

Research Article

Multimodal Thinking Spaces: A Qualitative Study of Interactive Science Notebook and Conceptual Understanding in Grade 10 Biology

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Abstract: Interactive science notebooks (ISNs) have gained renewed attention as multimodal spaces where learners record ideas, construct representations, and reflect on their understanding of science concepts. This article investigated how ISNs influence Grade 10 learners' conceptual understanding in a Philippine public secondary school. Drawing on focus group discussion and notebook artifacts from twenty-five (25) students who used an interactive science notebook over four weeks of biology instruction, the study employed narrative-thematic analysis to examine learners' experiences. Four interrelated themes emerged: (1) conceptualizing through arts and crafts, as learners used drawings, foldables, and color-coding to make abstract biological concepts more concrete; (2) systematizing notes leading to mastery, where structured layouts, guidelines, and page organization helped learners track ideas and review efficiently; (3) note-taking and referencing strategies, as students developed personal conventions for summarizing, paraphrasing, and linking new content with prior lessons; and (4) engagement through interactive learning, where the notebook functioned as a personal learning space that sustained attention, enjoyment, and participation during biology lessons. These findings illuminate the mechanisms by which ISNs support conceptual understanding, not only as the conventional notebook, but as cognitive, metacognitive, and affective tools. The article discusses implications for Philippine science teachers seeking to design notebook-based activities that foreground meaning-making, and calls for further research on digital and hybrid notebook formats.

Keywords: interactive science notebook; conceptual understanding; biology education; note-taking; arts integration; student engagement

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1. Introduction

Difficulties in developing robust conceptual understanding in biology remain a persistent concern in secondary science education. Many learners can recall isolated facts but struggle to explain processes such as photosynthesis, homeostasis, or heredity in coherent, connected ways. Recent studies continue to report gaps in students' conceptual understanding alongside improvements in access and curriculum reforms (Constantia et al., 2023). In the Philippine context, results from large-scale assessments and local classroom-based studies suggest that science learning often remains fragmented and heavily textbook-driven, with limited opportunities for learners to externalize and reorganize their thinking (Bouchrika, 2025; Elechicon & Paris, 2024).

Parallel advances in note-taking research reinforce the value of such tools. Contemporary work highlights note-taking as an active, constructive process that supports deeper processing when students summarize, reorganize, and connect ideas instead of merely transcribing content. Deep note-taking strategies such as paraphrasing, diagramming, and linking concepts are associated with better learning outcomes than shallow, verbatim notes. However, students vary widely in their note-taking tendencies and metacognitive skills; many need explicit scaffolding to adopt productive strategies (Salame et al., 2024).

A second strand of recent scholarship underscores the role of arts integration in science learning. Integrating artistic elements – sketching, visual metaphors, creative layouts into science tasks – have been shown to promote creativity, engagement, and more holistic

understanding without compromising conceptual rigour (Namukasa, 2024; Chen et al., 2025). Arts-enhanced science activities help students visualise complex ideas, personalise explanations, and remember content more effectively (Namukasa, 2024; Yunzal et al., 2024). Interactive notebooks, where learners routinely draw, colour-code, and design pages, naturally sit at the intersection of note-taking and arts-integrated pedagogy.

Moreover, studies in science education emphasise the centrality of student engagement, behavioural, cognitive, and emotional – for improved learning outcomes (Chen et al., 2025; Demelash et al., 2024). Interactive and student-centred approaches, including flipped and inquiry-based models, have been shown to raise engagement and conceptual gains in life sciences and chemistry (Chen et al., 2025; Demelash et al., 2024). Yet, little has been known how learners themselves experience engagement when working with ISNs, particularly in resource-constrained public school contexts.

In a prior quasi-experimental report from the same project, Elechicon and Paris (2024) showed that Grade 10 learners exposed to interactive notebook instruction achieved significantly higher gains in conceptual understanding in biology compared with students taught through conventional methods. While these quantitative results establish the effectiveness of ISNs, they do not reveal how learners actually use notebooks to think, feel, and make sense of biology concepts. A few international case studies provide descriptive accounts of notebook use, but qualitative work drawing on learners' voices remains limited, especially in Southeast Asian and Philippine settings.

