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

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**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

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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.,

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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

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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

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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 ($\beta$) 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

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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

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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.

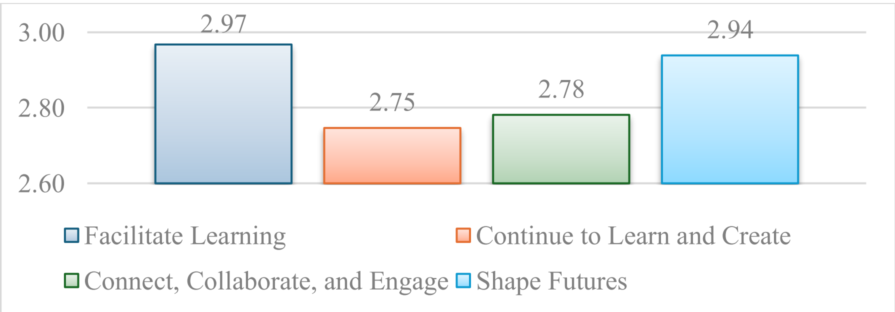


Figure 2. Mean Scores of Perceived Teacher ESD Competency Sub-scales

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

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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).

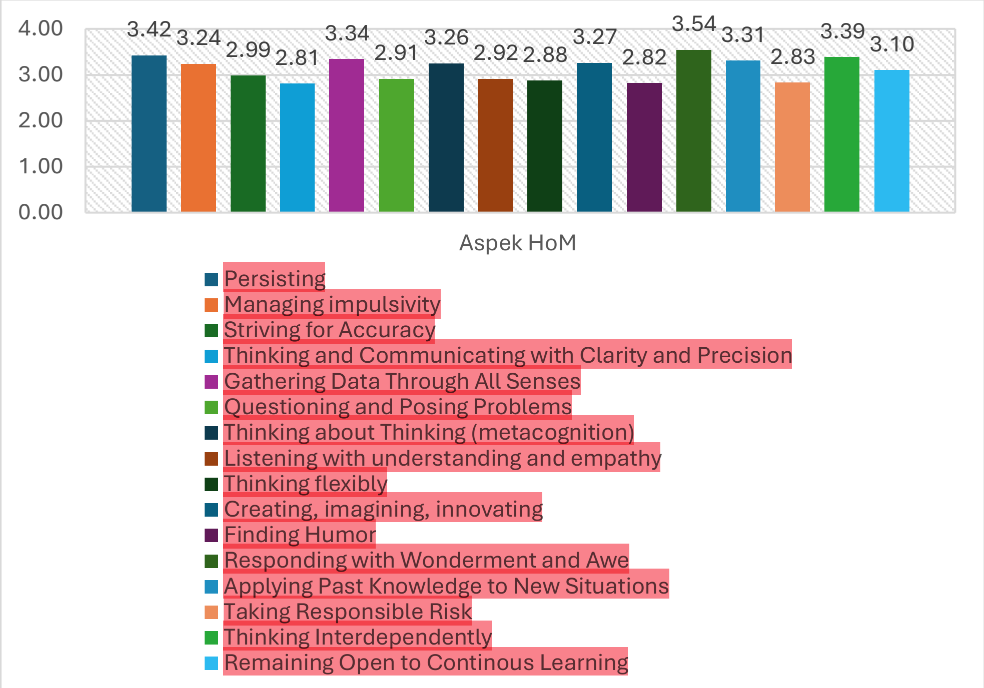


Figure 3. Mean Scores Across the 16 Aspects of Habits of Mind Among Pre-service Biology Teachers.

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

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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).*

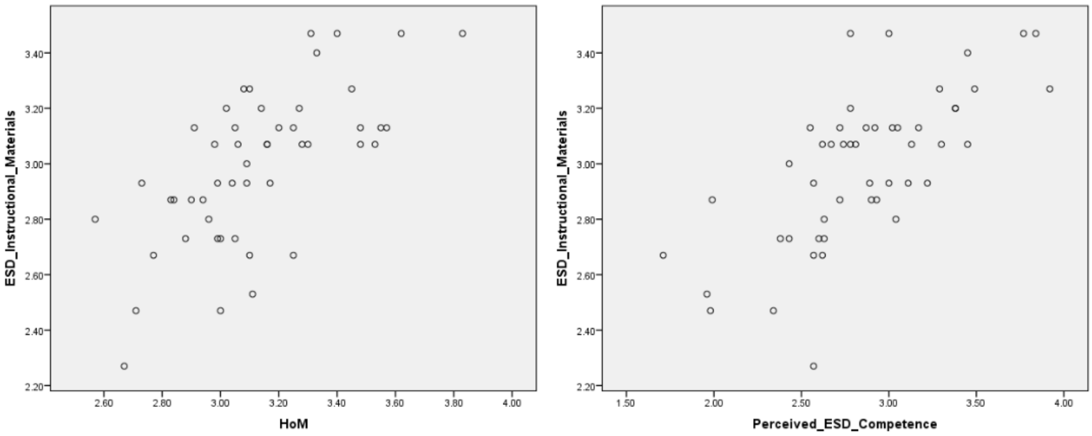


Figure 4. Scatterplot Illustrating the Strong Positive Correlation (R = .802) and the Synergistic Loop Between Internal Determinants and Instructional Design Execution

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.

