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Leveraging Educational Technology to Connect Mathematics, Digital Design, and Entrepreneurship in CLC Students' Souvenir Production

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ABSTRACT

Purpose of the study: This study aims to investigate how mathematics, digital technology, and entrepreneurship are integrated through the digital printing workflow in the production of souvenir keychains by CLC students, with a particular focus on how these activities support the development of creative thinking skills.

Methodology: This research employed a qualitative case study using classroom observations, semi-structured interviews, document analysis, and design file reviews. Canva (web-based design platform), Heat Gun KOVA 2000W, and shrink-film materials were used during production, supported by thematic analysis of learning artifacts and performance documentation.

Main Findings: The findings show that students developed applied mathematical competencies particularly measurement, proportion, and spatial reasoning while engaging in iterative digital design using Canva. Students demonstrated significant growth in digital literacy, creativity, and product refinement, and successfully produced approximately ninety keychains, all of which were sold during an exhibition, indicating emerging entrepreneurial capability.

Novelty/Originality of this study: This study offers originality by demonstrating how a low-cost digital design and fabrication workflow can bridge technological learning gaps in non-formal CLC environments. Unlike prior research conducted in well-resourced settings, this study shows how accessible tools enable learners with limited technological exposure to integrate mathematics, digital production, and entrepreneurship within an authentic, technology-enhanced learning model.

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1. INTRODUCTION

Digital integration has significantly transformed learning approaches in Community Learning Centers (CLCs), which possess unique characteristics requiring contextual pedagogical strategies. CLCs have implemented digital-based adult learning education through cooperative, participatory, and collaborative methods, providing tailored materials and digital exercises to meet learners' specific needs [1]. The COVID-19 pandemic accelerated the shift from face-to-face to online learning using Information, Communication and Technology (ICT), with

CLCs demonstrating flexibility in adapting to these changes [2]-[4]. However, challenges persist as approximately 20% of CLCs continue conventional learning due to inadequate IT equipment and learner preferences for face-to-face instruction [1]. CLCs integrate local values through storytelling, role-playing, and collaborative projects while incorporating digital tools to harmonize tradition with modernity [5]. Technology integration in community learning environments enhances digital literacy and impacts education, health, and occupational growth [6]-[8].

There are challenges in connecting mathematics education with the context of real-world entrepreneurship, particularly in the environment of Community Learning Centers (CLC). Traditional mathematics teaching often fails to relate concepts to students' life experiences, leading to disengagement [9]. To address this, realistic mathematics education approaches incorporating entrepreneurship contexts through traditional markets, malls, and 3D printing technology have been proposed to enhance student interest and problem-solving abilities [10]-[12]. CLCs face substantial obstacles in optimizing entrepreneurship activities, including limited understanding of e-commerce, lack of expertise in creating online stores, insufficient smartphone utilization for marketing, and poor operational skills for digital marketing tools [13]. Similarly, Italian Contamination Labs demonstrate weak adoption of digital technologies beyond basic social media and digital platforms used primarily for promotion and communication purposes [14]. These findings highlight the critical need for enhanced digital technology integration in entrepreneurship education to improve innovation and visual appeal of student products.

The relationship between entrepreneurship education, digital technology integration, and students' creative thinking skills is becoming increasingly clear and relevant in the context of modern learning. Entrepreneurship education positively influences both product innovation and creativity, with creativity serving as a mediator between entrepreneurship education and product innovation outcomes [15]-[17]. This educational approach successfully enhances students' abilities to identify opportunities, solve problems creatively, and adapt to change [18]-[20]. The integration of digital technology and innovation in entrepreneurship education is essential for enhancing entrepreneurial intention and motivation, contributing to technological revolution and economic development [21]-[23]. Teacher creativity plays a crucial role in this process, positively affecting both entrepreneurship education delivery and students' creativity development [24]-[26]. These findings suggest that educational institutions should prioritize entrepreneurship education activities that promote creativity and innovation, particularly through digital technology integration, to optimize students' entrepreneurial potential and creative thinking capabilities.

Recent research has increasingly emphasized the importance of integrating digital technology in entrepreneurship education to enhance students’ innovation capacity, digital literacy, and business readiness. Septiawan’s systematic review highlights that digital entrepreneurship is driven by technological opportunities, flexibility, and access to digital tools, although it is frequently constrained by low digital literacy and infrastructure inequality among learners [27]. Similarly, Udekwe and Iwu [28], report that digital technology strengthens entrepreneurial intention and motivation, yet external barriers such as technological access, experience, and institutional support remain significant challenges. Studies using structural equation modeling also show that digital engagement enhances students’ collaborative skills, creativity, and academic performance, particularly in social entrepreneurship contexts [29], [30]. To respond to the demands of Industry 4.0, entrepreneurship education must therefore cultivate digital competencies, creativity, and problem-solving skills to prepare future digitalpreneurs [29].

