AI-Assisted Workbooks in Basic Education: Enhancing Students' 21st-Century Skills

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ABSTRACT

The growing integration of artificial intelligence (AI) in instructional materials necessitates systematic evaluation of its alignment with 21st-century competencies. This study examined the integration of Critical Thinking, Creativity, Collaboration, and Communication (4Cs) in AI-assisted workbooks developed for Basic Education at Cebu Institute of Technology–University. Anchored in the Partnership for 21st Century Learning framework, the study employed a descriptive qualitative content analysis of selected Elementary and Junior High School workbook activities to determine the extent and depth of skill integration. A structured 4Cs Evaluation Matrix was used to code observable indicators across activities. Findings revealed that Critical Thinking is largely limited to lower-order processes such as recall and procedural tasks, with only emerging evidence of higher-order skills in Junior High School materials. Creativity is evident in language-based and performance tasks, though innovation and technology-integrated activities remain limited. Collaboration is present in group-based tasks but lacks structured roles and sustained interaction. Communication is the most developed competency, particularly in written forms, but shows limited use of multimodal and digital platforms. Overall, results indicate partial and uneven integration of the 4Cs. The study highlights the need for a more systematic and cross-curricular approach to embedding higher-order thinking, innovation, structured collaboration, and multimodal communication in AI-assisted instructional materials.

Keywords: AI-assisted workbooks, 4Cs framework, 21st-century skills, critical thinking, 4Cs framework, Basic education

INTRODUCTION

The rapid transformation of the global labor market necessitates a reexamination of the competencies learners must develop to remain competitive and employable. Automation, artificial intelligence (AI), and the knowledge economy increasingly demand adaptability, higher-order thinking, collaboration, and lifelong learning. Today's learners—Generation Z and Generation Alpha—are digital natives who grow up immersed in technology-rich environments. While technological innovation creates new professional opportunities, it also introduces complex cognitive and ethical challenges. In response, education systems worldwide are prioritizing the structured development of 21st-century competencies aligned with workforce and societal demands.

Grounded in this shift, global competency frameworks consistently highlight the centrality of higher-order skills in education. The Partnership for 21st Century Learning (P21) identifies Critical Thinking, Communication, Collaboration, and Creativity—the "4Cs"—as foundational learning and innovation skills. Similarly, the OECD Learning Framework 2030 emphasizes transformative competencies, including creating new value, reconciling tensions and dilemmas, and taking responsibility. These frameworks underscore that education must extend beyond content mastery toward the cultivation of analytical reasoning, innovation, ethical judgment, and meaningful social interaction.

Among the 4Cs, Critical Thinking involves purposeful, reasoned, and goal-directed thinking characterized by analysis, evaluation, contextualized problem-solving, and reflective judgment. In an era of misinformation and algorithmic automation, critical thinking is widely regarded as a "job-proof" skill that remains uniquely human in its depth of reasoning and ethical discernment (Dumitru & Halpern, 2023). Collaboration and Communication

enable learners to apply critical thinking in social and professional contexts. Effective communication mediates other competencies by allowing individuals to articulate reasoning, negotiate meaning, and achieve shared objectives, while collaboration fosters teamwork, adaptability, and collective problem-solving (Riaz & Din, 2023). Creativity represents the capacity to generate original ideas and innovative solutions and can be cultivated through supportive and technology-enhanced learning environments (Dilekçi & Karatay, 2023).

Developing these competencies requires more than the transmission of disciplinary knowledge. Effective instruction connects content to learners' lived experiences, interests, and real-world challenges. Artificial intelligence (AI) technologies offer new possibilities in this regard by enabling personalized, adaptive, and interactive learning environments. The rapid advancement of generative AI has introduced transformative paradigms in education, allowing educators to design contextualized learning experiences and scaffold higher-order thinking processes (Chun et al., 2025; Pesovski et al., 2024). By leveraging AI-generated recommendations and adaptive systems, educators can tailor instructional materials to individual learning needs, thereby enhancing engagement and learning outcomes.