Furthermore, there is a need for in-depth qualitative evidence that unpacks the mechanisms by which ISNs shape learners' conceptual understanding through arts-based representational work, note-taking practices, and engagement in interactive learning in real classroom contexts. This is particularly important in the Philippines, where teachers are encouraged to adopt learner-centred, multimodal strategies but often lack concrete models grounded in local data. Hence, this article addresses that gap by exploring Grade 10 learners' experiences of using an interactive science notebook in biology.

Specifically, this study aimed to explore how Grade 10 learners experience the use of an interactive science notebook as they develop conceptual understanding in biology. This study was guided by the following questions: (1) How do learners use arts-based elements of the interactive science notebooks to conceptualize biology topics? (2) How do organizational features of the notebook support or hinder learners' efforts to master biology concepts? (3) What note-taking and referencing strategies do learners employ when working with the interactive science notebooks? (4) In what ways does participation in notebook-mediated activities influence learners' engagement?

2. Materials and Methods

This study employed a narrative-thematic design to explore learners' experiences with the interactive science notebook. Following Jaladanki and Bhattacharya's (2014) use of qualitative case studies in science education, narrative accounts from learners were analyzed to identify patterns of meaning related to conceptual understanding, note-taking, and engagement.

Twenty-five (25) Grade 10 learners enrolled in the biology class where the interactive science notebook was implemented participated in the study. Focus group discussions (FGD) were conducted with a purposively selected subgroups of learners representing varied achievement levels and notebook quality, as assessed through their conceptual test scores and notebook checks. Each focus group included 6-8 learners to encourage conversational sharing allowing all participants to speak.

The interactive science notebook used in the study followed a structured yet flexible format adapted from the existing ISN models. Each page was organized into teacher-input and student-output sections. On the input side, learners recorded key ideas, diagrams, and guided notes from teacher explanations, demonstrations, or readings. On the output side, learners created their own representations such as summaries, drawings, analogies, concept maps, question-and-answer pairs, and reflections. The notebook format encouraged arts-integrated elements such as color-coding, foldables, interactive flaps, and creative page layouts. Learners were given guidelines on labelling, dating, and numbering to support systematic organization and easy referencing for review. Notebook tasks were aligned with targeted biology concepts, and students regularly used their notebooks during lessons, seatwork, and review activities.

For the data collections, two main sources were used. Semi-structured FGDs explored

learners' experiences of using the interactive science notebook, including how they designed pages, how the notebook helped or did not help them understand the biology concepts, and how it influenced their motivation and classroom engagement. Aside from the FGD transcripts, learners' notebooks were collected at the end of the intervention and examined for patterns or representation, organizations, and reflective statements that illustrated conceptual understanding. Representative pages were photographed and linked to FGD excerpts to provide contextualized examples of learners' practices.

Data were analyzed following an iterative narrative-thematic procedures. In familiarization stage, transcripts and notebook images were read repeatedly to gain an overall sense of learners' stories and artifact features. In initial stage, meaning units related to how the notebook supported understanding, organization, and engagement were coded inductively. In theme development, codes were clustered into broader themes and subthemes, with attention to how arts-integrated representations, systematic organization, and note-taking practices intersected with conceptual understanding. Lastly, in refinement and triangulation, the themes were refined by constantly comparing FGD transcripts with notebook artifacts. Divergent cases were examined to avoid overly positive portrayal.

Furthermore, the study adhered to institutional guidelines for research involving human participants. Permissions were secured from school authorities and parents/guardians, and assent was obtained from learners before data collection. Learners were informed that participation was voluntary and that pseudonyms would be used in all reports.

3. Results

3.1. *Conceptualizing through Arts and Crafts*

Learners consistently described the interactive notebook as a space where biology concepts became visible through drawings, colour-coding, and creative layouts. In line with recent work on arts integration in science, learners used visual and tactile elements to anchor abstract ideas, treating images and crafted artefacts as parallel representations of formal content rather than mere decoration (Namukasa, 2024; Tupas & Matsuura, 2020). Learners reported that sketching structures and processes in their own style helped them see relationships among parts, echoing findings that multimodal representations in STEAM environments can deepen conceptual connections (Amanova et al., 2025; Fajardo et al., 2019).