However, most existing studies are situated in formal higher education settings and focus on broad constructs such as entrepreneurial intention, digital readiness, or technology adoption. Very few studies examine how digital technology is used by students to create tangible, marketable products, and even fewer integrate mathematical reasoning as part of the production process. While prior work has explored the infusion of entrepreneurship into mathematics learning [21], [31], [32], [32], these studies primarily use classroom tasks, simulations, or teacher-designed interventions rather than authentic product-based experiences.

Furthermore, although CLCs (Community Learning Centers) have been increasingly recognized as flexible and adaptive learning spaces for marginalized communities [1], [2], [5], [8], research rarely explores how mathematics, digital fabrication, and entrepreneurship intersect in these non-formal environments. Existing studies on CLC entrepreneurship highlight difficulties such as limited e-commerce literacy, unfamiliarity with digital marketing, and minimal use of technology beyond simple social media promotion [13], [14]. These limitations indicate that CLC learners need concrete, accessible, technology-supported entrepreneurship activities that build both digital skills and applied mathematical competencies.

This study aims to investigate how the integration of digital technology and mathematical concepts is applied in souvenir-making activities by CLC students. In addition, this study also aims to describe the use of various mathematical concepts by students when they perform digital design as part of the souvenir production process. Furthermore, this study analyzes the development of students' creativity, digital literacy, and entrepreneurial motivation while participating in learning based on the integration of digital design and mathematics. This study also seeks to identify the challenges faced and opportunities that arise in the implementation of this integrative approach in order to provide recommendations for the development of more effective entrepreneurial learning at CLC.

2. RESEARCH METHOD

2.1. Research Design

This study employed a qualitative case study design to investigate how mathematics, digital technology, and entrepreneurship were integrated within a Community Learning Center (CLC). A case study approach enables researchers to analyze a phenomenon in depth and within its real-life context [34], making it suitable for capturing students' authentic learning actions, design decisions, and production processes. Qualitative inquiry further allows for a rich description of participants' experiences and meaning-making [35], [36].

2.2. Participants and Research Context

Participants consisted of CLC students enrolled in a Digital Printing Skills Program and previously recognized in a public skills exhibition. The CLC setting represents a unique non-formal learning environment where students have varied educational backgrounds and limited access to formal STEM instruction. Such contexts are important to examine because they offer flexible learning opportunities and often support marginalized learners [37], [38].

2.3. Research Instruments

Three main instruments were used for data collection: an observation protocol, a semi-structured interview guide, and a document analysis rubric. These instruments were employed in an integrated manner to obtain comprehensive and in-depth data aligned with the objectives of the study. Instrument development followed standard qualitative research guidance emphasizing alignment with research objectives and constructs [39]. An instrument was prepared to maintain systematic alignment among constructs, indicators, and data sources. Such grids are commonly used to strengthen transparency and construct mapping in qualitative instrument design [40].

Table 1. Research Instrument

Construct	Indicators	Data Source / Instrument
Mathematical competencies	Measurement accuracy; proportional reasoning; scaling calculations; geometric manipulation; spatial optimization	Observation sheet; interview guide; design-file analysis
Digital literacy skills	Canva tool use (resize, rotate, align, layer); file management; design iteration	Observation sheet; documentation; screen recordings
Creativity in design	Originality; draft refinement; variation of visual elements; aesthetic coherence	Design analysis rubric; interviews
Entrepreneurial behavior	Cost estimation; material efficiency; layout optimization; pricing decisions; sales data	Observation protocol; interviews; exhibition records
Workflow engagement	Collaboration; problem solving; sequencing of digital and physical tools	Observations; photos and videos

Content validity was evaluated by three experts using the Content Validity Index (CVI) procedure [41]. Experts assessed each item's relevance on a four-point scale. The resulting indices were:

I-CVI range : 0.83–1.00
S-CVI/Ave : 0.93

These scores exceed the recommended thresholds (I-CVI $\geq$ 0.78 and S-CVI $\geq$ 0.90) indicating strong content validity. Items with lower ratings were revised for clarity prior to field implementation, following standard instrument development practices [41].

2.4. Data Collection Procedures

Data collection occurred across several production sessions covering the complete souvenir-making workflow. Observations captured students' learning behaviors, decision-making, and the use of digital and physical tools. Semi-structured interviews were conducted to obtain deeper insights into students' reasoning and reflections. Additional documentation including photos, videos, design drafts, printed templates, and final products was gathered for triangulation, consistent with recommendations for qualitative data richness.