Recent studies highlight the pedagogical potential of AI-assisted learning environments. For instance, AI-generated instructional materials have been shown to significantly enhance learners' positive-activating emotions, situational interest, and self-efficacy while reducing cognitive load, thereby improving the overall learning experience (Lademann et al., 2025). Similarly, educational chatbots have demonstrated the capacity to engage learners, personalize instruction, and provide insights into learning behaviors, although their effectiveness depends on contextual adaptation and thoughtful instructional design (Kuhail et al., 2023).

AI also plays a critical role in the development of instructional materials. It enables teachers to generate lesson plans, create differentiated content, and design innovative learning tasks efficiently (Qodri et al., 2025). Generative AI platforms, such as ChatGPT and similar systems, have been found to support educators in producing relevant and engaging teaching materials while optimizing time and productivity (Pesovski et al., 2024). However, despite these advantages, challenges remain, particularly in ensuring the accuracy, reliability, and contextual appropriateness of AI-generated content. Studies emphasize that AI outputs often require careful verification and pedagogical refinement by educators to ensure alignment with learning objectives (Qodri et al., 2025).

Moreover, the effective integration of AI in education requires comprehensive teacher training, ethical considerations, and well-defined implementation frameworks. Without these, AI risks being used merely as a tool for efficiency rather than as a means of transforming learning experiences (Kosmas et al., 2025). Thus, while AI holds significant potential to enhance the development of 21st-century competencies, its impact is highly dependent on intentional instructional design and human oversight.

Instructional materials are central to operationalizing these competencies within classroom practice. Workbooks, in particular, structure daily learning tasks, practice opportunities, and formative assessment. Traditional coursebooks, while foundational, often struggle to keep pace with rapidly evolving knowledge domains. AI-assisted workbooks provide a dynamic alternative by generating updated, contextualized, and differentiated content aligned with learners' needs. Through adaptive and data-driven mechanisms, AI-assisted materials can support the development of the 4Cs by embedding inquiry-based, collaborative, and creative learning tasks.

Despite their increasing adoption, empirical evidence regarding the effectiveness of AI-assisted workbooks in fostering the 4Cs remains limited. Existing research suggests that while learners demonstrate competence in digital skills, learning and innovation competencies are less systematically developed (Riaz & Din, 2023; Unsi et al., 2021). Furthermore, the success of AI-assisted materials depends on content authenticity, pedagogical alignment, and ethical considerations, including bias and reliability (Celik et al., 2022; Dei, 2025; Labadze et al., 2023). These findings highlight the need for systematic evaluation of AI-assisted instructional materials to ensure meaningful competency development.

At Cebu Institute of Technology–University (CIT-U), Philippines, Basic Education teachers develop AI-assisted workbooks aligned with the Department of Education curriculum guide. The development process includes instructional planning, AI-generated content creation, teacher revision, and expert validation prior to classroom

implementation. While this initiative represents a promising integration of AI within formal education, its alignment with 21st-century competency frameworks has not been systematically examined.

This study, therefore, addresses a critical research gap by analyzing selected AI-assisted Basic Education workbooks to determine the extent to which the 4Cs are present and integrated within workbook activities. Specifically, it aims to:
(1) examine how 21st-century competencies are embedded within AI-assisted workbook activities;
(2) identify competencies that are underdeveloped or unevenly distributed; and
(3) propose evidence-based pedagogical and design recommendations to enhance systematic 4Cs integration.

By situating AI-assisted instructional materials within established global competency frameworks, this investigation contributes to the growing body of research on AI in education and provides institutional guidance for designing competency-centered, future-ready learning resources.

LITERATURE REVIEW

Recent studies highlight the transformative potential of generative artificial intelligence (AI) in personalizing and enhancing instructional material development across educational contexts. The integration of AI enables the automated generation of learning materials tailored to specific learning outcomes, offering multiple content variations that increase student engagement, motivation, and study time, particularly among learners who struggle with content mastery (Pesovski et al., 2024). Features such as auto-generated assessments further support self-regulated learning and immediate feedback. In basic education settings, AI has also been shown to improve teachers' efficiency and instructional quality by supporting the design of contextually relevant materials, reducing workload, and fostering sustainable technology integration through structured training and mentoring (Diana et al., 2025). Moreover, broader analyses emphasize AI's capacity to generate text and multimedia resources, develop adaptive learning systems, and create intelligent assessment tools, ultimately enhancing the accessibility and effectiveness of education (Zaudinova et al., 2025). Collectively, these findings suggest that AI-driven instructional design not only supports personalized and adaptive learning experiences but also empowers educators to innovate in material development. However, successful implementation depends on teachers' digital readiness, proper training, and thoughtful integration of AI tools within pedagogically sound frameworks.

