supported by the data presented.

e-ISSN XXXX-XXXX. DOI. 11.11111/X.v.XiX.X

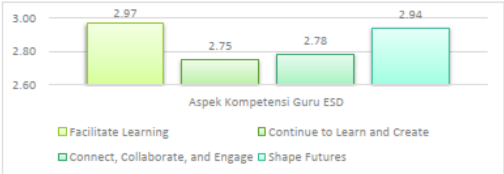

Figure 2. *Mean Scores of Perceived Teacher ESD Competency Sub-scales*

This insecurity is understandable when we view ESD instructional design through the lens of Cognitive Flexibility Theory. Spiro et al. (1988) define "ill-structured domains" as areas where knowledge application is context-dependent and requires the synthesis of multiple perspectives. Designing a biology module that integrates *Sustainable Development Goals* (SDGs) is a classic ill-structured problem. It forces students to reconcile the objectivity of biological science with the normative values of sustainability (Abdildauly et al., 2025; Kim & Diong, 2012; Kioupi & Voulvoulis, 2019; Wibowo & Sadikin, 2019). Our data suggests that students with lower competence scores struggle to navigate this complexity, retreating to "safe," linear designs rather than embracing the messiness of real-world problem solving.

The qualitative evidence supports this quantitative trend. Low-competence students, even those with moderate HoM, tended to produce modules that were merely "bolted-on" versions of traditional lesson, adding a paragraph about the environment at the end of a genetics lesson, for instance. They lacked the agency to restructure the lesson around a sustainability problem. This corroborates the work of Redman and Wiek (2021), who argue that true sustainability competencies involve "strategic thinking" and "integrated problem-solving," not just additive content knowledge. The fear of "doing it wrong" in an ill-structured domain paralyzes the creative process. Conversely, the significant contribution of Habits of Mind ($\beta = 0.445$) highlights the cognitive engine required to support this agency. A detailed breakdown of the mean scores for all 16 HoM aspects is presented in Figure 3, revealing varying levels of maturity across different cognitive dispositions.

Commented [FU4]: "Aspek kompetensi guru ESD" in English

BIODIDAKTIKA: Jurnal Biologi dan Pembelajarannya, Vol.X, No.X, 20XX, pp. X-X
e-ISSN XXXX-XXXX. DOI. 11.11111/X.vXiX.X

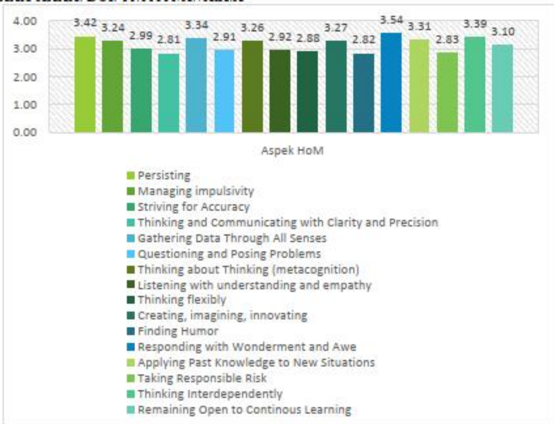

Figure 3. Mean scores across the 16 aspects of Habits of Mind among pre-service biology teachers.

Among the HoM indicators shown in Figure 3, Thinking Flexibly (M=3.27) and Metacognition (M=3.26) appeared most critical in the qualitative analysis of the high-performing group. Designing for ESD requires the mental agility to shift between the micro-level (biological mechanisms) and the macro-level (global sustainability impact) (Biletska et al., 2021; Chisingui & Costa, 2020; Salsabila et al., 2025). Students with developed habits of flexible thinking were able to weave these levels together seamlessly in their modules. For example, they could connect the concept of "biodiversity loss" not just to ecosystem stability (biology), but to "poverty reduction" (SDG 1) and "climate action" (SDG 13), demonstrating the systems thinking advocated by (UNESCO, 2017).

Metacognition served as the quality control mechanism during the design process. High-performing students utilized reflective practices, akin to Moon (2013) description of "reflective learning", to constantly evaluate the alignment of their learning objectives with ESD goals. In their reflective journals, these students documented an internal dialogue: *"Is this activity really changing students' attitudes, or just teaching them facts?"* This self-monitoring capability, a core component of Costa and Kallick (2009) framework, allowed them to refine their modules iteratively. In contrast, low-HoM students often lacked this internal feedback loop, resulting in disjointed instructional designs. It is also worth noting the prominent role of *Responding with Wonderment and Awe*. As illustrated in Figure 2, this aspect received the highest mean score

e-ISSN XXXX-XXXX. DOI. 11.11111/X.v-XiX.X
(M=3.54) among all 16 habits. Hadzigeorgiou (2011) emphasizes that a sense of wonder is a prerequisite for deep scientific engagement. In our study, students who scored high on this habit tended to design modules that included inquiry-based activities and outdoor learning, attempting to spark the same wonder in their future students. Those with low scores on this habit produced dry, textbook-centric designs. This suggests that a teacher's own emotional and intellectual disposition toward nature directly filters down into their pedagogical planning (Ariyati & Fitriyah, 2024; Ghurrotul & Hertien Koosbandiah, 2024; Stratton, Hagevik, Feldman, & Bloom, 2015).

However, the moderate mean score of HoM (M=3.13) in our sample indicates that these dispositions are still developing. This "developmental" status explains why the interaction between HoM and Competence is so vital. As Altan (2017); Altan, Lane, and Dottin (2017) suggest, habits of mind are not fixed traits but learned behaviours. The data reveals that high Perceived Competence can seemingly "compensate" for moderate HoM to some extent, by driving the student to persist in the face of design challenges. Bandura (1977) calls this "resilient self-efficacy." When students believe they *can* make a difference (high competence), they are more likely to deploy whatever thinking habits they possess to solve the design problem.

The strong correlation between X1, X2, and Y confirms that these constructs do not operate in isolation. As detailed in the Pearson correlation matrix (Table 3), HoM and Perceived Competence both show strong, highly significant positive correlations with Instructional Design Skills ($r = .665$ and $r = .704$, respectively, $p < .01$). Furthermore, the multiple correlation coefficient ($R = .802$) underscores their combined predictive strength. This robust linear relationship is visually depicted in Figure 4, which plots the positive trajectory of instructional design execution as both internal determinants increase.

Table 3. Pearson Correlation Matrix for Habits of Mind, Perceived Teacher ESD Competency, *and Instructional Design Skills (N = 49)*

Variables	**1**	**2**	**3**
1. Habits of Mind (HoM)	1		
2. Perceived Teacher ESD Competency	.427**	1	
3. Instructional Design Skills	.665**	.704**	1

*** Correlation is significant at the 0.01 level (2-tailed).*

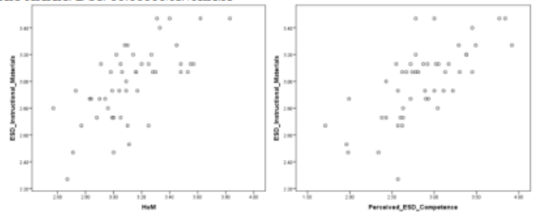

Figure 4. Scatterplot illustrating the strong positive correlation (R = .802) and the synergistic loop between internal determinants and instructional design execution.

Furthermore, the influence of Contextual Knowledge cannot be ignored. The study was situated in a Conservation Biology course. As noted by Hogan and O'Flaherty (2021), biology education offers a unique platform for ESD because the content is inherently relevant. However, our results show that relevance alone does not guarantee integration. The variable *Perceived Competence* specifically measures the confidence to *facilitate learning* and *connect/collaborate* (Okayama University, 2020). Students who viewed themselves merely as "biology teachers" rather than "sustainability educators" failed to leverage the conservation content effectively. They treated conservation as a topic to be covered, not a value to be lived (Abdildauly et al., 2025; Biletska et al., 2021; Chisingui & Costa, 2020).

The gap between the potential (HoM) and the execution (Design) is effectively bridged by the perception of competence. This finding aligns with the Action Competence Approach Ekanara et al. (2026); Mogensen and Schnack (2010); Sinakou et al. (2022), which posits that environmental education should aim to build the *capacity* and *willingness* to participate in solving societal problems. In our case, the "problem" was the design of the module itself. Students with high Action Competence (reflected in high X2 scores) approached the design task as a form of activism, a way to influence the future, whereas others approached it merely as an academic assignment.

Interestingly, as detailed in Table 5, the lowest-scoring aspect of the module designs was the Instructional Content component (M=2.80), not the pedagogical strategies or assessments. Pre-service teachers struggled significantly to seamlessly blend sustainability issues with pure biological facts. Even students with high HoM struggled here, suggesting that while HoM helps in conceptualizing the lesson's activities, specific interdisciplinary content knowledge is needed to synthesize the material. This confirms that integrating normative values (SDGs) with objective science (Biology) is the ultimate *ill-structured problem* that cannot be solved by pedagogical skills alone.

e-ISSN XXXX-XXXX. DOI. 11.11111/X.v.XiX.X

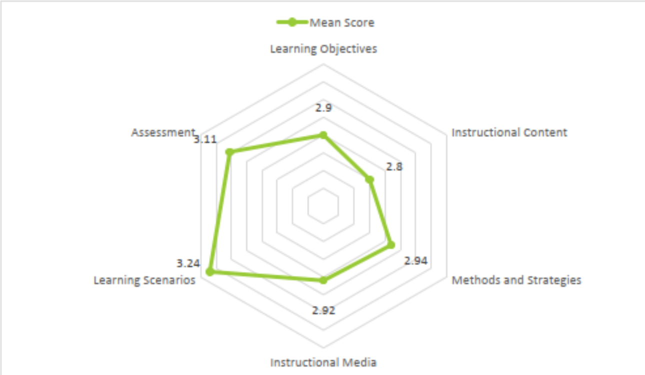

Figure 5. Mean scores across the Instructional Design Rubric components, highlighting the deficit in Instructional Content integration.

The findings also shed light on the "Risk-Taking" habit (*Taking Responsible Risks*). ESD pedagogy often requires teachers to cede control to students. This is risky for a novice teacher. Our regression analysis suggests that Perceived Competence acts as a buffer against this perceived risk. As Tschannen-Moran and Hoy (2001) argue, teachers with higher efficacy are more open to new ideas and more willing to experiment with methods that better meet student needs. Without this sense of efficacy, the habit of "taking risks" remains dormant, suppressed by the fear of classroom failure.

In summary, the quantitative data paints a picture of a "Pedagogical Threshold." Below a certain level of Perceived Competence and HoM, pre-service teachers are unable to cross the threshold from "teaching biology" to "teaching for sustainability." They remain stuck in transmissive modes of instruction. Above this threshold, a transformation occurs. The synergy of flexible thinking (HoM) and professional confidence unlocks the ability to design modules that are systems-oriented, learner-centered, and transformative.

This implies that Teacher Education Programs cannot treat ESD Competence as a byproduct of content mastery. It must be explicitly cultivated. As highlighted by Evans et al. (2017), learning to embed sustainability requires a fundamental shift in identity. The strong predictive power of our model (64.3%) is a clarion call: to improve the quality of ESD in schools, we must first attend to the *minds* and *beliefs* of the teachers we are training.

Ultimately, this discussion establishes that the "Hardware" (Instructional Design Skills) is dependent on the "Software" (Habits of Mind) and the "Power Supply" (Perceived

BIODIDAKTIKA: Jurnal Biologi dan Pembelajarannya, Vol.X, No.X, 20XX, pp. X-X
e-ISSN XXXX-XXXX. DOI. 11.11111/X.v.XiX.X
Competence). Neglecting any of these components results in a system failure, in this case, the failure to prepare the next generation for a sustainable future. A comprehensive overview of each aspect of HoM, Teacher ESD Competency, and ESD Instructional Design Skills is presented in Figure 6. The ensuing qualitative analysis will further unravel *how* these high-performing students specifically navigated the "ill-structured" challenges of their design tasks, providing a granular look at the mechanism of this statistical relationship.

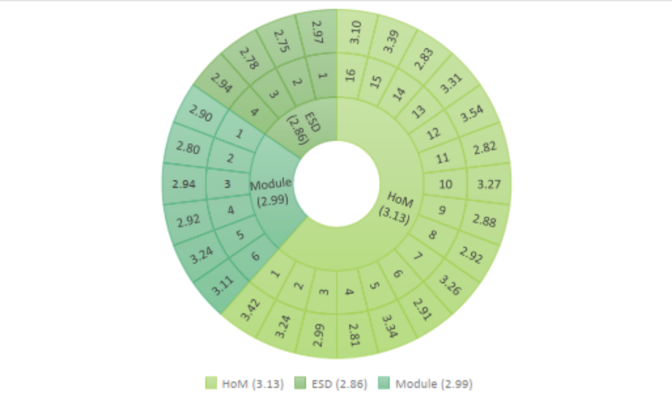

Figure 6. A comprehensive overview of each aspect of HoM, Teacher ESD Competency, and ESD Instructional Design Skills

Unpacking the Mechanism – Qualitative Insights

While the quantitative data established the predictive power of our variables, the qualitative phase of this study, involving in-depth interviews and reflective journal analysis of nine selected participants, serves to open the "black box" of the instructional design process. It reveals the cognitive and psychological mechanisms that differentiate the transformative designers (High Achievers) from the conventional designers (Low Achievers). The qualitative data crystallizes three dominant themes that explain how Habits of Mind and Perceived Competence operate in real-time: (1) Cognitive Flexibility as the Architect of Integration, (2) Metacognition as the Quality Control System, and (3) Perceived Teacher ESD Competence as the Driver of Pedagogical Risk-Taking.

e-ISSN XXXX-XXXX. DOI. 11.11111/X.v.XiX.X

Theme 1: Cognitive Flexibility as the Architect of Integration

The first and most striking difference between the groups lies in how they conceptualized the "ill-structured" problem of ESD. Participants in the High-Performing Group (HPG) demonstrated a high degree of the Habit of Mind known as *Thinking Flexibly*. When asked how they approached the design of their modules, HPG students described a non-linear process. They did not start with the biology textbook; they started with a "messy" real-world problem. For instance, one participant (HPG-1) demonstrated this interdependent thinking by stating:

> *"I cannot just talk about forest destruction biologically. It must also include why the local community does it, which involves economic factors and government policies. My module must trigger a discussion about this dilemma"* (HPG-1, Interview Transcript).