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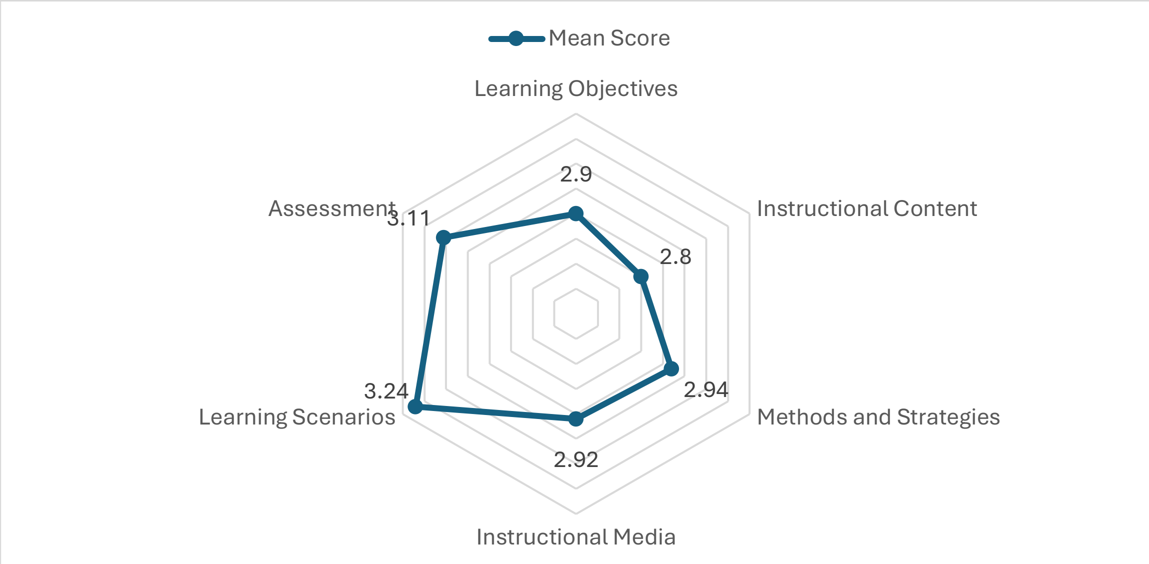


Figure 5. Mean Scores Across the Instructional Design Rubric Components, Highlighting the Deficit in Instructional Content Integration

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.

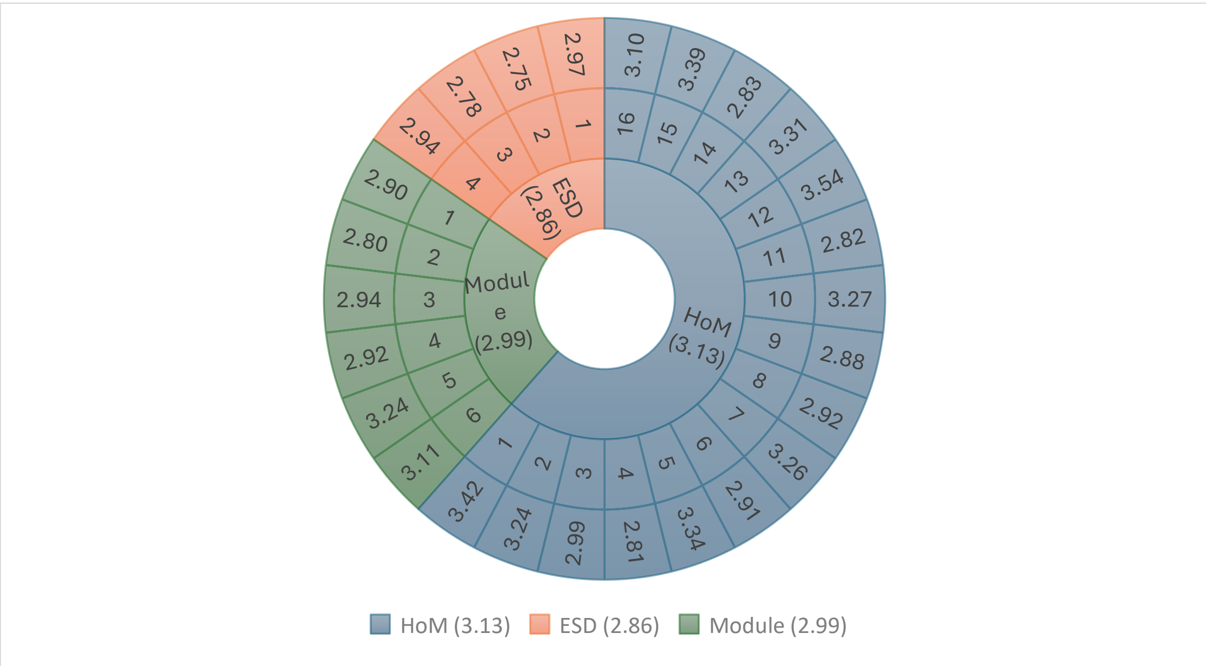


Figure 6. A Comprehensive Overview of Each Aspect of HoM, Teacher ESD Competency, and ESD Instructional Design Skills

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**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:

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*"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).

1

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

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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

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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.

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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:<br><br>Perceived Competency (β=0.514) is a stronger predictor than Habits of Mind (β=0.445) in determining design skills. | Pedagogical Execution:<br><br>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:<br><br>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:<br><br>Strong correlation exists between flexible thinking and overall module quality. | Architect of Integration:<br><br>High achievers restructure biological content to address real-world sustainability problems, whereas low achievers strictly follow linear, textbook-based syllabi. | Navigating Ill-Structured Domains:<br><br>Designing ESD materials is an ill-structured problem that demands epistemic flexibility to shift from delivering isolated facts to facilitating systemic solutions. |
| Metacognitive Regulation:<br><br>Metacognition scores correlate strongly with the competency sub-scale "Continue to Learn and Create." | Quality Control System:<br><br>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:<br><br>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:<br><br>The Instructional Content component received the lowest mean score (M=2.80) across all participants. | The Integration Barrier:<br><br>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:<br><br>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

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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.

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