To deepen the conceptual grounding of this study, the 4Cs framework is examined as an integrated model of cognitive, social, and creative competencies that underpin 21st-century learning. These competencies are not discrete skills but interdependent domains that collectively shape learners' ability to think critically, create meaningfully, collaborate effectively, and communicate purposefully (Thornhill-Miller et al., 2023).

Critical Thinking (CT) is conceptualized as an active and reflective process through which learners construct knowledge by analyzing information, evaluating evidence, and making reasoned judgments. It goes beyond factual recall and emphasizes deep engagement in the learning process (Stanikzai, 2023). Meaningful learning cannot occur without the ability to think critically, as learners must interpret, question, and apply knowledge in diverse contexts.

Instructional strategies such as brainstorming, inquiry-based tasks, and problem-based learning enhance CT by encouraging learners to generate questions, explore alternatives, and construct their own understanding. In contemporary education, CT is particularly essential in navigating complex information environments and addressing real-world problems.

Creativity refers to the capacity to generate original and meaningful ideas, approach problems from multiple perspectives, and produce innovative solutions. It involves imagination, flexibility, and originality, as well as the ability to refine and evaluate ideas (Stanikzai, 2023). Creativity is not limited to artistic expression but extends to all domains of learning where innovation and problem-solving are required.

Educational environments that promote openness, exploration, and idea generation are critical for developing creativity. Techniques such as brainstorming and project-based tasks enable learners to experiment with ideas

and produce creative outputs. Creativity should be embedded across curricula as a fundamental component of learning rather than treated as an isolated skill.

Collaboration is defined as the ability to work effectively with others to achieve shared goals through collective effort, shared responsibility, and mutual decision-making. It is both a competency and a pedagogical strategy that promotes social interaction and cooperative learning (Mugabekazi et al., 2025).

Collaborative learning environments enhance not only social skills but also cognitive development by exposing learners to diverse perspectives and encouraging dialogue. Strategies such as group work, peer-assisted learning, and cooperative tasks foster teamwork and shared accountability. However, effective collaboration requires structured interaction and alignment with learning objectives to ensure meaningful engagement (Sun et al., 2022).

Technological advancements have further expanded collaborative opportunities through digital platforms, virtual environments, and social media, enabling learners to engage in real-time interaction beyond physical classrooms. Emerging approaches such as problem-based learning and inquiry-based learning emphasize collaborative problem-solving and deeper engagement (Liu & Lipowski, 2021).

Communication encompasses the ability to express ideas clearly and effectively through verbal, nonverbal, and digital means. It includes articulating reasoning, engaging in dialogue, listening actively, and adapting messages to different audiences and contexts (Stanikzai, 2023).

In educational settings, communication is developed through activities such as discussions, presentations, debates, and reflective writing. These practices enable learners to articulate their thoughts, justify their ideas, and engage with others constructively. Collaborative environments further strengthen communication by requiring learners to negotiate meaning and provide feedback.

Research highlights that integrating communication across the curriculum, supported by technology and interactive learning approaches, significantly enhances students' communicative competence (Haphasari & Prasetyarini, 2025).

Instructional approaches such as problem-based learning, inquiry-based learning, and collaborative tasks have been shown to effectively develop these competencies in an integrated manner (Liu & Lipowski, 2021; Ye & Xu, 2023). However, research also indicates that the implementation of the 4Cs remains uneven, often limited by insufficient instructional design, lack of alignment with curriculum standards, and inadequate integration in learning materials (Sun et al., 2022).