This approach exemplifies what Spiro et al. (1988) describe as *Advanced Knowledge Acquisition* in ill-structured domains. The HPG students treated biology content not as an end in itself, but as a tool to solve a sustainability problem. They were able to shift their mental perspective from teacher as transmitter of facts to teacher as designer of solutions. This mental agility allowed them to weave Sustainable Development Goals (SDGs), specifically SDG 14 (Life Below Water) and SDG 12 (Responsible Consumption), seamlessly into the biological narrative. The result was a module where the ESD value was intrinsic, not additive. In stark contrast, the Low-Performing Group (LPG) exhibited what Costa and Kallick (2009) term "egocentric" or linear thinking. Their interview responses revealed a rigid adherence to the standard curriculum sequence. One LPG participant admitted:

> *"I just focus on the photosynthesis material, not too much on social issues. The students will get confused later. Anyway, a teacher's job is to deliver the material in the curriculum"* (LPG-3, Interview Transcript).

This reflects a lack of cognitive flexibility. They viewed the biology content and the ESD context as separate, competing entities rather than a unified system. The consequence of this rigid thinking was evident in their products. The LPG modules were essentially traditional lectures with a sustainability garnish. They failed to make the systemic connections that are the hallmark of true ESD (Frey, Beege, Renkl, & Riess, 2025; Kioupi & Voulvoulis, 2019; Lorente-Echeverría, Canales-Lacruz, & Murillo-Pardo, 2023; Peretz, 2025). Where HPG students saw a web of relationships (e.g., how economic habits drive biological loss), LPG students saw a checklist of topics to be covered. This finding suggests that *Thinking Flexibly* is the primary intellectual prerequisite for interdisciplinary design. Without it, ESD integration remains superficial.

e-ISSN XXXX-XXXX. DOI. 11.11111/X.v-XiX.X
Furthermore, the HPG students demonstrated the habit of *Applying Past Knowledge to New Situations*. They successfully transferred knowledge from their Conservation Biology lectures into their Instructional Design tasks. They could articulate how the conservation ethics they learned should manifest in a classroom activity. The LPG students, despite having attended the same lectures, struggled to bridge this gap. They compartmentalized their learning, viewing conservation as subject matter and teaching as method, failing to synthesize the two.

Theme 2: Metacognition as the Quality Control System

The second mechanism revealed by the qualitative data is the regulatory role of *Metacognition*. The design of an ESD module is a complex, iterative process that requires constant self-monitoring. HPG students engaged in what Moon (2013) calls "reflection-in-action." During the interviews, they described an internal dialogue where they constantly questioned the effectiveness of their own design choices. This adaptive self-correction was vividly captured in one student's reflection:

> *"After the first draft was critiqued by the lecturer, I immediately knew the objectives were too cognitive. I reflected, 'Am I sure I can make the students take action?'. Finally, I completely overhauled it so there would be a decision-making simulation activity"* (HPG-2, Reflective Journal).

This statement is profound. It shows that the student was not just executing a plan, but evaluating the *impact* of that plan on future students' minds. This metacognitive loop allowed for self-correction before the product was even finished. It acted as an internal quality control system that elevated the final output. Conversely, the LPG students showed a distinct lack of metacognitive awareness. When asked why they chose a certain teaching method (e.g., lecture or simple discussion), their common response was, *"Because that's what is usually done,"* or *"That is the easiest way."* They were on "autopilot," reproducing familiar scripts of schooling rather than critically evaluating whether those scripts served the goals of sustainability.

This lack of metacognition meant that LPG students were often blind to the inconsistencies in their own modules. For example, some designed modules with the stated goal of "creating environmental stewards" but used assessment methods that only tested rote memory of definitions. They could not see the misalignment between their *intent* (ESD) and their *action* (Pedagogy). This confirms the assertion by Marzano et al. (2001) that without metacognitive control, learners fail to transfer their intentions into effective performance.

The reflective journals provided further evidence. HPG journals were filled with questions and doubts (e.g., *"I am not sure if this is too hard for students," "I need to find a better example"*). Paradoxically, the "High" achievers expressed more doubt than the "Low" achievers. This

e-ISSN XXXX-XXXX. DOI. 11.11111/X.v.XiX.X
aligns with the Dunning-Kruger effect, but in a positive sense: their metacognition made them aware of the complexity of the task, driving them to refine their work. The LPG journals were brief and descriptive, often just listing what they did, without analysing *why*.

Theme 3: Perceived Competence as the Courage to Innovate

While Habits of Mind provided the cognitive tools, *Perceived Competence* determined the students' courage to use them. The qualitative data strongly suggests that Perceived Competence acts as a gatekeeper for pedagogical innovation. This was most evident when discussing the "Action" component of their modules. ESD requires "Action Competence", the ability to take action to solve problems (Mogensen & Schnack, 2010; Sinakou et al., 2022; Vidal & Kuckuck, 2025). Designing learning activities that require school students to go outside, interview community members, or conduct audits is risky. It involves a loss of teacher control. HPG students, who scored high on the *Shape Futures* and *Facilitate Learning* competency scales, viewed this risk as a necessary challenge.

An HPG student remarked, *"I know taking students to the river is risky and messy, but I feel confident I can manage it, and it's the only way they will really understand."* Here, *Perceived Competence* (Self-Efficacy) is functioning exactly as Bandura (1977) predicted: it provides the resilience to choose a difficult but effective path over an easy but ineffective one. They trusted their own agency to handle the unpredictability of an ESD classroom. In contrast, LPG students were paralyzed by what we term "Pedagogical Anxiety". Their low competence scores were reflected in statements expressing passive and pessimistic attitudes toward innovation:

> *"I know there should be a strong ESD element, but I am not sure high school students can understand overly complex concepts. I better follow existing examples rather than failing to teach the material well later. I lack confidence in new methods"* (LPG-1, Interview Transcript).

This fear led them to retreat to the safety of the classroom and the textbook. Their low self-efficacy became a self-fulfilling prophecy: because they didn't believe they could facilitate complex learning, they designed simple, low-level learning modules. This finding highlights a critical "Competence-Innovation Gap." The LPG students often *knew* (cognitively) that project-based learning was better for ESD, but they *felt* (psychologically) unable to execute it. This explains the discrepancy found in our regression analysis where Competence was a stronger predictor than HoM. You can be smart (HoM), but if you are scared (Low Competence), you will not design a transformative module.

The consequence of this "Competence-Innovation Gap" was strikingly visible in the final products. Document analysis of the instructional modules revealed that HPG students successfully formulated transformative learning objectives spanning cognitive, socio-emotional, and behavioral domains. Their modules featured "Real Sustainability Action" sections, demanding students to design social campaigns within the school environment, complete with grading rubrics for solution-negotiation skills. Conversely, LPG students produced conventional modules heavily skewed toward cognitive mastery. Their learning activities often halted at case discussions without progressing to actionable follow-ups or decision-making, reflecting a "safe" but superficial approach to ESD.

Theme 4: The Shared Struggle – The Content Integration Barrier

Interestingly, the qualitative data revealed one area where both groups struggled: Integrating the Instructional Content. Even HPG students found it incredibly difficult to avoid "bolting on" ESD issues to biology topics. During interviews, they expressed frustration, saying, "I know how to teach the biology concepts, and I know how to make active learning scenarios, but making the sustainability issue feel like the main core of the biological content without losing the science is really hard." This shared struggle points to a systemic gap in their subject-matter training. While HoM and Competence helped them design good activities (M=3.24 for Scenarios), they lacked the specific interdisciplinary literacy to restructure the content itself. This suggests that "Content Integration" requires a distinct epistemological shift, independent of general Habits of Mind.

Synthesizing these themes, we can construct the anatomy of a pre-service teacher capable of designing high-quality ESD materials. This student is not just "knowledgeable" in biology. They are a Flexible Thinker who can deconstruct and reconstruct curriculum to fit real-world problems. They are a Reflective Practitioner (Metacognitive) who constantly debugs their own pedagogical logic. And crucially, they are a Confident Agent who believes in their power to shape the future, giving them the courage to employ risky, transformative pedagogies.

The interaction between these factors is synergistic. The HPG students described a positive spiral: their flexibility allowed them to see connections, their metacognition helped them plan effectively, and their perceived competence gave them the drive to execute that plan. The result was a module that didn't just "teach" sustainability, but modelled it. Conversely, the failure of the LPG students was not a failure of biology knowledge. It was a failure of disposition and belief. Trapped in rigid thinking and held back by low self-efficacy, they could only reproduce the status quo. This confirms our thesis that ESD implementation is not a curriculum problem, but a human capacity problem. Therefore, the qualitative evidence validates and enriches the

e-ISSN XXXX-XXXX. DOI. 11.11111/X.vXiX.X
statistical model ($R^2 = 64.3\%$). It tells us that the variance in design skills is largely a variance in the *maturity* of the student's mind and the *strength* of their professional heart.

In conclusion, the qualitative inquiry demonstrates that *Habits of Mind* and *Perceived Competence* function as the "software" and "operating system" of the teacher's professional practice. Without the software of flexible thinking and metacognition, the complex data of ESD cannot be processed. Without the operating system of self-competence, the program cannot run. This deep understanding of the *internal mechanisms* of pre-service teachers provides a clear directive for Teacher Education Institutions (LPTKs). We cannot simply add "ESD" as a new subject. We must cultivate the *habits* and *beliefs* that make ESD possible. The implications of these findings for the broader landscape of biology teacher education will be discussed in the final section of this manuscript.

Integrating the Minds and Beliefs of Future Teachers

The integration of quantitative and qualitative data in this study allows us to construct a comprehensive model of how pre-service biology teachers navigate the complexities of Education for Sustainable Development (ESD). While the regression analysis ($R^2 = 64.3\%$) confirmed *that* Habits of Mind (HoM) and Perceived Competence are powerful predictors, the qualitative inquiry elucidated *how* these factors interact to produce instructional designs of varying quality. Synthesizing these findings, we propose that effective ESD instructional design is the product of a "Cognitive-Agentic Synergy." Table 4 presents the joint display of our mixed-methods analysis, mapping the quantitative statistical trends with the qualitative thematic explanations to yield the overarching meta-inferences.

Table 4. Joint Display of Quantitative and Qualitative Findings Yielding Meta-Inferences

Quantitative Results (The "What")	**Qualitative Findings (The "How" & "Why")**	**Meta-Inferences (The Integrated Synthesis)**
Dominance of Competence: Perceived Competence (β=0.514) is a stronger predictor than Habits of Mind (β =0.445) in determining design skills.	Pedagogical Courage vs. Anxiety: High achievers take pedagogical risks (e.g., outdoor projects). Low achievers retreat to safe, transmissive methods due to fear of losing control.	The Agency Catalyst: Intellectual capacity (HoM) remains dormant without professional self-efficacy. ESD design is fundamentally an action-oriented task requiring pedagogical agency.
Cognitive Flexibility Impact: Strong correlation between the HoM indicator *Thinking Flexibly* and the module product quality.	Architect of Integration: High achievers restructure biological content to solve real-world sustainability problems. Low achievers strictly follow linear, textbook-based syllabi.	Navigating Ill-Structured Domains: Designing ESD is an ill-structured problem that demands epistemic flexibility to shift from teaching isolated facts to teaching systemic solutions.
Metacognitive Regulation:	Quality Control System:	The Regulatory Bridge:

e-ISSN XXXX-XXXX. DOI. 11.11111/X.vXiX.X

Quantitative Results (The "What")	**Qualitative Findings (The "How" & "Why")**	**Meta-Inferences (The Integrated Synthesis)**
Metacognition scores correlate strongly with the competence sub-scale *Continue to Learn and Create*.	High achievers engage in "reflection-in-action" to constantly debug their designs. Low achievers operate on "autopilot" with no self-correction.	Metacognition serves as the critical bridge connecting thinking habits to competence, allowing pre-service teachers to evaluate and align their intentions with pedagogical actions.
The Content Deficit:	The Integration Barrier:	Interdisciplinary Literacy Gap:
The *Instructional Content* component received the lowest mean score (M=2.80) in the Instructional Design Rubric across all participants, highlighting a specific weakness in content synthesis.	Both high and low achievers expressed profound difficulty in seamlessly synthesizing sustainability issues (SDGs) with pure biological facts. They struggled to avoid making the ESD values feel merely "bolted-on" to the science topics.	General cognitive habits (HoM) and pedagogical skills are insufficient for complex content synthesis. Merging objective science with normative ESD values is the ultimate "ill-structured" challenge, revealing a critical, universal deficit in interdisciplinary literacy within current teacher education programs.

A critical insight from the integrated data is the explanation for why Perceived Competence (β= 0.514) served as a stronger predictor than Habits of Mind (β = 0.445). Quantitatively, this seemed to suggest that "belief" matters more than "thinking." Qualitatively, we found this to be true because ESD is inherently an *action-oriented* pedagogy. As observed in the Low-Performing Group (LPG), students often possessed adequate cognitive capacity (Moderate HoM) to understand sustainability issues. However, they lacked the *pedagogical agency* to translate that understanding into classroom activities. They suffered from what we term "Pedagogical Inertia", a tendency to revert to safe, teacher-centered methods despite knowing better. This confirms Bandura's (1997) postulate that without self-efficacy, potential skills remain dormant. In the context of ESD, a teacher needs the "courage to create" (Competence) just as much as the "capacity to think" (HoM).