Some learners explained that when they drew and decorated their pages, they were not merely making the notebook beautiful; they were re-processing information. A typical comment was that colouring and labelling helped them remember details more clearly during quizzes. These accounts resonate with evidence that elaborative, personally meaningful note-taking and visual representation promote deeper conceptual encoding and better retrieval (Cubio & Yusico, 2025; Salame et al., 2024).

Notebook artifacts supported these narratives. Pages showed carefully designed foldables, layered flaps, and before-and-after diagrams that contrasted misconceptions with scientifically accurate explanations. These arts-based constructs served as cognitive organisers that made it easier for learners to revisit and refine their understanding over time, similar to how interactive science notebooks have been shown to support both achievement and reflective study habits in other science contexts (Elechicon & Paris, 2024; Fajardo et al., 2019; Mollet, 2017).

3.2. *Systematizing Notes Leading to Mastery*

A second theme emphasised the value of systematic organization. Learners highlighted how guidelines on page numbering, consistent headings, and designated spaces for input and output helped them trace lessons across the unit. When preparing for assessments, students relied on this organization to locate topics quickly instead of scanning scattered worksheets or loose handouts, mirroring research that emphasises the role of structured notebooks and journals in improving study efficiency and content mastery (Fajardo et al., 2019; Salame et al., 2024).

Learners also indicated that the repetitive structure of notebook tasks – date, topic, input notes, and output activity helped them develop routines. Over time, they reportedly spent less energy figuring out how to organize notes and more effort thinking about what the content meant. This progression aligns with studies showing that well-structured note-taking environments can reduce extraneous processing and allow learners to invest more cognitive resources in understanding key concepts (Cubio & Yusico, 2025; Salame et al., 2024). In resource-constrained classrooms, such routines may function as low-cost metacognitive

scaffolds that normalize systematic reviewing and self-checking.

In several notebooks, margins were used for side-comments, small self-tests, or arrows linking related ideas across pages. Such features illustrated how systematization supported not just neatness but ongoing monitoring and rehearsal of concepts. Similar margin-based annotations and self-generated prompts have been linked to improved self-regulation and exam preparation in note-taking research, where revisiting and reorganizing one's own notes is associated with deeper learning (Carroll, 2024; Kitjaroonchai et al., 2025; Salame & Thompson, 2020).

3.3. Note-taking and Referencing Strategies

Learners described adopting a range of notebook-based strategies to capture and revisit conceptual content. Rather than copying the whole board or slide, some shared that intentionally summarizing in shorter phrases, using arrows and symbols to show cause-and-effect relationships. Others wrote questions to themselves in one colour and answers in another, effectively turning their notebook into a self-quizzing tool. These patterns reflect what recent work terms “constructive” note-taking including paraphrasing, organizing, and encoding ideas in personally meaningful ways (Cubio & Yusico, 2025; Salame et al., 2024).

These practices align with research emphasizing deep, generative note-taking strategies such as summarizing, questioning, and connecting ideas as predictors of better conceptual learning compared with verbatim transcription (Adhikari, 2025; Salame & Thompson, 2020). Students also described borrowing ideas from peers' notebooks when they missed a lesson or misunderstood an activity, illustrating the external storage function of notes documented in the literature on collaborative and comparative note use (Carroll, 2024; Kitjaroonchai et al., 2025).

Referencing strategies extended beyond individual lessons. Learners explained that they used the table of contents and page numbers to revisit earlier topics when new concepts built on prior ones. In doing so, learners enacted a form of spiral review that supported cumulative conceptual understanding, consistent with findings that repeated, structured revisiting of earlier notes strengthens long-term retention and transfer in science courses (Amanova et al., 2025; Elechicon & Paris, 2024; Fajardo et al., 2019).