Empirical studies underscore the effectiveness of structured instructional designs in developing students' 4Cs skills—critical thinking, creativity, collaboration, and communication. Using project-based learning (PjBL), students were found to exceed the 70% competency benchmark across all four domains, with particularly strong performance in collaboration (85.42%) and communication (83.33%), followed by creativity (80.56%) and critical thinking (70.83%), demonstrating the value of systematically designed learning phases such as Compose, Clarify, Comprehend, and Come Together (Somphol et al., 2022). Complementing these findings, evidence from multi-context pilot implementations reveals that communication and critical thinking show the most consistent and significant improvement over time, especially when supported by structured and well-aligned instructional interventions (Romero, 2026). However, creativity appears to be context-dependent, while collaboration emerges as the most vulnerable competency, often stagnating or declining during scaling processes. Collectively, these findings suggest that the development and sustainability of 4Cs skills are not solely dependent on learner ability but are strongly influenced by instructional design, assessment alignment, and the structure of learning activities, highlighting the need for intentional, competency-sensitive approaches in curriculum and instructional material development.

The 4Cs function as an integrated system of competencies essential for holistic learning. Critical thinking provides the foundation for reasoning and analysis; creativity enables innovation and idea generation;

collaboration facilitates shared learning and collective problem-solving; and communication allows for the effective expression and exchange of ideas.

METHODOLOGY

This study employed a qualitative content analysis design to systematically examine AI-assisted workbooks developed for Basic Education. Content analysis is a widely used qualitative research technique. Rather than being a single method, current applications of content analysis show three distinct approaches: conventional, directed, or summative. All three approaches are used to interpret meaning from the content of text data and, hence, adhere to the naturalistic paradigm. The major differences among the approaches are coding schemes, origins of codes, and threats to trustworthiness. In conventional content analysis, coding categories are derived directly from the text data (Hsieh, H.-F., & Shannon, S. E., 2005). Qualitative content analysis enables the structured identification, categorization, and interpretation of patterns within instructional materials.

The analytical framework was anchored on the 4Cs model of 21st-century competencies—Critical Thinking, Creativity, Collaboration, and Communication—which served as the conceptual lens for evaluating skill integration. The primary units of analysis were selected AI-assisted workbooks used in Basic education classes at Cebu Institute of Technology–University (CIT-U), Philippines. These materials were developed by teachers using AI-generated content, subsequently revised and validated prior to classroom implementation.

A purposive sampling strategy was employed to ensure representation across:

1. Multiple subject areas (e.g., English, Mathematics, Science, Araling Panlipunan),
2. Different grade levels, and
3. Varied activity types (individual, collaborative, written, performance-based).

Both teacher-designed prompts and AI-generated instructional content embedded in the workbooks were included in the analysis to capture the complete instructional structure. A structured 4Cs Evaluation Matrix was developed to operationalize each competency into observable and measurable indicators. The matrix served as the primary coding instrument for analyzing workbook activities. Activities were coded according to the criteria summarized in Table 1.

Table 1

4Cs Evaluation Matrices

Competency	Indicators	Description
Critical Thinking	Analysis	Requires learners to analyze information, ideas, or problems rather than recall facts
	Evaluation	Engages learners in judging, justifying, or defending answers or decisions
	Problem Solving	Involves real-world or contextualized problems requiring reasoning
	Reflection	Encourages learners to reflect on learning, strategies, or outcomes
Creativity	Idea Generation	Encourages original ideas or multiple solutions
	Creative Output	Produces original texts, designs, performances, or products
	Innovation	Uses AI or tools in novel or meaningful ways

	Imagination	Encourages imagination, storytelling, or alternative perspectives
Collaboration	Group Work	Requires learners to work in pairs or groups
	Shared Responsibility	Assigns roles or collective outputs
	Peer Interaction	Encourages interaction, negotiation, or peer feedback
	Collaborative Output	Produces a joint product or performance
Communication	Written Expression	Structured written responses beyond short-answer exercises
	Oral Communication	Includes presentations, discussions, or oral explanations
	Audience Awareness	Considers purpose, audience, or context
	Multimodal Communication	Uses visuals, digital tools, or AI-generated media meaningfully

The matrix allowed systematic identification of both the presence and depth of competency integration, including whether AI tools enhanced higher-order engagement.