The study reinforces the characterization of ESD design as an "ill-structured problem" (Spiro et al., 1988). The quantitative data showed a high correlation between *Thinking Flexibly* and *Product Quality*. The qualitative interviews explained this mechanism: High-Performing (HPG) students treated the curriculum as a flexible web, while LPG students treated it as a rigid linear sequence. This difference in epistemic cognition is crucial. The HPG students demonstrated *Cognitive Flexibility* by rearranging biology topics to fit sustainability themes (e.g., teaching ecosystem balance through the lens of local waste management). This ability to "restructure" knowledge is the hallmark of advanced learning in complex domains. Conversely, the LPG students' failure was not a lack of biological knowledge, but a rigidity in organizing that knowledge.

The integrated findings highlight *Metacognition* as the bridge between HoM and Competence. Quantitatively, metacognition items correlated strongly with the "Continue to Learn and

e-ISSN XXXX-XXXX. DOI. 11.11111/X.v.XiX.X
Create" competence domain. Qualitatively, this was manifested in the "self-correction" behavior of HPG students. They used their metacognitive awareness to identify gaps in their own competence, which then drove them to seek new information (enhancing their competence). This suggests a reciprocal causality: better thinking habits lead to better self-assessment of competence, which in turn leads to better performance. This aligns with Marzano's (2001) view that metacognition is the "executive control" of the learning process.

Situated in a Biology Education program at a state University, the study offers a unique contextual insight. The quantitative scores for *Responding with Wonderment and Awe* were relatively high across the board. However, the qualitative data revealed a nuance: for many students, this "awe" was spiritual or personal, not pedagogical. They loved nature, but didn't know how to teach that love. Only the students with high *Instructional Design Skills* (Y) successfully translated this personal value into learning activities (e.g., outdoor reflection). This indicates that values alone are insufficient for ESD; they must be mediated by professional competence. This challenges the assumption often held in value-based institutions that "good character" automatically leads to "good teaching."

A striking convergence in both datasets is the profound weakness in Instructional Content design. Quantitatively, this was the lowest-scoring component of the module rubric (M=2.80). Qualitatively, both HPG and LPG students expressed confusion about how to merge science and values without losing the biological essence. This points to a systemic gap in the teacher education curriculum regarding interdisciplinary literacy. While HoM helps students design creative activities, it does not instinctively teach them how to synthesize distinct academic disciplines. This finding suggests that LPTKs need to provide specific interventions on interdisciplinary content mapping to complement general dispositional training.

These findings have significant implications for the *Technological Pedagogical Content Knowledge* (TPACK) framework, which is widely used in teacher education (Mishra & Koehler, 2008). Our study suggests that for ESD, the standard TPACK components (Content, Pedagogy, Technology) are insufficient. We propose an extended model: TPACK-Dispositions. A teacher may have the Content (Biology) and the Pedagogy (Teaching Strategies), but without the *Dispositions* (Habits of Mind) and *Self-Beliefs* (Competence), the integration of ESD will not occur. The "Instructional Design Skill" is the visible output of this invisible internal synergy.

In sum, the integration of data reveals that the "quality" of a future biology teacher is not a single variable but a complex psychological configuration. The students who succeed in designing transformative ESD modules are those who have successfully married their intellectual habits (flexible, reflective thinking) with their professional identity (competent, agentic change-makers). The "knowing-doing gap" observed in the wider population is effectively a "thinking-believing gap." To close it, teacher education must intervene on both cognitive and psychological fronts.

We must also consider the broader cultural and national educational context. Within the Indonesian teacher education curriculum, character education and environmental stewardship are strongly emphasized as core values for prospective science teachers. While this provides a robust normative foundation, our data shows that such foundational values do not automatically translate into instructional design skills without the mediation of specific professional competencies. The high *Wonderment and Awe* scores observed in this study might be linked to this cultural and ethical appreciation of nature; however, without the requisite *Instructional Design* competence, this appreciation remains a personal disposition rather than an actionable pedagogical skill.

Limitations of the Study

Despite the robust insights generated by the mixed-methods design, this study has several limitations that should be acknowledged. First, the quantitative phase utilized a relatively small sample size (N=49) drawn from a single state university in Indonesia. While this sample was sufficient to identify significant predictive trends within this specific context, caution must be exercised when generalizing the multiple regression model to the broader population of pre-service biology teachers. However, this statistical limitation is substantially mitigated by the explanatory sequential design; the deep qualitative analysis of the instructional modules and in-depth interviews provides a rigorous understanding of the *mechanisms* behind these trends. Consequently, while the statistical generalizability may be bounded, the theoretical transferability regarding the "Cognitive-Agentic Synergy" remains highly relevant for teacher education programs. Future studies are recommended to validate this predictive model using a larger, multi-institutional sample.

CONCLUSION

This study establishes that designing effective instructional materials for Education for Sustainable Development (ESD) is not merely a technical pedagogical exercise, but a complex psychological endeavour. The quantitative findings demonstrate that Habits of Mind and Perceived Teacher ESD Competency are robust and simultaneous predictors, accounting for 64.3% of the variance in instructional design quality. Crucially, the primacy of Perceived Competence over Habits of Mind underscores a fundamental reality in teacher education:

intellectual capacity (the ability to think flexibly and reflectively) remains largely dormant without the professional agency (self-efficacy) to take pedagogical risks.

The integrated qualitative data conceptualizes this phenomenon as a "Cognitive-Agentic Synergy." Transformative module designers utilize their cognitive flexibility to navigate the ill-structured nature of ESD, driven by the courage to implement action-oriented pedagogies. Conversely, students lacking this synergy suffer from "pedagogical doubt," retreating to safe, transmissive teaching scripts. Furthermore, the study uncovers a critical "Content Integration Barrier." Evidenced by the universally low scores in the Instructional Content component of the module designs, pre-service teachers face profound difficulties in seamlessly synthesizing normative sustainability values (SDGs) with objective biological science, often resulting in superficial, "bolted-on" additions.

These findings carry urgent implications for Teacher Education Institutions (LPTKs). Bridging the "knowing-doing gap" requires a paradigm shift from traditional content-delivery models to transformative dispositional training. The traditional TPACK framework must be expanded to intentionally cultivate intellectual habits and resilient self-efficacy. Moreover, specific instructional interventions targeting interdisciplinary literacy are needed to help future teachers map and merge distinct academic disciplines. Ultimately, if education is to act as a catalyst for global sustainability, teacher preparation programs must go beyond teaching the science of biology; they must cultivate the resilient minds and the agentic beliefs required to design the future.

SUGGESTIONS

Derived from the integrated findings of this study, several critical recommendations are proposed for Teacher Education Institutions (LPTKs) and future educational researchers to bridge the gap between theoretical knowledge and practical ESD implementation:

1. Explicit Interdisciplinary Content Mapping: Given the profound deficit observed in the *Instructional Content* design (M=2.80), LPTKs must stop teaching environmental issues and biological sciences as parallel or additive subjects. Curricula, particularly in applied courses like Conservation Biology, must explicitly model how to map Sustainable Development Goals (SDGs) onto biological core competencies. Pre-service teachers require targeted workshops on interdisciplinary literacy, teaching them how to synthesize normative values with objective science without compromising the rigor of the biological content.
2. Cultivating "Pedagogical Courage" through Mastery Experiences: Since Perceived Teacher ESD Competency is the strongest predictor of design quality (β=0.514), teacher

training programs must actively build this professional self-efficacy. Micro-teaching and practicum experiences should be redesigned to function as "safe laboratories" where pre-service teachers are encouraged and graded on their willingness to take pedagogical risks. Rewarding innovative, action-oriented pedagogies over safe, transmissive lectures will help dismantle the pervasive "pedagogical doubt."

3. Institutionalizing Metacognitive Reflection: To strengthen the *Habits of Mind* (particularly *Thinking Flexibly* and *Metacognition*), reflective practices must be institutionalized. The use of structured reflective journals should be embedded throughout the teacher preparation program, transitioning students from merely describing what they taught to critically evaluating *why* their instructional design choices effectively promote sustainability consciousness.
4. Expanding Frameworks for Future Research: Future research should move beyond correlational or explanatory models toward intervention designs. There is a pressing need to develop and validate specific instructional modules or training programs—perhaps integrating extended frameworks like TPACK-ESD or the Asia-Pacific ESD Teacher Competency Framework to systematically cultivate both the cognitive dispositions and the agentic beliefs of pre-service teachers. Evaluating the impact of such targeted interventions on the actual classroom execution of ESD materials will provide the next crucial step in advancing sustainability education.

REFERENCES

Abdildauly, A., Bakhtaulova, A. S., Mukasheva, D. M., & Haas, M. (2025). Education for sustainable development: comparative analysis of internship programs in preparing biology teachers. *IOP Conference Series: Earth and Environmental Science, 1544*(1), 012015. doi:https://doi.org/10.1088/1755-1315/1544/1/012015

Ahmad, N., Toro-Troconis, M., Ibahrine, M., Armour, R., Tait, V., Reedy, K., . . . Inzolia, Y. (2023). CoDesignS Education for Sustainable Development: A Framework for Embedding Education for Sustainable Development in Curriculum Design. *Sustainability, 15*(23), 16460. doi:https://doi.org/10.3390/su152316460

Altan, S. (2017). *Teachers' dispositions as habits of mind : insights from a narrative inquiry into the significant life experiences of Turkish teachers*. (Ph.D. (Doctor of Philosophy)), Bilkent University. Retrieved from http://hdl.handle.net/11693/33206

Altan, S., Lane, J. F., & Dottin, E. (2017). Using Habits of Mind, Intelligent Behaviors, and Educational Theories to Create a Conceptual Framework for Developing Effective Teaching Dispositions. *Journal of Teacher Education, 70*(2), 169-183. doi:https://doi.org/10.1177/0022487117736024

Ardoin, N. M., Bowers, A. W., & Gaillard, E. (2020). Environmental education outcomes for conservation: A systematic review. *Biological Conservation, 241*, 108224. doi:https://doi.org/10.1016/j.biocon.2019.108224

Ariyati, E., & Fitriyah, F. (2024). An Investigation into Habits of Mind Prospective Teacher: Do They Have it? *Revista de Gestão Social e Ambiental, 18*, e05632. doi:https://doi.org/10.24857/rgsa.v18n5-087

Bandura, A. (1977). *Self-Efficacy: The Exercise of Control*.

Beasy, K., Richey, S., Brandsema, J., & To, V. (2024). Embedding Sustainability across a Teacher Education Course: Teacher Educator Experiences. *Australian Journal of Environmental Education, 40*(4), 722-739. doi:https://doi.org/10.1017/aee.2024.36

Biletska, H., Mironova, N., Yefremova, O., Barna, L., & Bloshchynskyi, I. (2021). The Future Biology Teachers Training for the Implementation of Sustainable Development Ideas in Ecological Education. *International Journal of Innovative Research and Scientific Studies, 4*(4), 229-237. doi:https://doi.org/10.53894/ijirss.v4i4.200

Bulut, B., & Elci Oksuzoglu, I. (2025). Teachers' Beliefs About Education for Sustainable Development: Challenges and Opportunities. *Sustainability, 17*(16), 7552. Retrieved from doi:https://doi.org/10.3390/su17167552

Bürgener, L., & Barth, M. (2018). Sustainability competencies in teacher education: Making teacher education count in everyday school practice. *Journal of Cleaner Production, 174*, 821-826. doi:https://doi.org/10.1016/j.jclepro.2017.10.263

Cebrián, G., Junyent, M., & Mulà, I. (2020). Competencies in Education for Sustainable Development: Emerging Teaching and Research Developments. *Sustainability, 12*(2), 579. Retrieved from doi:https://doi.org/10.3390/su12020579

Chisingui, A. V., & Costa, N. (2020). Teacher Education and Sustainable Development Goals: A Case Study with Future Biology Teachers in an Angolan Higher Education Institution. *Sustainability, 12*(8), 3344. Retrieved from doi:https://doi.org/10.3390/su12083344

Costa, A. L., & Kallick, B. (2000). Describing 16 habits of mind. *Alexandria, VA: ASCD.*

Costa, A. L., & Kallick, B. (2009). *Habits of mind across the curriculum: Practical and creative strategies for teachers*: ASCD.

Creswell, J. W. (2022). *A concise introduction to mixed methods research 2nd ed*: SAGE publications.

de Jong, T. (2010). Cognitive load theory, educational research, and instructional design: some food for thought. *Instructional Science, 38*(2), 105-134. doi:https://doi.org/10.1007/s11251-009-9110-0

Dittrich, A.-K. (2024). An International Reconstruction of Teachers' and Teacher Educators' Perspectives on the Challenges of Education for Sustainable Development in Teacher Education. *Journal of Education for Sustainable Development, 18*(2), 122-141. doi:https://doi.org/10.1177/09734082241309704

Ekanara, B., Riandi, R., Rahman, T., Solihat, R., & Rusyati, L. (2026). Empowering Pre-service Biology Teachers through Sustainability Action: An Ethnobotanical Inventory Project in Cirebon. *Biodidaktika: Jurnal Biologi dan Pembelajarannya, 21*(1), 100-112.