3.4. Engagement through Interactive Learning

Finally, learners attributed increased engagement in biology lessons to the interactive nature of science notebook activities. They contrasted just listening and copying with more active episodes of cutting, arranging, colouring, and explaining their own representations to classmates. These accounts echo broader findings that interactive, student-centred environments and flipped-style activities can heighten engagement and learning outcomes in science and health-related disciplines (Baig & Yadegaridehkordi, 2023; Mengesha et al., 2024; Mallaevna, 2025). In particular, hands-on, multimodal tasks have been shown to make abstract content more accessible and enjoyable for secondary learners (Plecis & Cheung, 2025; Fajardo et al., 2019).

Learners described feeling excited when a new notebook activity was announced, noting that such tasks broke the monotony of traditional lectures. Several remarked that the notebook felt like a personalized space where they could express themselves while still focusing on the lesson objective. For some who were initially hesitant to participate verbally in class, the interactive science notebook work offered a quieter mode of contribution that later translated into greater willingness to share. These experiences are consistent with evidence that active and flipped learning environments can enhance student confidence, participation, and sense of ownership over learning (Baig & Yadegaridehkordi, 2023; Rahmatika et al., 2024; van Vliet et al., 2015).

Artifacts showed evidence of this engagement: pages annotated with personal reflections, emojis, or short phrases expressing difficulty and eventual understanding. Such affective traces suggest that ISNs may help sustain emotional investment in science learning, a key component of engagement models and a recognised factor in students' persistence in science courses (van Vliet et al., 2015; Yıldız et al., 2022). Within a self-determination theory lens, personalised pages and visible progress may contribute to learners' experiences of autonomy, competence, and relatedness, which are known to support intrinsic motivation and sustained effort (Deci & Ryan, 2000; Niemiec & Ryan, 2009). Therefore, these findings indicate that ISNs function not only as cognitive tools but also as motivational supports that integrate affective engagement with key self-determination needs, thereby reinforcing students' sustained participation in science learning.

4. Discussion

This qualitative analysis clarifies how interactive science notebooks supported Grade 10 learners' conceptual understanding in biology in four interrelated ways: by enabling arts-based conceptualization, structured organization, strategic note-taking, and sustained engagement. Taken together, the themes point to ISNs not merely as containers of work but as multimodal thinking spaces where learners can externalize, organize, and revisit their ideas about biological phenomena (Elechicon & Paris, 2024; Fajardo et al., 2019).

First, the theme of conceptualizing through arts and crafts supports recent evidence that integrating artistic modalities into science learning fosters creativity, critical thinking, and deeper understanding. Learners' descriptions of drawing, color-coding, and designing foldables as meaning-making tools suggest that ISNs function as sites of multimodal representation rather than mere storage of text (Namukasa, 2024; Tupas & Matsuura, 2020). Their experiences resonate with arguments that arts-integrated science curricula can turn abstract concepts into more memorable packages without diluting scientific rigor, especially when they are grounded in local contexts and resources (Amanova et al., 2025; Tupas & Matsuura, 2020).

Second, systematizing notes leading to mastery underscores the importance of structure in supporting conceptual understanding. Organized page layouts, consistent headings, and page numbering gave students a stable scaffold for encoding and retrieving information, aligning with research that shows the organization and quality of notes, particularly those arranged around key ideas, are associated with better academic performance (Cubio & Yusico, 2025; Salame et al., 2024). For learners who navigate multiple subjects and limited resources, such systematization can act as a practical metacognitive support that helps them manage content load and prepare more efficiently for assessments (Kitjaroonchai et al., 2025).

Third, learners' evolving note-taking and referencing strategies illustrate core principles of constructive note-taking. Learners described moving from copying toward summarizing, questioning, and linking ideas, practices that research associates with deeper processing and stronger conceptual gains in science and other content areas (Adhikari, 2025; Salame & Thompson, 2020). These findings converge with international work on interactive science notebooks that emphasises the notebook as a space where students work on the content through writing and drawing, not just record it (Elechicon & Paris, 2024; Fajardo et al., 2019; Mollet, 2017).