Data Collection Procedures

Data collection followed a structured process:

1. Compilation of selected AI-assisted workbooks from participating teachers.
2. Organization of workbook activities according to instructional sections.
3. Application of the 4Cs evaluation matrices to each activity.
4. Documentation of coding results in a structured analysis sheet capturing competency category, indicator type, activity format, cognitive level, and AI involvement.

Data Coding and Analysis

Workbook activities were systematically coded and categorized using the 4Cs matrices. The analysis consisted of four complementary components.

Trustworthiness and Rigor

To enhance methodological rigor, the coding framework was reviewed by an independent curriculum expert. Discrepancies were resolved through discussion to achieve consensus. Alignment of indicators with established 4Cs frameworks strengthened conceptual validity and analytic reliability.

RESULTS AND DISCUSSION

Within the Critical Thinking domain, both the Junior High School (JHS) and Elementary AI-Assisted Workbooks demonstrate a strong emphasis on foundational cognitive processes, particularly recall, recognition, and procedural fluency. A significant proportion of activities fall under identification, multiple choice, matching type, and true-or-false formats. These tasks primarily measure content mastery and lower-order thinking skills.

In the JHS workbooks, however, there is a developing integration of higher-order thinking components. Analytical, evaluative, and contextualized problem-solving tasks are evident, particularly in Araling Panlipunan

and selected Mathematics word problems. Despite this progress, reflective thinking and metacognitive engagement remain inconsistently embedded across subjects.

Similarly, in the Elementary workbooks, higher-order skills—such as evaluation, contextualized application, and reflective reasoning—are present but not systematically integrated across grade levels. Overall, Critical Thinking development shows progression but remains predominantly content-centered and procedure-driven, indicating the need for more intentional scaffolding of metacognition and inquiry-based tasks.

Under the Creativity component, the workbooks demonstrate varying degrees of integration across disciplines. In JHS, creativity is strongly manifested in language-based subjects through artistic, literary, and expressive outputs. Idea generation and imagination are particularly evident in narrative writing, literary interpretation, and performance-based activities. However, creativity is unevenly distributed across subject areas. Mathematics and innovation-driven tasks—especially those involving technological or AI applications—are significantly underrepresented. Innovation, as a higher-level creative dimension, remains limited across disciplines, suggesting the need for cross-curricular creativity strategies.

Elementary AI-assisted workbooks strongly embed creative output and imagination across various subjects. Students consistently engage in artistic, narrative, and design-oriented activities that promote expressive and values-driven creativity. Nevertheless, innovation through digital and AI tools remains concentrated in Computer-related subjects, revealing an opportunity to expand technological creativity across the broader curriculum.

Thus, while imagination and creative expression are well represented, innovation and interdisciplinary creativity require stronger and more balanced integration.

In JHS, collaboration is most evident in experiential, laboratory-based, and performance-oriented subjects. Group work is commonly assigned; however, the presence of group tasks does not consistently ensure deep collaboration. Elements such as shared responsibility, structured peer interaction, and collective output are only moderately represented. Collaboration appears activity-based rather than process-oriented, indicating the need for clearer structures that promote interdependence and shared accountability.

In the Elementary workbooks, collaboration is more consistently embedded across subject areas. Performance-based and output-oriented group activities are prevalent, suggesting stronger integration of collaborative learning experiences. However, as with JHS, ensuring that collaboration moves beyond task completion toward meaningful peer engagement remains an area for enhancement. Overall, collaboration is present but would benefit from more intentional design emphasizing co-construction of knowledge and defined collaborative roles.

In the Communication component, both levels show strong development in written communication but varying degrees of integration in other communication modalities.

In JHS, written communication is the most dominant skill across subjects, particularly in Araling Panlipunan, English, Filipino, and Technology and Livelihood Education. Students frequently produce essays, reaction papers, proposals, letters, and analytical responses. Oral communication is present in science discussions, Filipino performances, simulations, and business presentations, but is not consistently embedded across disciplines. Audience awareness is gradually developing, yet multimodal and digitally integrated communication tasks remain underrepresented. This suggests the need to broaden communication practices to include visual, media-based, and technology-supported outputs.