Fischer, D., King, J., Rieckmann, M., Barth, M., Büssing, A., Hemmer, I., & Lindau-Bank, D. (2022). Teacher Education for Sustainable Development: A Review of an Emerging Research Field. *Journal of Teacher Education, 73*(5), 509-524. doi:https://doi.org/10.1177/00224871221105784

Franco, I., Saito, O., Vaughter, P., Whereat, J., Kanie, N., & Takemoto, K. (2019). Higher education for sustainable development: actioning the global goals in policy, curriculum and practice. *Sustainability Science, 14*, 1621-1642. doi:https://doi.org/10.1007/s11625-018-0628-4

Frey, S., Beege, M., Renkl, A., & Riess, W. (2025). The Impact of System Models on Systems Thinking in the Context of Climate Change in Elementary School. *Systems, 13*(4), 220. Retrieved from doi:https://doi.org/10.3390/systems13040220

Ghurrotul, B., & Hertien Koosbandiah, S. (2024). The potential of TPACK-based biology learning to improve students' habits of mind. *Jurnal Mangifera Edu, 8*(2). doi:https://doi.org/10.31943/mangiferaedu.v8i2.178

Hadzigeorgiou, Y. (2011). Fostering a Sense of Wonder in the Science Classroom. *Research in Science Education - RES SCI EDUC, 42*. doi:https://doi.org/10.1007/s11165-011-9225-6

Hallinger, P., & Chatpinyakoop, C. (2019). A Bibliometric Review of Research on Higher Education for Sustainable Development, 1998–2018. *Sustainability, 11*, 2401. doi:https://doi.org/10.3390/su11082401

Hogan, D., & O'Flaherty, J. (2021). Addressing Education for Sustainable Development in the Teaching of Science: The Case of a Biological Sciences Teacher Education Program. *Sustainability, 13*(21), 12028. doi:https://doi.org/10.3390/su132112028

Isfiani, I. R., & Ekanara, B. (2022). Cognitive Anxiety and Habits of Mind: A Study of the Interrelationships with Biology Learning Outcomes. *2022, 11*(2), 13. doi:10.24235/sc.educatia.v11i2.10909

Isfiani, I. R., & Ekanara, B. (2024). Mapping The Habits of Mind of Pre-Service Biology Teacher Students In Supporting Education for Sustainable Development (ESD). *Jurnal Pengajaran Matematika dan Ilmu Pengetahuan Alam, 29*(2).

Khairati, I., Lufri, L., Festiyed, F., Mawardi, M., & Usmeldi, U. (2025). Managing biology learning for sustainability: Prospective teachers' perceptions and readiness. *BIO-INOVED : Jurnal Biologi-Inovasi Pendidikan, 7*, 337. doi:https://doi.org/10.20527/bino.v7i3.21765

Kim, M., & Diong, C. H. (2012). *Biology education for social and sustainable development* Retrieved from https://search.ebscohost.com/login.aspx?direct=true&scope=site&db=nlebk&db=nlabk&AN=508740 doi:https://doi.org/10.1007/978-94-6091-927-5

Kioupi, V., & Voulvoulis, N. (2019). Education for Sustainable Development: A Systemic Framework for Connecting the SDGs to Educational Outcomes. *Sustainability, 11*(21), 6104. Retrieved from doi:https://doi.org/10.3390/su11216104

Lorente-Echeverría, S., Canales-Lacruz, I., & Murillo-Pardo, B. (2023). Whole Systems Thinking and Context of the University Teacher on Curricular Sustainability in Primary Education Teaching Degrees at the University of Zaragoza. *Education Sciences, 13*(4), 341. Retrieved from doi:https://doi.org/10.3390/educsci13040341

Malandrakis, G., Papadopoulou, P., Gavrilakis, C., & Mogias, A. (2018). An education for sustainable development self-efficacy scale for primary pre-service teachers: construction and validation. *The Journal of Environmental Education, 50*, 1-18. doi:https://doi.org/10.1080/00958964.2018.1492366

Marzano, R. J., Pickering, D., & Pollock, J. E. (2001). *Classroom instruction that works: Research-based strategies for increasing student achievement*: Ascd.

Miles, M., Huberman, M., & Saldaña, J. (2014). *Qualitative Data Analysis: A Methods Sourcebook (3rd Edition)* (Vol. 28).

Mishra, P., & Koehler, M. J. (2008). *Handbook of Technological Pedagogical Content Knowledge (TPCK) for Educators (1st ed.)*: Routledge.

Mogensen, F. M., & Schnack, K. (2010). The action competence approach and the 'new' discourses of education for sustainable development, competence and quality criteria. *Environmental Education Research, 16*, 59 - 74. doi:https://doi.org/10.1080/13504620903504032

Moon, J. A. (2013). *A handbook of reflective and experiential learning: Theory and practice*: Routledge.

Munasi, K. R. (2024). Evaluating the Integration of Education for Sustainable Development in the Life Sciences Curriculum: A Case Study of Grade 11 Teachers in Vhembe East

e-ISSN XXXX-XXXX. DOI. 11.11111/X.v.XiX.X
District. *Sustainability, 16*(24), 10918. Retrieved from doi:https://doi.org/10.3390/su162410918

Okayama University. (2020). Guide for the Effective Dissemination of the Asia-Pacific ESD Teacher Competency Framework : The Second Report of the Project "Teacher Education for ESD in the Asia-Pacific Region". *Okayama University ESD Promotion Centre*.

Peretz, R. (2025). Integrating Systems Thinking into Sustainability Education: An Overview with Educator-Focused Guidance. *Education Sciences, 15*(12), 1685. Retrieved from doi:https://doi.org/10.3390/educsci15121685

Purwianingsih, W., Novidsa, I., & Riandi, R. (2022). Program for Integrating Education for Sustainable Development (ESD) into Prospective Biology Teachers' Technological Pedagogical Content Knowledge (TPACK). *Jurnal Pendidikan IPA Indonesia, 11*. doi:https://doi.org/10.15294/jpii.v11i2.34772

Rauch, F., & Steiner, R. (2013). Competences for Education for Sustainable Development in Teacher Education. *CEPS Journal, 3*. doi:https://doi.org/10.26529/cepsj.248

Redman, A., & Wiek, A. (2021). Competencies for Advancing Transformations Towards Sustainability. *Frontiers in Education, 6*, 484. doi:https://doi.org/10.3389/feduc.2021.785163

Rieckmann, M. (2018). Chapter 2 – Learning to transform the world: key competencies in ESD (pp. 39-59).

Rikizaputra, R., Lufri, L., Andromeda, A., & Mufit, F. (2021). Analysis of Student Independence and Habits of Mind of Students in Biology Learning in Class X MIA through Portfolio Assessment. *Jurnal Penelitian Pendidikan IPA, 7*(2), 232-238. doi:10.29303/jppipa.v7i2.630

Salsabila, A., Suyono, S., & Supardi, Z. A. I. (2025). Analysis of student worksheets on compost making based on ESD-TPack to improve students' scientific attitudes in biology learning. *Biosfer: Jurnal Pendidikan Biologi, 18*(2), 303-314. doi:https://doi.org/10.21009/biosferjpb.52768

Saraswati, D., Riandi, R., Kadarohman, A., Suhandi, A., Samsudin, A., Zulva, R., . . . Supriatna, A. (2023). Workshop on Strengthening TPACK in ESD-Based Science Learning in Implementing the Merdeka Curriculum [Workshop Penguatan TPACK pada Pembelajaran IPA Berbasis ESD dalam Implementasi Kurikulum Merdeka]. *Jurnal Pengabdian Isola, 2*, 126-134. doi:https://doi.org/10.17509/jpi.v2i2.63499

Sinakou, E., Donche, V., & Van Petegem, P. (2022). Action-orientation in education for sustainable development: Teachers' interests and instructional practices. *Journal of Cleaner Production, 370*, 133469. doi:https://doi.org/10.1016/j.jclepro.2022.133469

Spiro, R., Coulson, R., Feltovich, P. J., & Anderson, D. (1988). Cognitive Flexibility Theory: Advanced Knowledge Acquisition in Ill-Structured Domains (Vol. 12, pp. 544-557).

Sternberg, R. J., & Grigorenko, E. L. (2003). *The psychology of abilities, competencies, and expertise*: Cambridge University Press.

Stratton, S. K., Hagevik, R., Feldman, A., & Bloom, M. (2015). Educating Science Teachers for Sustainability. *Teaching and Learning Faculty Publications*.

Tschannen-Moran, M., & Hoy, A. (2001). Teacher Efficacy: Capturing an Elusive Construct. *Teaching and Teacher Education, 17*, 783-805. doi:https://doi.org/10.1016/S0742-051X(01)00036-1

UNESCO. (2017). Education for Sustainable Development Goals: Learning Objectives. *Paris: UNESCO*. doi:https://unesdoc.unesco.org/ark:/48223/pf0000247444?posInSet=2&queryId=4827a035-6c47-4399-9e98-39ea7b9c358f

UNESCO. (2019). Framework for the Implementation of Education for Sustainable Development (ESD) beyond 2019. *UNESCO*.

doi:https://unesdoc.unesco.org/ark:/48223/pf0000370215?posInSet=1&queryId=16f3d2a7-ac06-4e92-849a-4890faa4a202

UNESCO. (2020). Education for Sustainable Development: A Roadmap. doi:https://doi.org/10.54675/YFRE1448

Vaughter, P., McKenzie, M., Lidstone, L., & Wright, T. (2016). Campus sustainability governance in Canada: A content analysis of post-secondary institutions' sustainability policies. *International Journal of Sustainability in Higher Education, 17*(1), 16-39. doi:https://doi.org/10.1108/ijshe-05-2014-0075

Vidal, S., & Kuckuck, M. (2025). Pre-Service Teacher Action Competence in Education for Sustainable Development: A Scoping Review. *Sustainability, 17*(9), 3856. doi:https://doi.org/10.3390/su17093856

Wals, A., & Benavot, A. (2017). Can we meet the sustainability challenges? The role of education and lifelong learning. *European Journal of Education, 52*. doi:https://doi.org/10.1111/ejed.12250

Wibowo, Y. G., & Sadikin, A. (2019). Biology in the 21st-Century: Transformation in biology science and education in supporting the sustainable development goals. *JPBI (Jurnal Pendidikan Biologi Indonesia), 5*(2), 285-296. doi:https://doi.org/10.22219/jpbi.v5i2.7956

Wiyarsi, A., Çalık, M., Priyambodo, E., & Dina, D.-. (2023). Indonesian Prospective Teachers' Scientific Habits of Mind:A Cross-Grade Study in the Context of Local and Global Socio-scientific Issues. *Science & Education*, 1 - 27. doi:https://doi.org/10.1007/s11191-023-00429-4

Commented [FU5]: Bandura need publisher information

Hasil Revisi

BIODIDAKTIKA: Jurnal Biologi dan Pembelajarannya, Vol.X, No.X, 20XX, pp. X-X
e-ISSN XXXX-XXXX. DOI. 11.11111/X.vXiX.X

From Thinking to Designing: How Habits of Mind and Perceived Teacher ESD Competence Shape Pre-service Teachers' ESD Instructional Materials

Submitted Date Month Year, Revised Date Month Year, Accepted Date Month Year

Authors

Afiliation and Address

*Corresponding Email:

Abstract

Future biology educators face a unique challenge when creating learning modules for Education for Sustainable Development (ESD): they must seamlessly fuse core biological science with broader sustainability values. To understand what drives success in this complex task, we explored how two internal factors—Habits of Mind (HoM) and Perceived Teacher ESD Competency—shape the way pre-service teachers craft their instructional designs. We approached this through an explanatory sequential mixed-methods framework. Initially, we gathered quantitative survey data from 49 prospective teachers in Indonesia. Building on those baseline numbers, we then dove deep into the qualitative experiences of nine selected individuals by analyzing their module documents, reflective journals, and semi-structured interview transcripts. Our statistical modelling showed a strong relationship: together, these cognitive and psychological traits accounted for 64.3% of the differences in module quality ($R^2 = 0.643$, $p < .001$). Interestingly, the students' own belief in their capabilities, or Perceived Competency ($\beta = 0.514$), played a more dominant role than their intellectual dispositions (HoM, $\beta = 0.445$). A closer look at the quantitative results uncovered a specific hurdle: the development of instructional content proved to be the weakest link in their module designs ($M = 2.80$). The qualitative insights explained why this discrepancy happens. While flexible thinking (HoM) gives teachers the mental framework to plan, they actually need high professional self-efficacy (Perceived Competency) to bravely execute transformative, action-oriented teaching methods. Both datasets ultimately point to a significant interdisciplinary gap. The prospective educators found it exceptionally difficult to naturally weave normative sustainability goals into objective biological facts. To better prepare future educators for ESD, teacher training programs must go beyond standard pedagogy. They need targeted strategies that actively build up the students' cognitive habits, boost their practical self-beliefs, and explicitly teach interdisciplinary content mapping.

Keywords: Education for Sustainable Development, Habits of Mind, Teacher ESD Competence, Instructional Design Skills, Pre-service Biology Teachers, Mixed Methods.

INTRODUCTION

As the world grapples with intensifying ecological and social emergencies, such as the rapid decline of biodiversity and escalating climate instability, the United Nations has positioned educational systems as the most crucial drivers of global change. In particular, Target 4.7 of the Sustainable Development Goals lays out a clear mandate: every student must be equipped with the practical and theoretical understanding necessary to advance sustainability (UNESCO, 2017, 2019, 2020). Navigating this international directive places a heavy burden on universities, and more specifically on programs designed to train future educators. These institutions are now tasked with a vital duty: they must forge the next generation of teachers who can take high-level sustainability ideals and turn them into actionable, day-to-day classroom activities (Beasy et al., 2024; Dittrich, 2024; Fischer et al., 2022; Franco et al., 2019; Wals & Benavot, 2017).

Because the study of biology revolves around ecological networks and the continuous interplay between humans and their environment, it serves as an ideal launching pad for

Education for Sustainable Development (ESD) (Abdildauly et al., 2025; Biletska et al., 2021; Hogan & O'Flaherty, 2021; Wibowo & Sadikin, 2019). Given this natural alignment, society expects tomorrow's biology educators to help their students grasp the big picture of how human choices ripple through the biosphere. Yet, equipping these teacher candidates with the necessary tools to actually deliver this systemic instruction proves to be incredibly difficult, involving multiple layers of pedagogical and cognitive hurdles (Ardoin et al., 2020; Bulut & Elci Oksuzoglu, 2025).

Standard science teaching typically relies on straightforward, step-by-step methods; however, teaching for sustainability demands a much broader strategy that crosses disciplinary lines, embraces ethical values, and drives concrete action (Ekanara et al., 2026; Rieckmann, 2018; Sinakou et al., 2022; UNESCO, 2017). Consequently, creating lesson materials for this type of education presents an "ill-structured problem" problem (Salsabila et al., 2025; Spiro et al., 1988). Instead of relying on a universal, foolproof template, student educators find themselves forced to juggle complicated socio-environmental factors and competing pedagogical goals to figure out what works best (Brundiers et al., 2010; Redman & Wiek, 2021; Wiek et al., 2011).