Fourth, engagement through interactive learning highlights the affective and motivational dimensions of ISNs. The notebooks appeared to transform some aspects of biology lessons into more participatory and enjoyable experiences, in line with research on active learning and flipped environments in the life sciences and health professions (Baig & Yadegaridehkordi, 2023; Mengesha et al., 2024; Özbay & Çınar, 2021). Within self-determination theory, such experiences may support learners' needs for autonomy (personalised pages), competence (visible evidence of progress), and relatedness (sharing notebooks with peers), thereby promoting more sustained engagement and persistence in challenging topics (Deci & Ryan, 2000; Niemiec & Ryan, 2009; Ryan & Deci, 2020).

Importantly, these mechanisms are not independent. Arts-based representations are embedded within organized pages; systematic layouts make strategic note-taking and spiral review feasible; and all three feed into learners' engagement. Together, they offer a plausible explanation for the improved conceptual understanding observed in the quantitative strand of the study, where the interactive notebook group outperformed the conventional group (Elechicon & Paris, 2024; Fajardo et al., 2019). In this sense, the qualitative findings provide process-level insights into how ISNs may mediate conceptual gains.

From a Philippine science education perspective, the findings suggest that ISNs can align well with curricula that emphasise learner-centred, contextualized, and multimodal pedagogies. Local scholarship on arts-integrated and contextualized science teaching has highlighted the value of connecting scientific ideas to familiar cultural and environmental resources, such as coastal and marine ecosystems (Tupas & Matsuura, 2020). Interactive notebooks can serve as concrete vehicles for such approaches by allowing learners to document community-based examples, embed locally relevant images, and articulate personal reflections alongside acknowledged biological content. At the same time, the study surfaces practical considerations: notebook implementation requires clear guidelines, time for modelling and feedback, and sensitivity to learners who may initially feel anxious about drawing or decorating, as also noted in broader ISN and active-learning literature (Baig & Yadegaridehkordi, 2023; Wilson, 2015).

The qualitative strand complements the quantitative evidence by showing that interactive notebooks supported not only what students learned but also how they made sense of biology. By foregrounding learners' voices and artifacts, the analysis underscores the potential of ISNs as a low-cost, high-impact strategy for strengthening conceptual understanding in secondary biology, particularly in public school systems where resources are limited but creativity and learner agency can be powerful levers for improvement.

5. Conclusions

This qualitative study shows that interactive science notebooks supported Grade 10 learners' conceptual understanding in biology by providing a personalized, arts-integrated space for representing ideas, a systematic structure for organizing and revisiting content, strategic note-taking opportunities that promoted deeper processing, and an engaging context for active participation in lessons. Taken together, these functions suggest that ISNs can serve as low-cost, high-impact multimodal thinking spaces in resource-constrained public school classrooms.

Aligned with the first research question, the findings indicate that arts-based elements such as drawings, colour-coding, foldables, and creative layouts helped learners make abstract biological processes visible, correct misconceptions, and remember key relationships among concepts. In relation to the second question, systematic organizational features – page numbering, headings, and clear input-output sections enabled students to trace lessons, prepare for assessments efficiently, and develop study routines. The third question was addressed through learners' descriptions of constructive note-taking and referencing strategies, including summarizing, questioning, and spiral review, which are consistent with evidence that deep note-taking supports stronger conceptual gains. Finally, in response to the fourth question, the notebooks were experienced as meaningful spaces that increased enjoyment, confidence, and willingness to participate, thereby strengthening behavioural, cognitive, and emotional engagement in biology.

For classroom practice, these results imply that teachers who wish to adopt ISNs should design notebook tasks that require learners to transform information into their own visual and written representations, provide simple but consistent organizational conventions, and explicitly model productive note-taking and self-review strategies. Purposeful opportunities for sharing notebooks, conducting gallery walks, and writing brief reflections can leverage ISNs as tools for dialogue and formative assessment.

Future studies could extend this work by exploring digital or hybrid notebook formats, examining how ISNs function across different grade levels and science topics, and documenting their use with diverse learners, including those with language or learning difficulties. Longitudinal and mixed-methods designs would help clarify the durability of conceptual gains and the development of notebook-based learning habits beyond an instructional unit.

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