In Elementary workbooks, communication skills are highly embedded. Structured writing tasks extend beyond short responses and require paragraph development, justification of ideas, reflection, and explanation of reasoning. Oral communication is strongly integrated through presentations, recitations, and performance tasks, promoting confidence and interactive engagement. Audience awareness is moderately to highly evident, although explicit instruction in adjusting tone and structure for varied audiences could be further strengthened.

Overall, communication competencies are strongly supported, particularly in literacy development, but multimodal and digital communication integration remains an area for growth.

Overall 4Cs Framework Interpretation

Across both Junior High School and Elementary AI-Assisted Workbooks:

1. Critical Thinking is developing but remains largely anchored in content mastery and procedural tasks.
2. Creativity is strong in expressive domains but uneven in innovation and technological integration.
3. Collaboration is present, particularly in performance-based activities, yet requires deeper structural design for authentic collaborative engagement.
4. Communication is the most strongly embedded competency, particularly in written literacy, though multimodal and digital communication skills need broader integration.

These findings suggest that while the AI-Assisted Workbooks demonstrate meaningful alignment with the 4Cs framework, integration across competencies is uneven and discipline-dependent. A more systematic, cross-curricular design approach would strengthen the holistic development of 21st-century skills.

RECOMMENDATIONS

The findings of this study underscore the necessity for systematic, competency-centered design in AI-assisted Basic Education workbooks. Although elements of Critical Thinking, Creativity, Collaboration, and Communication (4Cs) were present, their integration was not consistently structured or balanced across subjects and grade levels. To strengthen alignment with 21st-century competency frameworks, the following integrated recommendations are proposed.

1. Systematic Embedding of 4Cs in Workbook Design

Develop explicit internal guidelines requiring each instructional unit to intentionally integrate at least two 4Cs competencies at higher-order cognitive levels. This ensures that AI-assisted materials move beyond procedural content reinforcement toward fostering analytical reasoning, creative problem-solving, structured collaboration, and effective communication.

A. Explicit Skill Labeling in Activities

Workbook developers should include a visible **"21st-Century Skill Focus"** label in selected activities. For example:

Skill Focus: Critical Thinking and Communication

Skill Focus: Creativity and Collaboration

Short learner-facing prompts may be embedded to signal cognitive expectations, such as:

"Explain your reasoning."

"Justify your answer using evidence."

"Work with a partner to compare and refine your solutions."

"Present your ideas to a specific audience."
Explicit labeling increases intentionality in instructional design and enhances learner awareness of targeted competencies. When students recognize that a task requires reasoning, collaboration, or creative output, engagement becomes more purposeful.

B. Revising Recall-Based Tasks into Analytical Prompts

Activities that focus primarily on recall or procedural responses should be revised to incorporate higher-order thinking components.

Example Revision:

Instead of: *Define climate change.*

Revise to: *Analyze two causes of climate change and evaluate which has the most significant long-term impact in your community. Justify your answer.*

This transformation embeds analysis, evaluation, contextual problem-solving, and justification—core elements of Critical Thinking. AI-generated content may assist in providing data or scenarios, but teacher-guided prompts ensure depth of reasoning.

C. Enhancing Creativity Through Open-Ended and Multimodal Outputs

To strengthen Creativity, workbooks should incorporate open-ended tasks that encourage idea generation and original production.

Proposed Revisions:

"Design a campaign poster promoting responsible AI use in schools."

"Create a short storyboard showing how this concept applies in real life."

"Generate three alternative solutions to this problem and explain which is most innovative."

AI tools may be used for brainstorming or drafting, but learners should be required to refine, adapt, and justify outputs.

Creativity must extend beyond decorative activities and require imaginative thinking, re-framing of problems, and meaningful innovation. Teacher oversight ensures AI functions as a support tool rather than a substitute for original thought.

D. Expanding Structured Collaboration

Collaboration should be intentionally embedded in at least one major activity per instructional unit.

Proposed Revisions:

- Convert selected individual tasks into group investigations.
- Assign defined roles such as facilitator, researcher, recorder, and presenter.
- Require a collective output rather than parallel individual answers.

Example Prompt:

In groups of four, analyze the case study and propose a solution. Assign roles and prepare a joint presentation defending your group's decision.