Caught in this web of complexity, teacher candidates frequently encounter a frustrating divide between what they understand about sustainability in theory and their actual capacity to build cohesive learning modules (Malandrakis et al., 2018; Saraswati et al., 2023). More often than not, this struggle leads to surface-level teaching where environmental issues are merely tacked onto the edges of a lesson, leaving the core pedagogical framework completely untouched. Researchers usually trace these shortcomings back to a fundamental gap in interdisciplinary literacy: future educators find it incredibly challenging to blend the moral imperatives of sustainability with hard biological facts without sacrificing the scientific rigor of their subject (Bürgener & Barth, 2018; Cebrián et al., 2020; Khairati et al., 2025; Purwianingsih et al., 2022).

Past research highlights that mastering this intricate teaching style depends heavily on a teacher's mental and psychological resilience. When upcoming educators try to force sustainability frameworks into rigid, traditional syllabi, they regularly run into severe cognitive overload (Ahmad et al., 2023; de Jong, 2010; Munasi, 2024). To navigate this, they must lean on two critical internal assets: Habits of Mind (HoM) and Perceived Teacher ESD Competency. HoM functions as the intellectual agility and self-awareness that educators tap into when obvious answers disappear (Costa & Kallick, 2000, 2009), giving them the mental stretch required to design lessons across varying disciplines (Isfiani & Ekanara, 2024; Marzano et al., 2001; Moon, 2013; Wiyarsi et al., 2023). On the psychological front, Perceived Teacher ESD Competency, rooted in self-efficacy models (Bandura, 1977) and the Asia-Pacific framework (Okayama University, 2020), acts as the inner engine driving them to actually pull off these ambitious teaching strategies. Unsurprisingly, evidence shows that educators who doubt their own ESD abilities tend to back away from innovative methods because they fear the risks of failing in the classroom (Malandrakis et al., 2018; Rauch & Steiner, 2013).

Even though these internal traits clearly matter on paper, a significant blind spot remains in the current research. Historically, investigators have primarily tied HoM to how well students perform on academic tests (Isfiani & Ekanara, 2022; Rikizaputra et al., 2021). On the flip side, when evaluating ESD readiness, researchers typically rely on broad, self-reported questionnaires or high-level curriculum audits rather than looking at practical outputs (Hallinger & Chatpinyakoop, 2019; Vaughter et al., 2016). Very rarely has anyone stepped back to see how a teacher's flexible thinking and professional confidence actually collaborate to shape the physical lesson modules they build. Ultimately, the field still needs hard evidence to understand exactly how these invisible mental traits transform into real-world teaching materials.

To fill this void, our research zeroes in on the micro-pedagogical realities of ESD integration. We specifically measure how Habits of Mind and Perceived Teacher ESD Competency dictate the instructional design skills of future biology educators. What sets this work apart is our deliberate shift away from relying merely on self-evaluations. Instead, we judged the actual lesson modules the students created using a concrete, product-based rubric tied directly to the UNESCO (2017) ESD Learning Objectives. By utilizing an Explanatory Sequential Mixed Methods approach, we first map out the statistical predictors of design quality, and then dive into qualitative data to unpack the hidden choices behind their module drafts. Ultimately, we hope these findings will provide universities with the hard evidence needed to build stronger teacher competency models and upgrade their training curricula for genuine ESD success. To steer this inquiry, we focused on two core questions: (1) How powerfully do Habits of Mind and Perceived Teacher ESD Competency predict the instructional design skills of pre-service biology teachers? and (2) How do these cognitive and psychological drivers work together to shape their pedagogical choices and interdisciplinary content blending?

METHODS

To capture both the hard numbers and the nuances behind them, we opted for an explanatory sequential mixed-methods framework (Creswell, 2022). We structured this

BIODIDAKTIKA: Jurnal Biologi dan Pembelajarannya, Vol.X, No.X, 20XX, pp. X-X
e-ISSN XXXX-XXXX. DOI. 11.11111/X.vXiX.X

research in two distinct phases: first, crunching the quantitative data to spot predictive links between the teachers' internal traits and their design capabilities, and then shifting to qualitative methods to decode the actual thought processes driving their lesson planning. We wove these two data streams together twice, once to help select our interview participants, and again during the final synthesis of our results. We carried out the fieldwork within a Biology Education department in Indonesia. Specifically, we embedded the investigation inside a mandatory "Conservation Biology" course, a setting naturally designed to force students to merge core biological science with pressing sustainability matters.

Our study population included every fifth-semester student taking this specific biology class. By surveying the entire cohort, we secured a baseline group of 49 prospective teachers ($N = 49$) to anchor the quantitative stage. To tackle the qualitative side, we deliberately handpicked nine individuals ($n = 9$) from that initial pool, using their survey results as our guide. We categorized these nine students into three distinct tiers depending on their combined scores for mental habits and perceived ESD readiness: top performers ($n = 3$), average performers ($n = 3$), and those struggling the most ($n = 3$). Relying on this maximum variation strategy allowed us to deeply contrast how students at entirely different capability levels mentally and psychologically approach lesson design (Miles et al., 2014).

To gather the numerical data, we deployed three distinct measurement tools. Initially, we used the Habits of Mind (HoM) Inventory, drawing on the framework by Costa & Kallick (2000, 2009), to map out 16 different cognitive traits via a 4-point Likert scale. After three independent specialists rigorously vetted the tool to ensure construct validity, our statistical checks confirmed its robust internal consistency (Cronbach's $\alpha = 0.91$). Next, we evaluated the participants' Perceived Teacher ESD Competency. For this, we modified a scale from the Asia-Pacific ESD Teacher Competency Framework (Okayama University, 2020) that captures three specific professional areas: Facilitating Learning; Continuing to Learn and Create; and Connecting, Collaborating, and Engaging. This second metric similarly proved highly reliable in our testing (Cronbach's $\alpha = 0.92$).

To measure our final target, Instructional Design Skills (Y), we applied a specialized Instructional Design Assessment Rubric. We anchored this grading tool directly to the (UNESCO, 2017) ESD Learning Objectives, breaking the assessment down into six distinct pedagogical pillars. Because evaluating lesson modules can easily become subjective, we handed the students' work over to three independent academic experts whose specialties bridge both biology education and sustainability. These raters reviewed the materials separately, and their scoring aligned exceptionally well; we calculated an Intraclass Correlation Coefficient (ICC) of 0.92, confirming a very strong and reliable consensus across the board.

To make sense of the numerical data, we ran a Multiple Linear Regression, looking to see exactly how much predictive power Habits of Mind (X1) and Perceived Competence (X2) held over the students' Instructional Design Skills (Y). Before jumping into the main hypothesis, we ran all the standard diagnostic checks required for parametric modeling. The dataset safely cleared every hurdle: a Kolmogorov-Smirnov test confirmed the scores were normally distributed ($p = 0.200 > 0.05$), visual scatterplots verified homoscedasticity, and we confidently ruled out multicollinearity since our Variance Inflation Factor (VIF) stayed well below 10 with healthy tolerance values (> 0.1). With this clean statistical foundation in place, our primary analysis zeroed in on unpacking the Coefficient of Determination (R^2) and the standardized beta coefficients (β) to weigh the true impact of each internal trait.

For the qualitative, which we built from reflective journals and semi-structured interviews, we leaned on the interactive analysis model introduced by Miles et al. (2014). This framework guided us through three overlapping phases: condensing the raw data down to its core themes, laying it out visually, and finally drawing and verifying our conclusions. Naturally, we secured informed consent from everyone involved, masking their real identities with descriptive codes (such as HPG-1 or LPG-2) to protect their privacy. Bringing it all together in the final analytical step, we built overarching meta-inferences by mapping our hard statistical predictors directly onto the qualitative themes that surfaced from the students' own words. By weaving these two distinct datasets together, we were able to clearly explain exactly how a future educator's mental habits and professional confidence join forces to dictate the caliber of their ESD learning modules.

Qualitative data, gathered through semi-structured interviews and reflective journals, were analysed using the interactive model proposed by. This entailed three concurrent flows: Data Condensation, Data Display, and Conclusion Drawing/Verification. All participants provided informed consent, and identities were anonymized (e.g., HPG-1, LPG-2) to maintain confidentiality. In the final analytical step, meta-inferences were formulated by systematically synthesizing the quantitative statistical determinants with the qualitative thematic explanations. This integration provided a detailed explanation of how intellectual dispositions and professional self-beliefs collectively drive the quality of ESD instructional design.

RESULTS AND DISCUSSION

The Determinants of Design Skills

BIODIDAKTIKA: Jurnal Biologi dan Pembelajarannya, Vol.X, No.X, 20XX, pp. X-X
e-ISSN XXXX-XXXX. DOI. 11.11111/X.vXiX.X

When we crunched the numbers, the multiple regression model revealed a compelling picture: together, a student's Habits of Mind (X1) and their Perceived Teacher ESD Competency (X2) account for a substantial 64.3% of the differences we saw in their instructional design skills ($R^2 = 0.643$, $F(2,46) = 44.220$, $p < .001$). Such a massive coefficient of determination tells us something crucial. Crafting effective, sustainability-infused biology modules demands far more than basic pedagogical training; it heavily depends on a tight interplay between how future educators think (cognitive dispositions) and what they believe they can achieve (professional self-beliefs). This statistical reality echoes the framework laid out by Sternberg & Grigorenko (2003), who argued that true instructional expertise only blossoms when raw cognitive skills are fueled by the inner motivation and self-regulation needed to take action.

Peeling back the layers of this predictive model, we found a clear hierarchy. The students' Perceived Teacher ESD Competency actually overpowered their Habits of Mind, emerging as the strongest single driver of design quality ($\beta = 0.514$, $p < .001$ versus $\beta = 0.445$, $p < .001$). What does this mean in practice? It shows that while having a flexible, intellectual mindset (HoM) is undoubtedly important, a teacher's sheer confidence in their ability to pull off complex ESD pedagogies ultimately dictates the caliber of the lesson module they produce. This perfectly mirrors Bandura (1977) classic assertion: self-efficacy acts as the gatekeeper that decides whether people will actually put their latent skills to work. A future biology teacher might possess incredible cognitive flexibility, but if they lack the specific self-belief that they can teach sustainability, their lesson plans will remain severely stunted. (For a complete breakdown of these regression weights, refer to Table 1, and see Figure 1 for the structural model mapping these effects).

Table 1. Summary of Multiple Linear Regression Analysis for Variables Predicting Instructional Design Skills

Predictor Variable	B	SE B	β	t	p
(Constant)	0.693	0.282		2.461	.018
Habits of Mind (X1)	0.461	0.099	.445	4.667	< .001
Perceived Competency (X2)	0.300	0.056	.514	5.387	< .001

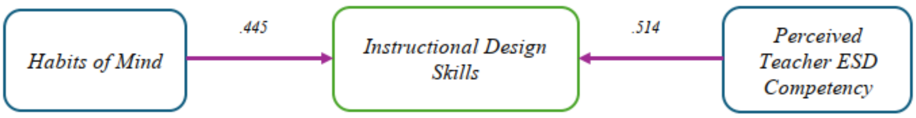

Figure 1. Structural Model Illustrating the Simultaneous and Partial Effects of Habits of Mind and Perceived Teacher ESD Competency on Instructional Design Skills

e-ISSN XXXX-XXXX. DOI. 11.11111/X.vXiX.X

Because this sense of capability drives the design process so heavily, we needed to look much closer at the baseline descriptive data. As laid out in Table 2, the students' overall scores for Perceived Teacher ESD Competency actually sat at the bottom of the pack compared to our other main variables, averaging just 2.86 and landing squarely in the "Moderate" zone.

Table 2. Descriptive Statistics and Categorization of Research Variables (N = 49)

Variables	Mean Score	Categories	Frequency (n)	Percentage (%)
Habits of Mind (HoM)	3.13	High	9	18.4%
		Moderate	29	59.2%
		Low	11	22.4%
Perceived Teacher ESD Competency	2.86	High	17	34.7%
		Moderate	28	57.1%
		Low	4	8.2%
Instructional Design Skills	2.99	High	5	10.2%
		Moderate	22	44.9%
		Low	22	44.9%

When we sliced that competency data even thinner to look at its specific sub-scales (visualized in Figure 2), a glaring issue surfaced: the "Continue to Learn and Create" dimension scored the absolute lowest at M=2.75. This dip points directly to a crisis in pedagogical confidence. Essentially, these upcoming teachers feel highly insecure about their capacity to build the complex, interdisciplinary learning environments that sustainability education demands. This hesitation makes perfect sense when viewed through the lens of Malandrakis et al. (2018), who noted that a teacher's confidence in handling ESD is typically much shakier than their general classroom confidence. Why? Because teaching sustainability forces educators to abandon safe, fact-memorization routines in favor of messy, action-driven, and value-heavy lessons.

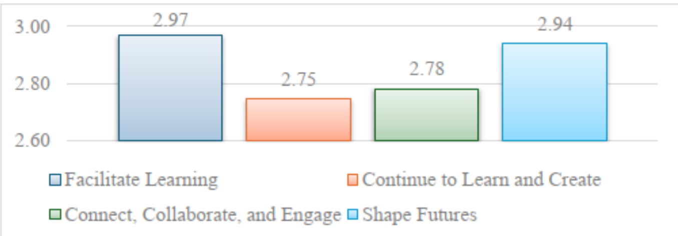

Figure 2. Mean Scores of Perceived Teacher ESD Competency Sub-scales

This pervasive hesitation ties directly into Cognitive Flexibility Theory. As Spiro et al. (1988) pointed out, "ill-structured domains" demand an ability to adapt knowledge fluidly across unpredictable, real-world contexts that lack standard answers. Building a biology learning module that incorporates Sustainable Development Goals (SDGs) is a classic ill-structured challenge: it forces student teachers to constantly balance unyielding biological

BIODIDAKTIKA: Jurnal Biologi dan Pembelajarannya, Vol.X, No.X, 20XX, pp. X-X
e-ISSN XXXX-XXXX. DOI. 11.11111/X.vXiX.X

truths against value-based, normative sustainability targets (Abdildauly et al., 2025; Kioupi & Voulvoulis, 2019; Wibowo & Sadikin, 2019). When prospective educators lack confidence in their ESD abilities, they flounder under this weight, almost always falling back on traditional, linear lesson structures instead of embracing complex, integrative problem-solving (Redman & Wiek, 2021).

At the same time, we cannot overlook the substantial weight carried by Habits of Mind ($\beta = 0.445$). While professional confidence provides the courage to act, these intellectual dispositions supply the essential cognitive mechanics required to actually blueprint a multi-layered lesson. To understand which specific mental habits were doing the heavy lifting, we surveyed all 16 HoM traits across the participant group (illustrated in Figure 3).

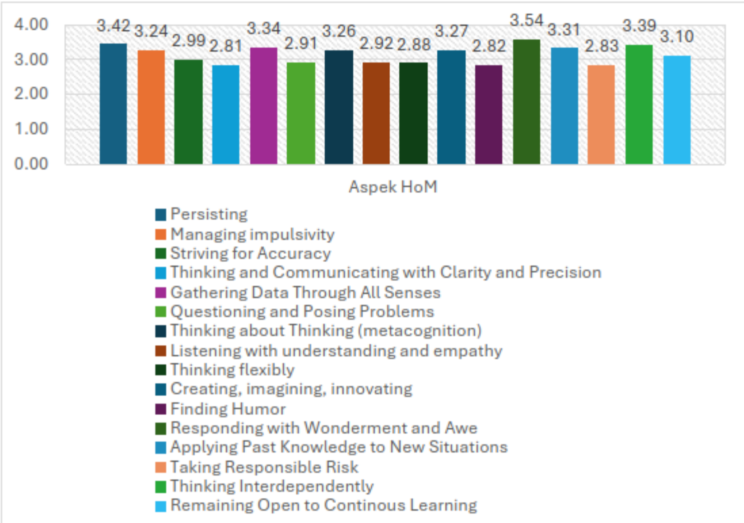

Figure 3. Mean Scores Across the 16 Aspects of Habits of Mind Among Pre-service Biology Teachers.

Looking closely at those traits, both Thinking Flexibly (M=3.27) and Metacognition (M=3.26) stand out as incredibly vital for sustainability education. Building a sustainability-focused curriculum demands serious mental gymnastics; teachers have to constantly pivot from tiny, micro-level biological processes to massive, macro-level global impacts (Biletska et al., 2021; Salsabila et al., 2025). Throughout this tangled design process, metacognition acts as an internal compass, helping educators critically evaluate their own choices and ensure their daily lesson goals actually line up with sweeping ESD targets (Costa & Kallick, 2009; Moon, 2013). Interestingly, the trait that topped the charts for these students was Responding with Wonderment and Awe (M=3.54). While Hadzigeorgiou (2011) rightly argues that a sense of wonder sparks genuine scientific curiosity, our findings reveal a hard truth: feeling amazed by

e-ISSN XXXX-XXXX. DOI. 11.11111/X.vXiX.X

nature is not enough on its own. Unless that sense of wonder is backed by solid professional competence, it will not magically turn into a high-quality lesson plan.

Ultimately, the tight statistical links between cognitive habits, professional self-belief, and final design quality prove that none of these factors operate in isolation. When you look at the Pearson correlation matrix (Table 3) and the matching scatterplots (Figure 4), they paint a vivid picture of this interconnectedness, displaying a deeply robust linear relationship (R = .802) across the board.

Table 3. Pearson Correlation Matrix for Habits of Mind, Perceived Teacher ESD Competency, and Instructional Design Skills (N = 49)

Variables	1	2	3
1. Habits of Mind (HoM)	1		
2. Perceived Teacher ESD Competency	.427**	1	
3. Instructional Design Skills	.665**	.704**	1

*** Correlation is significant at the 0.01 level (2-tailed).*

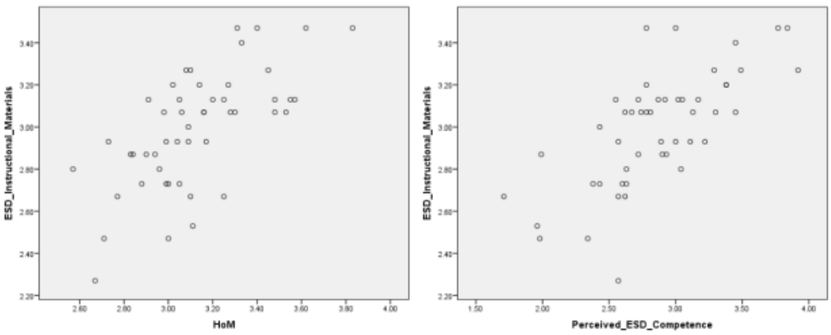

Figure 4. Scatterplot Illustrating the Strong Positive Correlation (R = .802) and the Synergistic Loop Between Internal Determinants and Instructional Design Execution

Digging deeper into the actual module evaluations, the grading rubric exposed a very specific weak spot. As mapped out in Figure 5, the "Instructional Content" pillar scored the lowest out of all the design elements, limping in at an average of just 2.80. The prospective educators found it exceptionally difficult to fuse real-world sustainability dilemmas with hard biological facts, exposing a severe gap in their interdisciplinary literacy. This shortfall sends a clear message: seamlessly blending the moral targets of the SDGs with objective scientific data is a high-level instructional hurdle. A teacher cannot simply rely on basic teaching know-how or a flexible mindset to magically bridge that gap.

e-ISSN XXXX-XXXX. DOI. 11.11111/X.vXiX.X

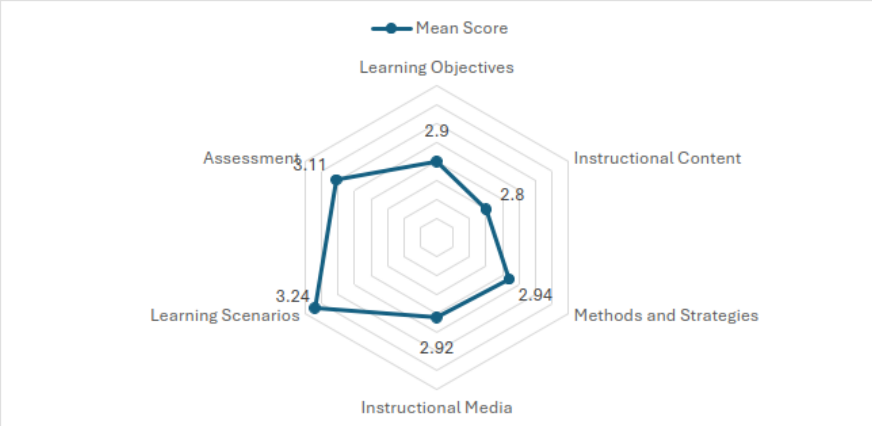

Figure 5. Mean Scores Across the Instructional Design Rubric Components, Highlighting the Deficit in Instructional Content Integration

Taking a step back, the hard numbers tell us that building transformative, student-focused ESD lessons requires a powerful synergy. A future teacher must combine the mental agility of HoM with the practical courage of professional self-efficacy. (For a bird's-eye view of how every aspect of these variables stacks up, take a look at Figure 6). To truly understand the "how" and "why" behind these numbers, our upcoming qualitative breakdown will dive into the minds of the highest-performing students. We want to see exactly how they tackled the messy, ill-structured reality of lesson design, giving us a much more granular look at the hidden mechanics of ESD integration.

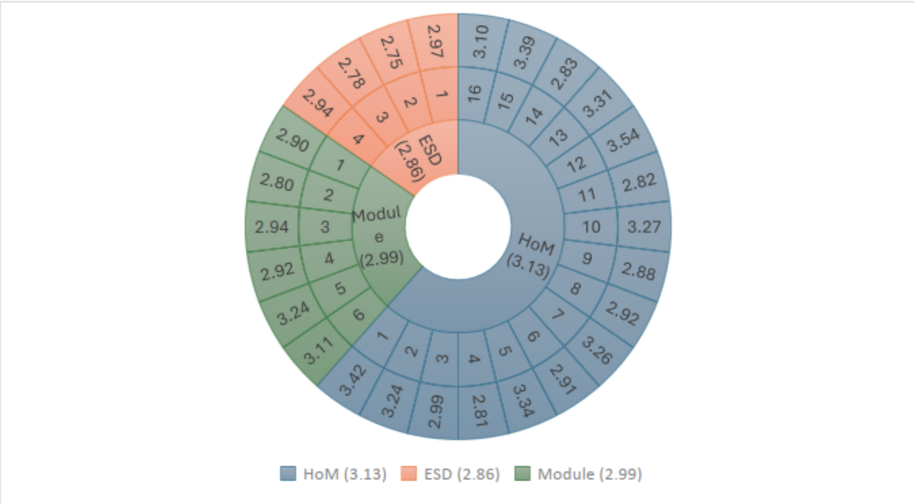

Figure 6. A Comprehensive Overview of Each Aspect of HoM, Teacher ESD Competency, and ESD Instructional Design Skills

e-ISSN XXXX-XXXX. DOI. 11.11111/X.vXiX.X

Unpacking the Mechanism – Qualitative Insights

By reading through the reflective journals and talking intimately with our nine selected students, we gained a front-row seat to their actual design processes. This qualitative deep-dive lays bare the mental and pedagogical gears that separate the high-performing group (HPG) from the low-performing group (LPG). As we sifted through their responses, four major themes naturally bubbled to the surface, showing us exactly what Habits of Mind and Perceived Competency look like out in the wild.

Theme 1: Cognitive Flexibility in Conceptualizing Integration

Right out of the gate, the most glaring difference between the two groups was how they handled the messy, unstructured nature of sustainability education. The top performers (HPG) showed an impressive amount of mental agility. In our conversations, they talked about sketching out their lesson plans in a non-linear way, choosing to chase down real-world environmental dilemmas first, rather than just marching rigidly through a list of biology facts. One standout example was HPG-1, who realized that you cannot teach forest destruction without dragging in local economics and government policies, showcasing a brilliant knack for interdependent thinking. This behavior is a textbook example of Spiro et al. (1988) theory, where students use raw knowledge as an active tool to solve problems rather than just passively storing it. Because of this flexible mindset, these high achievers managed to weave massive global targets, like SDGs 12 and 14, seamlessly into their biological storylines. To see this interdependent thinking in action, consider how HPG-1 explained their thought process:

"I cannot just talk about forest destruction biologically. It must also include why the local community does it, which involves economic factors and government policies. My module must trigger a discussion about this dilemma" (HPG-1, Interview Transcript).

On the other side of the spectrum, the low-performing group (LPG) clung tightly to the safety of standard curriculum sequences. Their interview answers revealed a strong habit of walling off biological facts from any messy socio-environmental realities. LPG-3, for instance, admitted they preferred teaching photosynthesis completely in a vacuum just to keep students from getting confused. Because of this tunnel vision, their final lesson plans looked highly traditional; sustainability ideas were just bolted onto the sides rather than woven into the core, completely stripping the modules of their transformative power (Frey et al., 2025; Kioupi & Voulvoulis, 2019; Lorente-Echeverría et al., 2023; Peretz, 2025). One LPG participant laid out this mindset perfectly:

e-ISSN XXXX-XXXX. DOI. 11.11111/X.vXiX.X

"I just focus on the photosynthesis material, not too much on social issues. The students will get confused later. Anyway, a teacher's job is to deliver the material in the curriculum" (LPG-3, Interview Transcript).

Beyond just flexible thinking, the top achievers also heavily leaned on the habit of *Applying Past Knowledge to New Situations*. They managed to effortlessly grab concepts they had absorbed during their Conservation Biology lectures and drop them right into their lesson planning. They could clearly picture how the conservation ethics they had studied would actually look and feel during a live classroom activity. The struggling students, however, could not build this bridge, even though they sat in the exact same lectures. They kept their brains compartmentalized, treating conservation purely as a topic to memorize and teaching strictly as a technical method, completely missing the chance to fuse the two together.

Theme 2: Metacognitive Regulation During Design

Crafting an effective ESD module is not a "set it and forget it" process; it demands a constant loop of self-monitoring. The top-tier students showed a remarkable level of metacognitive awareness, constantly pausing to check if their planned classroom activities actually mirrored the big-picture goals of sustainability. Looking through their reflective journals, we found a trail of ongoing internal debates. For instance, HPG-2 actively questioned whether their lesson goals were just asking students to memorize facts or if they were truly pushing them to take real-world action. This habit of checking in on themselves aligns perfectly with Costa & Kallick (2009) framework, and it was the secret ingredient that allowed them to continuously polish and upgrade their module drafts. You can clearly see this adaptive self-correction playing out in one of the journal entries:

"After the first draft was critiqued by the lecturer, I immediately knew the objectives were too cognitive. I reflected, 'Am I sure I can make the students take action?'. Finally, I completely overhauled it so there would be a decision-making simulation activity" (HPG-2, Reflective Journal).

The struggling participants (LPG), however, showed very little of this internal dialogue. When we asked them why they chose certain teaching methods, they usually pointed to whatever was easiest to pull off or whatever was traditionally done, rather than asking if it actually served the broader sustainability mission. Because they rarely evaluated their own choices, their final lesson plans often felt disjointed, what they claimed they wanted to achieve with ESD rarely matched the actual quizzes or assignments they handed out. This disconnect stands as solid proof of Marzano et al. (2001) argument: without metacognitive regulation, you simply cannot transfer your good educational intentions into a functional, hard-hitting instructional design.