Structured collaboration ensures shared responsibility and meaningful interaction. Clear roles and collective outputs prevent superficial grouping and promote negotiation, peer feedback, and accountability.

E. Strengthening Communication Through Audience-Aware Tasks

Communication tasks should extend beyond short written responses to include oral, multimodal, and audience-sensitive outputs.

Proposed Revisions:

“Write a persuasive letter to your school principal proposing this solution.”

“Explain this concept to a Grade 4 learner using simple language.”

“Record a short video reflection discussing what strategy worked best and why.”

Audience-awareness tasks cultivate clarity, purpose, and adaptability in communication. These elements strengthen real-world applicability and align learning with authentic societal contexts.

2. Cross-Disciplinary Mapping and Balanced Competency Distribution

To ensure coherence and balance, curriculum designers should implement cross-disciplinary mapping of the 4Cs across subject areas. This process can:

- Identify competencies that are overrepresented or underdeveloped.
- Ensure more even distribution across English, Mathematics, Science, and Araling

  Panlipunan
- Prevent clustering of higher-order tasks within limited subject areas.
- Guide balanced integration across grade levels.

Alignment with authentic societal contexts, including themes related to the Sustainable Development Goals (SDGs), is also recommended. Embedding real-world challenges—such as environmental sustainability, digital citizenship, or community health—enhances relevance and learner engagement.

3. Institutional 4Cs Integration Checklist

To institutionalize quality assurance, a standardized 4Cs Integration Checklist should be embedded within the workbook development and validation process.

Before finalization:

- Developers verify the presence of at least two targeted competencies per unit.
- Peer reviewers assess balance and cognitive depth.
- Identified gaps are revised before printing or classroom implementation.

This mechanism ensures that competency integration becomes systematic rather than incidental.

4. Teacher Professional Development in AI-Enhanced Instructional Design

The effective implementation of AI-assisted workbooks depends significantly on educators’ pedagogical capacity. The presence of 4Cs in instructional materials does not automatically guarantee meaningful classroom enactment.

Professional development programs should therefore focus on:

- Designing AI-enhanced higher-order questioning,
- Scaffolding metacognitive reflection,
- Facilitating collaborative inquiry,
- Guiding students in refining AI-generated outputs,
- Embedding creativity and innovation in task design.
- Training must emphasize pedagogical intentionality—not merely technological proficiency. Teachers should be equipped to critically evaluate AI-generated content, contextualize tasks, and maintain ethical oversight.

By strengthening teachers' competence in mediating AI-assisted tasks, the transformative potential of AI in education can be more fully realized.

CONCLUSION

The findings of this study reveal that AI-assisted workbooks in both Elementary and Junior High School demonstrate partial alignment with the 4Cs framework, with varying degrees of integration across competencies and subject areas. Critical Thinking is present but remains largely anchored in lower-order cognitive processes, with most activities emphasizing recall, recognition, and procedural fluency. Although higher-order thinking tasks are emerging—particularly in the JHS level—metacognitive and reflective components are not consistently embedded, indicating the need for more intentional scaffolding of inquiry-based and reflective learning.

Creativity is strongly manifested in expressive and language-based activities, especially in writing, performance, and artistic outputs. However, innovation and technology-integrated creativity remain underdeveloped, suggesting that creativity is often limited to traditional forms rather than extended to digital and interdisciplinary applications. Collaboration is evident, particularly in group-based and performance-oriented tasks, yet it is often activity-based rather than process-oriented, lacking clearly defined roles, shared accountability, and structured peer interaction. Communication emerges as the most consistently developed competency, with strong emphasis on written expression; however, multimodal and digitally mediated communication are insufficiently integrated.

These findings imply that while AI-assisted instructional materials provide opportunities for embedding 21st-century skills, their effectiveness depends on intentional, competency-driven design and pedagogical implementation. A more systematic, cross-curricular approach is necessary to ensure balanced development of the 4Cs.

This study is limited by its reliance on content analysis of workbook activities, which does not account for actual classroom implementation or learner outcomes. Additionally, the evaluation is confined to selected workbooks, which may limit generalizability. Future research may explore classroom enactment, teacher mediation, and student performance outcomes to provide a more comprehensive understanding of 4Cs development.

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