Theme 3: Perceived Competency and Pedagogical Execution

While strong mental habits lay down the theoretical blueprint, our qualitative findings prove that a teacher's perceived competency is what actually pulls the trigger on action-oriented teaching. Because ESD is all about pushing students to take real action (Mogensen & Schnack, 2010; Sinakou et al., 2022; Vidal & Kuckuck, 2025) it inherently involves running chaotic, student-driven activities. The top-tier students (HPG) were not afraid of this chaos. They openly embraced the messy, unpredictable nature of things like outdoor fieldwork or community projects, treating these hurdles as non-negotiable parts of genuine sustainability education. An HPG student captured this bravery perfectly:

"I know taking students to the river is risky and messy, but I feel confident I can manage it, and it's the only way they will really understand" (HPG-1, Interview Transcript).

Watching this unfold, it becomes clear that Perceived Competence is doing exactly what Bandura (1977) said it would: it gives educators the grit to take a hard but effective route instead of settling for an easy, useless one. These high achievers genuinely trusted their own ability to command an unpredictable ESD classroom. On the flip side, the struggling group (LPG) backed away from anything innovative. They openly admitted they just did not have the confidence to juggle complex, interdisciplinary lessons (as seen with LPG-1). This deep-seated hesitation anchored them to old-school, teacher-talking-at-students methods. It is a stark reminder that knowing the theories behind ESD means nothing if a teacher lacks the professional courage to actually weave them into a lesson plan. We saw this lack of confidence bleed into their interviews, manifesting as highly passive and pessimistic views on trying anything new:

"I know there should be a strong ESD element, but I am not sure high school students can understand overly complex concepts. I better follow existing examples rather than failing to teach the material well later. I lack confidence in new methods" (LPG-1, Interview Transcript).

Paralyzed by the fear of failing, these students retreated to the comfortable safety of textbooks and four walls. Their low self-efficacy essentially morphed into a self-fulfilling prophecy: because they were convinced they could not run a complex lesson, they actively designed basic, low-level modules to avoid having to try. The heart of the issue was not a lack of knowledge, the LPG students often knew in their heads that project-based learning was the gold standard for ESD. They just felt psychologically unequipped to actually execute it. This emotional block perfectly explains the surprise in our earlier regression data, neatly answering why raw Competence ultimately overpowered Habits of Mind as the main driver of design quality.

Theme 4: The Shared Challenge: The Content Integration Barrier

Even with the stark contrasts in how the two groups planned their lessons, one glaring obstacle united everyone: actually, blending the subject matter. This qualitative reality perfectly mirrors the massive drop we saw earlier in the quantitative rubric, where the "Instructional Content" pillar bombed with an average score of just 2.80. When we spoke to them, students from the top, middle, and bottom tiers all confessed to hitting a brick wall here. They found it agonizingly difficult to weave normative sustainability dilemmas into standard biology lessons without feeling like they were watering down or betraying the hard science.

What this universal struggle tells us is that forcing value-driven ESD ideals to play nicely with objective biological facts is an entirely separate, heavyweight challenge. Simply being a flexible thinker or knowing a lot of teaching tricks will not save an educator if they lack deeply rooted, cross-disciplinary content knowledge. We call this the "Content Integration Barrier," and it stands as a massive roadblock in biology education that universities must tackle head-on with targeted training interventions.

Stepping back, these qualitative conversations finally lift the veil on how invisible mental habits and psychological beliefs pull the strings during lesson planning. The highest achievers succeeded because they managed to marry a highly adaptable mindset with the professional bravery needed to run action-packed classrooms. On the flip side, those plagued by self-doubt and rigid thinking simply fell back into safe, outdated teaching routines. Above all else, the fact that everyone stumbled over content integration proves that future biology teachers desperately need specialized help to build their interdisciplinary literacy before they step foot in a real classroom.

Integrating the Minds and Beliefs of Future Teachers

Bringing the numbers and the narratives together gives us a 360-degree view of how future biology educators actually survive the hurdles of Education for Sustainable Development (ESD). While our regression models clearly flagged Habits of Mind (HoM) and Perceived Competency as the heavy hitters, the qualitative interviews cracked open the "black box" of how these two traits actually feed off each other. To lay this out clearly, Table 4 maps our joint-display analysis, anchoring the cold statistical trends directly to the human stories behind them to forge our final, overarching meta-inferences.

e-ISSN XXXX-XXXX. DOI. 11.11111/X.vXiX.X

Table 4. Joint Display of Quantitative and Qualitative Findings Yielding Meta-Inferences

Quantitative Results (The "What")	**Qualitative Findings (The "How" & "Why")**	**Meta-Inferences (The Integrated Synthesis)**
Dominance of Competency: Perceived Competency (β=0.514) is a stronger predictor than Habits of Mind (β=0.445) in determining design skills.	Pedagogical Execution: High achievers confidently implement complex, action-oriented pedagogies. Low achievers retreat to conventional methods due to a lack of confidence in managing interdisciplinary learning.	The Agency Catalyst: Intellectual capacity (HoM) requires the catalyst of professional self-efficacy to be actualized in instructional design. ESD is inherently action-oriented, demanding pedagogical agency.
Cognitive Flexibility Impact: Strong correlation exists between flexible thinking and overall module quality.	Architect of Integration: High achievers restructure biological content to address real-world sustainability problems, whereas low achievers strictly follow linear, textbook-based syllabi.	Navigating Ill-Structured Domains: Designing ESD materials is an ill-structured problem that demands epistemic flexibility to shift from delivering isolated facts to facilitating systemic solutions.
Metacognitive Regulation: Metacognition scores correlate strongly with the competency sub-scale "Continue to Learn and Create."	Quality Control System: High achievers engage in continuous self-reflection to refine their designs. Low achievers operate with minimal self-correction, leading to misaligned objectives.	The Regulatory Bridge: Metacognition serves as the critical mechanism connecting cognitive habits to professional competency, allowing pre-service teachers to align their intentions with pedagogical actions.
The Content Deficit: The Instructional Content component received the lowest mean score (M=2.80) across all participants.	The Integration Barrier: Both high and low achievers expressed profound difficulty in seamlessly synthesizing sustainability issues with biological facts without making the ESD values feel "added on."	Interdisciplinary Literacy Gap: General cognitive habits and pedagogical skills are insufficient for complex content synthesis. This reveals a critical deficit in targeted interdisciplinary literacy within teacher education programs.

The most striking takeaway from mixing these datasets is finally understanding exactly why Perceived Competency outpunched Habits of Mind in our statistical model. Because teaching sustainability is fundamentally about driving action, merely having the brainpower to grasp environmental issues is just not enough; a teacher needs the sheer pedagogical agency to turn that understanding into live classroom tasks. This perfectly backs up Bandura (1977) classic theory: if you lack self-efficacy, your potential skills will just sit on the shelf gathering dust.

On top of this, seeing both datasets collide around the "Content Integration Barrier" was a massive wake-up call. The fact that almost every student struggled to organically fuse moral ESD goals with hard biology highlights a severe crack in how we train them on subject matter.

Having a flexible mind might help a teacher dream up fun activities, but it certainly does not hand them the magic formula for blending two entirely different academic worlds.

Ultimately, these realities shake up how we view the Technological Pedagogical Content Knowledge (TPACK) framework, which heavily dominates modern teacher training (Mishra & Koehler, 2006, 2008). Our data strongly suggests that when it comes to sustainability, just mashing together Content, Pedagogy, and Technology will fall short if we ignore what goes on inside the teacher's head. We argue that universities need to widen their lens and adopt a more robust framework, one that actively targets a teacher's mental habits and professional self-belief as foundational pillars for handling complex instructional designs.

Limitations of the Study

No study is without its boundaries, and ours is no exception. For the quantitative leg of this research, we worked with a fairly contained group of 49 students from a single university in Indonesia. Because of this localized focus, we have to be careful about casting a wide net and assuming these exact statistical models will perfectly map onto all future biology teachers everywhere. That said, our mixed-methods approach helps cushion this limitation. By digging deeply into their actual lesson plans and interviewing the creators, we built a solid, granular understanding of *why* those numbers look the way they do. Moving forward, the logical next step is for other researchers to take this framework and test it across much larger, diverse university networks.

CONCLUSION

Ultimately, this research confirms that building top-notch learning materials for sustainability is not just a technical skill; it is a complex mental and psychological balancing act. Together, a student’s Habits of Mind and their Perceived Teacher ESD Competency dictate a massive 64.3% of how well they design their lessons. More importantly, the fact that their self-belief overpowered their cognitive habits sends a loud message: raw brainpower and flexible thinking are virtually useless unless a teacher has the professional courage to pull the trigger on action-oriented teaching.

On top of that, we uncovered a glaring "Content Integration Barrier" that tripped up almost everyone. Since students across the board struggled immensely to blend moral sustainability goals with hard biological facts, it is clear that creating ESD modules is not as simple as tweaking a standard science lesson. To actually close this gap, teacher training programs need to tear down their traditional, lecture-heavy models. They must actively and intentionally build up their students' interdisciplinary literacy and self-efficacy if we ever hope to see truly transformative sustainability education in our schools.

SUGGESTIONS

Derived from the integrated findings, the following recommendations are proposed for Teacher Education Institutions and future educational researchers:

1. To fix the glaring hole in instructional content, university curricula need to stop assuming students will figure out integration on their own. Professors must explicitly model exactly how to map the SDGs onto core biological concepts, giving future teachers a practical blueprint for fusing moral values with objective science.
2. Since self-belief proved to be the ultimate dealbreaker for design quality, universities have to stop just teaching theory and start actively building self-efficacy. Teaching practicums should transform into safe "sandboxes" where student teachers can experiment with chaotic, action-driven ESD methods without the looming terror of failing a grade.
3. If we want to sharpen their Habits of Mind, reflective journaling needs to be hardwired into the entire teacher preparation experience. Instead of just summarizing what they did in class, students must be pushed to brutally evaluate whether their lesson choices actually force their future pupils to think sustainably.
4. Finally, researchers need to move past merely observing the problem and start testing real interventions. The field desperately needs scholars to build, test, and measure specific training programs designed to deliberately boost both the mental agility and the professional courage of our future educators before they hit the real world.

REFERENCES

Abdildauly, A., Bakhtaulova, A. S., Mukasheva, D. M., & Haas, M. (2025). Education for sustainable development: comparative analysis of internship programs in preparing biology teachers. *IOP Conference Series: Earth and Environmental Science, 1544*(1), 12015. https://doi.org/10.1088/1755-1315/1544/1/012015

Ahmad, A., Akhsani, L., & Mohamed, Z. (2023). The profile of students' mathematical representation competence, self-confidence, and habits of mind through problem-based learning models. *Infinity Journal, 12*(2), 323–338. https://doi.org/10.22460/infinity.v12i2.p323-338

Ardoin, N. M., Bowers, A. W., & Gaillard, E. (2020). Environmental education outcomes for conservation: A systematic review. *Biological Conservation, 241*, 108224. https://doi.org/10.1016/j.biocon.2019.108224

Bandura, A. (1977). *Self-Efficacy: The Exercise of Control*. New York. Freeman & Company.

Beasy, K., Richey, S., Brandsema, J., & To, V. (2024). Embedding Sustainability across a Teacher Education Course: Teacher Educator Experiences. *Australian Journal of Environmental Education, 40*(4), 722–739. https://doi.org/10.1017/aee.2024.36

Biletska, H., Mironova, N., Yefremova, O., Barna, L., & Bloshchynskyi, I. (2021). The Future Biology Teachers Training for the Implementation of Sustainable Development Ideas in Ecological Education. *International Journal of Innovative Research and Scientific Studies, 4*(4), 229–237. https://doi.org/10.53894/ijirss.v4i4.200

Brundiers, K., Wiek, A., & Redman, C. L. (2010). Real‐world learning opportunities in sustainability: from classroom into the real world. *International Journal of Sustainability in Higher Education, 11*(4), 308–324. https://doi.org/10.1108/14676371011077540

Bulut, B., & Elci Oksuzoglu, I. (2025). Teachers' Beliefs About Education for Sustainable Development: Challenges and Opportunities. In *Sustainability* (Vol. 17, Number 16, p. 7552). https://doi.org/10.3390/su17167552

Bürgener, L., & Barth, M. (2018). Sustainability competencies in teacher education: Making teacher education count in everyday school practice. *Journal of Cleaner Production, 174*, 821–826. https://doi.org/10.1016/j.jclepro.2017.10.263

Cebrián, G., Junyent, M., & Mulà, I. (2020). Competencies in Education for Sustainable Development: Emerging Teaching and Research Developments. In *Sustainability* (Vol. 12, Number 2, p. 579). https://doi.org/10.3390/su12020579

Costa, A. L., & Kallick, B. (2000). Describing 16 habits of mind. Alexandria, VA: ASCD.

Costa, A. L., & Kallick, B. (2009). Habits of mind across the curriculum: Practical and creative strategies for teachers. ASCD.

Creswell, J. W. (2022). A concise introduction to mixed methods research 2nd ed. SAGE publications.

de Jong, T. (2010). Cognitive load theory, educational research, and instructional design: some food for thought. *Instructional Science, 38*(2), 105–134. https://doi.org/10.1007/s11251-009-9110-0

Dittrich, Ann-Kathrin. (2024). An International Reconstruction of Teachers' and Teacher Educators' Perspectives on the Challenges of Education for Sustainable Development in Teacher Education. *Journal of Education for Sustainable Development, 18*(2), 122–141. https://doi.org/10.1177/09734082241309704

Ekanara, B., Riandi, R., Rahman, T., Solihat, R., & Rusyati, L. (2026). Empowering Pre-service Biology Teachers through Sustainability Action: An Ethnobotanical Inventory Project in Cirebon. *Biodidaktika: Jurnal Biologi Dan Pembelajarannya, 21*(1), 100–112.

Fischer, D., King, J., Rieckmann, M., Barth, M., Büssing, A., Hemmer, I., & Lindau-Bank, D. (2022). Teacher Education for Sustainable Development: A Review of an Emerging Research Field. *Journal of Teacher Education, 73*(5), 509–524. https://doi.org/10.1177/00224871221105784

Franco, I., Saito, O., Vaughter, P., Whereat, J., Kanie, N., & Takemoto, K. (2019). Higher education for sustainable development: actioning the global goals in policy, curriculum and practice. *Sustainability Science, 14*, 1621–1642. https://doi.org/10.1007/s11625-018-0628-4

Frey, S., Beege, M., Renkl, A., & Riess, W. (2025). The Impact of System Models on Systems Thinking in the Context of Climate Change in Elementary School. In *Systems* (Vol. 13, Number 4, p. 220). https://doi.org/10.3390/systems13040220

Hadzigeorgiou, Y. (2011). Fostering a Sense of Wonder in the Science Classroom. *Research in Science Education - RES SCI EDUC, 42*. https://doi.org/10.1007/s11165-011-9225-6

Hallinger, P., & Chatpinyakoop, C. (2019). A Bibliometric Review of Research on Higher Education for Sustainable Development, 1998–2018. *Sustainability, 11*, 2401. https://doi.org/10.3390/su11082401

Hogan, D., & O'Flaherty, J. (2021). Addressing Education for Sustainable Development in the Teaching of Science: The Case of a Biological Sciences Teacher Education Program. *Sustainability, 13*(21), 12028. https://doi.org/10.3390/su132112028

Isfiani, I. R., & Ekanara, B. (2022). Metacognition profile on habits of mind in biology learning. *Jurnal Pendidikan Indonesia Gemilang, 2*(2), 95–104. https://doi.org/10.53889/jpig.v2i2.138

Isfiani, I. R., & Ekanara, B. (2024). Mapping The Habits of Mind of Pre-Service Biology Teacher Students In Supporting Education for Sustainable Development (ESD). *Jurnal Pengajaran Matematika dan Ilmu Pengetahuan Alam, 29*(2).

Khairati, I., Lufri, L., & Fadilah, M. (2025). Empirical Evidence of Students' Systems Thinking Skills in ESD-Oriented: A Rasch Analysis Approach. *Journal of Biological Education Indonesia (Jurnal Pendidikan Biologi Indonesia), 11*(1), 438–449.

Kioupi, V., & Voulvoulis, N. (2019). Education for Sustainable Development: A Systemic Framework for Connecting the SDGs to Educational Outcomes. In *Sustainability* (Vol. 11, Number 21, p. 6104). https://doi.org/10.3390/su11216104

Lorente-Echeverría, S., Canales-Lacruz, I., & Murillo-Pardo, B. (2023). Whole Systems Thinking and Context of the University Teacher on Curricular Sustainability in Primary Education Teaching Degrees at the University of Zaragoza. In *Education Sciences* (Vol. 13, Number 4, p. 341). https://doi.org/10.3390/educsci13040341

Malandrakis, G., Papadopoulou, P., Gavrilakis, C., & Mogias, A. (2018). An education for sustainable development self-efficacy scale for primary pre-service teachers: construction and validation. *The Journal of Environmental Education, 50*, 1–18. https://doi.org/10.1080/00958964.2018.1492366

Marzano, R. J., Pickering, D., & Pollock, J. E. (2001). Classroom instruction that works: Research-based strategies for increasing student achievement. Ascd.

Miles, M., Huberman, M., & Saldaña, J. (2014). Q*ualitative Data Analysis: A Methods Sourcebook* (3rd Edition) (Vol. 28).

Mishra, P., & Koehler, M. J. (2006). Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge. *Teachers College Record, 108*(6), 1017–1054. https://doi.org/10.1111/j.1467-9620.2006.00684.x

Mishra, P., & Koehler, M. J. (2008). *Handbook of Technological Pedagogical Content Knowledge (TPCK) for Educators* (1st ed.). Routledge. https://doi.org/10.4324/9781315759630

Mogensen, F. M., & Schnack, K. (2010). The action competence approach and the 'new' discourses of education for sustainable development, competence and quality criteria. *Environmental Education Research, 16*, 59–74. https://doi.org/10.1080/13504620903504032

Moon, J. A. (2013). *A handbook of reflective and experiential learning: Theory and practice*. Routledge.

Munasi, K. R. (2024). Evaluating the Integration of Education for Sustainable Development in the Life Sciences Curriculum: A Case Study of Grade 11 Teachers in Vhembe East District. In *Sustainability* (Vol. 16, Number 24, p. 10918). https://doi.org/10.3390/su162410918

Okayama University. (2020). Guide for the Effective Dissemination of the Asia-Pacific ESD Teacher Competency Framework: The Second Report of the Project "Teacher Education for ESD in the Asia-Pacific Region." Okayama University ESD Promotion Centre.

Peretz, R. (2025). Integrating Systems Thinking into Sustainability Education: An Overview with Educator-Focused Guidance. In *Education Sciences* (Vol. 15, Number 12, p. 1685). https://doi.org/10.3390/educsci15121685

Purwianingsih, W., Novidsa, I., & Riandi, R. (2022). Program for Integrating Education for Sustainable Development (ESD) into Prospective Biology Teachers' Technological Pedagogical Content Knowledge (TPACK). *Jurnal Pendidikan IPA Indonesia, 11*. https://doi.org/10.15294/jpii.v11i2.34772

Rauch, F., & Steiner, R. (2013). Competences for Education for Sustainable Development in Teacher Education. *CEPS Journal, 3*. https://doi.org/10.26529/cepsj.248

Redman, A., & Wiek, A. (2021). Competencies for Advancing Transformations Towards Sustainability. *Frontiers in Education, 6*, 484. https://doi.org/10.3389/feduc.2021.785163

Rieckmann, M. (2018). Learning to transform the world: Key competencies in Education for Sustainable Development. *Issues and Trends in Education for Sustainable Development, 39*(1), 39–59.

Rikizaputra, R., Lufri, L., Andromeda, A., & Mufit, F. (2021). Analysis of Student Independence and Habits of Mind of Students in Biology Learning in Class X MIA through Portfolio Assessment. *Jurnal Penelitian Pendidikan IPA, 7*(2), 232–238. https://doi.org/10.29303/jppipa.v7i2.630

Salsabila, A., Suyono, S., & Supardi, Z. A. I. (2025). Analysis of student worksheets on compost making based on ESD-TPack to improve students' scientific attitudes in biology learning. *Biosfer: Jurnal Pendidikan Biologi, 18*(2), 303–314. https://doi.org/10.21009/biosferjpb.52768

Saraswati, D., Riandi, R., Kadarohman, A., Suhandi, A., Samsudin, A., Zulva, R., Fitriani, A., Rosyidah, T., Ashidiq, R., & Supriatna, A. (2023). Workshop on Strengthening TPACK in ESD-Based Science Learning in Implementing the Merdeka Curriculum [Workshop Penguatan TPACK pada Pembelajaran IPA Berbasis ESD dalam Implementasi Kurikulum Merdeka]. *Jurnal Pengabdian Isola, 2*, 126–134. https://doi.org/10.17509/jpi.v2i2.63499

Sinakou, E., Donche, V., & Van Petegem, P. (2022). Action-orientation in education for sustainable development: Teachers' interests and instructional practices. *Journal of Cleaner Production, 370*, 133469. https://doi.org/10.1016/j.jclepro.2022.133469

Spiro, R., Coulson, R., Feltovich, P. J., & Anderson, D. (1988). Cognitive Flexibility Theory: Advanced Knowledge Acquisition in Ill-Structured Domains (Vol. 12, pp. 544–557). https://doi.org/10.1017/CBO9780511529863.023

Sternberg, R. J., & Grigorenko, E. L. (2003). *The psychology of abilities, competencies, and expertise*. Cambridge University Press.

UNESCO. (2017). *Education for Sustainable Development Goals: Learning Objectives*. Paris: UNESCO. https://doi.org/10.54675/CGBA9153

UNESCO. (2019). *Framework for the Implementation of Education for Sustainable Development (ESD) beyond 2019*. UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000370215?posInSet=1&queryId=16f3d2a7-ac06-4e92-849a-4890faa4a202

UNESCO. (2020). *Education for Sustainable Development: A Roadmap*. https://doi.org/10.54675/YFRE1448

Vaughter, P., McKenzie, M., Lidstone, L., & Wright, T. (2016). Campus sustainability governance in Canada: A content analysis of post-secondary institutions' sustainability policies. *International Journal of Sustainability in Higher Education, 17*(1), 16–39. https://doi.org/10.1108/ijshe-05-2014-0075

Vidal, S., & Kuckuck, M. (2025). Pre-Service Teacher Action Competence in Education for Sustainable Development: A Scoping Review. *Sustainability, 17*(9), 3856. https://doi.org/10.3390/su17093856

Wals, A., & Benavot, A. (2017). Can we meet the sustainability challenges? The role of education and lifelong learning. *European Journal of Education, 52*. https://doi.org/10.1111/ejed.12250

Wibowo, Y. G., & Sadikin, A. (2019). Biology in the 21st-Century: Transformation in biology science and education in supporting the sustainable development goals. *JPBI (Jurnal Pendidikan Biologi Indonesia), 5*(2), 285–296. https://doi.org/10.22219/jpbi.v5i2.7956

Wiek, A., Withycombe, L., & Redman, C. L. (2011). Key competencies in sustainability: a reference framework for academic program development. *Sustainability Science, 6*(2), 203–218. https://doi.org/10.1007/s11625-011-0132-6

Wiyarsi, A., Çalık, M., Priyambodo, E., & Dina, D.-. (2023). Indonesian Prospective Teachers' Scientific Habits of Mind:A Cross-Grade Study in the Context of Local and Global Socio-scientific Issues. *Science & Education, 1–27*. https://doi.org/10.1007/s11191-023-00429-4

3. Keterangan *Accepted*

Indah Juwita Sari <indah.juwitasari@untirta.ac.id>
kepada ekanara, saya, isfianiilma

Sel, 12 Mei, 18.39

Dear Bambang Ekanara

We have reached a decision regarding your submission to Biodidaktika : Jurnal Biologi dan Pembelajarannya, "From Thinking to Designing: How Habits of Mind and Perceived Teacher ESD Competence Shape Pre-service Teachers' ESD Instructional Materials" has been accepted for Publication in Vol. 21, No.2, July 2026.

You will receive an e-mail in due course regarding the production process.

FYI. For publication fee is 1,000,000 (IDR) via Bank Negara Indonesia (BNI) with account name Indah Juwita Sari with account number 0305873129. Please send the information through this email after you have transferred it successfully. If you have difficulty, please don't hesitate to contact me.

Assoc. Prof. Indah Juwita Sari, Ph.D
(Web of Science Researcher ID: AAE-6742-2019, h-index =2)(Scopus ID: 57208302163, h-index: 6) Department of Biology Education, Faculty of Teacher Training and Education, Universitas Sultan Ageng Tirtayasa
indah.juwitasari@untirta.ac.id

4. Bukti *Publish*

Biodidaktika
Jurnal Biologi dan Pembelajarannya

HOME | ABOUT | LOGIN | REGISTER | CATEGORIES | SEARCH | CURRENT | ARCHIVES | ANNOUNCEMENTS

Home > Archives > **Vol 21, No 2 (2026)**

Vol 21, No 2 (2026)

DOI: http://dx.doi.org/10.62870/biodidaktika.v21i2

Table of Contents

Articles

ISSN: 2527-4562

QUICK MENU
- Focus & Scope
- Copyright Notice
- Publication Ethics
- Editorial Boards
- Peer Reviewers
- Peer Review Process
- Article Processing Charges & Article Submission Charges
- Publication Frequency
- Author Guidelines
- Online Submission
- Journal Scientific Statement
- Retraction
- Indexing and Archiving
- Screening for Plagiarism
- Contact Us

ARTICLE TEMPLATE

From Thinking to Designing: How Habits of Mind and Perceived Teacher ESD Competence Shape Pre-service Teachers' ESD Instructional Materials

Bambang Ekanara, Ilma Riksa Isfiani

Abstract

Future biology educators face a unique challenge when creating learning modules for Education for Sustainable Development (ESD): they must seamlessly fuse core biological science with broader sustainability values. To understand what drives success in this complex task, we explored how two internal factors—Habits of Mind (HoM) and Perceived Teacher ESD Competency—shape the way pre-service teachers craft their instructional designs. We approached this through an explanatory sequential mixed-methods framework. Initially, we gathered quantitative survey data from 49 prospective teachers in Indonesia. Building on those baseline numbers, we then dove deep into the qualitative experiences of nine selected individuals by analyzing their module documents, reflective journals, and semi-structured interview transcripts. Our statistical modelling showed a strong relationship: together, these cognitive and psychological traits accounted for 64.3% of the differences in module quality ($R^2=0.643$, $p<.001$). Interestingly, the students' own belief in their capabilities, or Perceived Competency ($\beta=0.514$), played a more dominant role than their intellectual dispositions (HoM, $\beta=0.445$). A closer look at the quantitative results uncovered a specific hurdle: the development of instructional content proved to be the weakest link in their module designs ($M=2.80$). The qualitative insights explained why this discrepancy happens. While flexible thinking (HoM) gives teachers the mental framework to plan, they actually need high professional self-efficacy (Perceived Competency) to bravely execute transformative, action-oriented teaching methods. Both datasets ultimately point to a significant interdisciplinary gap. The prospective educators found it exceptionally difficult to naturally weave normative sustainability goals into objective biological facts. To better prepare future educators for ESD, teacher training programs must go beyond standard pedagogy. They need targeted strategies that actively build up the students' cognitive habits, boost their practical self-beliefs, and explicitly teach interdisciplinary content mapping.

Keywords

Education for Sustainable Development, Habits of Mind, Teacher ESD Competence, Instructional Design Skills, Pre-service Biology Teachers, Mixed Methods

Full Text:

PDF

References