2.5. Data Analysis

Data were analyzed using thematic analysis following Braun and Clarke's six-phase framework [42]. Codes were generated inductively to identify recurring patterns across mathematical reasoning, digital literacy development, creativity, and entrepreneurial actions. Artifacts such as Canva drafts and printed templates were analyzed visually to trace iterative improvements. Triangulation was achieved by comparing observations, interviews, and artifact analysis, while member-checking was conducted with participants to enhance credibility. Reflexive notes were maintained throughout the analysis to strengthen confirmability.

3. RESULTS AND DISCUSSION

3.1. Development of Mathematical Competencies Throughout the Digital Printing Process

The findings show a notable development of students' mathematical competencies as they progressed through the digital printing activities. During the initial sessions, students displayed limited accuracy in determining the dimensions for their digital keychain designs. Several early printouts were either misaligned, disproportionate, or did not match the intended size. Through repeated feedback and hands-on practice, students gradually learned to adjust fixed dimensions for example, a 5 × 5 cm template more accurately within Canva. They routinely verified measurements using rulers, compared printed outputs to the digital canvas, and corrected discrepancies within a margin of 1–2 millimeters.

Students' increasing precision became visible when they started calculating how many keychain templates could fit on a single vinyl sheet. Through observation, students were seen arranging 6 to 8 templates per A4 sheet to minimize waste, demonstrating early optimization strategies. Interviews supported these observations; one student explained, "*Even a slight difference in size will result in an uneven cut. So we always make sure the size matches the template..*"

The students' work with measurements, proportions, and geometric transformations closely aligns with research showing that authentic design-based tasks naturally foster mathematical engagement [32], [33], [43], [44]. Unlike traditional classroom exercises, the measurement activities in this study carried tangible consequences: imprecise measurements led to misaligned prints or wasted materials, while accurate calculations resulted in aesthetically balanced and saleable products [44]. This practical relevance appears to have motivated students to refine their mathematical precision, supporting the argument that mathematics becomes more meaningful when embedded in real production workflows [45]. The improvement in students' ability to determine dimensions, optimize layout configurations, and align printed outputs reflects a shift from procedural to applied mathematical understanding an outcome that aligns with the goals of contextual mathematics education..

3.2. Increasing Digital Technology Mastery Through Iterative Design

Students demonstrated significant growth in their ability to use digital design tools. At the beginning of the program, most students relied on default Canva templates and basic text insertion. However, by the third session, they began exploring advanced features such as layering, background removal, transparency adjustment, and custom color blending. This shift marked the development of more sophisticated digital literacy skills.

Observations revealed that students frequently improved their designs through iterative experimentation. Many created multiple versions of the same keychain in some cases, up to seven iterations where each revision reflected changes in typography, icon placement, color contrast, or proportional resizing. These iterative efforts were facilitated by the accessibility of digital tools, which allowed students to undo mistakes, re-edit elements quickly, and receive instant visual feedback. Interviews further highlighted this process, with students reporting that digital tools made them "*more courageous in trying new designs because the risk of error is very small*".

The finalized design outputs produced using Canva are presented in Figure 1, while documentation capturing CLC students' engagement with the Canva platform during the design process is provided in Figure 2.

Figure 1. Canva design result

Figure 2. Students engaging with digital design tools

Students moved beyond basic template use toward sophisticated manipulations involving layers, color gradients, transparency, and geometric adjustments. This progression mirrors the digital design learning trajectory described in studies of computer-supported creativity, where iterative exploration serves as a vehicle for deeper conceptual understanding [46], [47]. In this context, Canva acted not merely as a tool for visual production but as a medium through which students experimented, evaluated, and refined ideas [48]. The accessibility and flexibility of digital tools reduced fear of failure, allowing students to take creative risks and iterate quickly. The strong improvement in digital literacy revealed in the rubric scores reinforces the proposition that technology-rich learning environments can accelerate design fluency, even among students with limited technological exposure.

3.3. Production Output and Entrepreneurial Engagement

The program produced tangible outcomes not only in digital design but also in physical product creation and entrepreneurial behavior. By the final session, students had successfully produced approximately ninety printed keychains with diverse themes, ranging from school-related identity badges to cartoon motifs and personalized name-based designs. The finished products displayed noticeable improvement in color consistency, edge alignment, and print clarity, suggesting a strong connection between the development of mathematical skills, digital capabilities, and production quality.

Students also actively engaged in entrepreneurial activities, particularly during preparation for the 2025 APKRES exhibition. They practiced determining prices based on material costs, calculating expected profits, and deciding on appropriate packaging. Discussions among students showed increasing awareness of target customers and market preferences. Several students proposed bundling three keychains for a discounted price to increase buyer interest, demonstrating sensitivity to pricing strategies.

The sales performance at the exhibition further reinforced the students' entrepreneurial engagement. Sales records indicated that all keychains were sold, generating a total revenue of RM 323. Bookkeeping notes collected from students displayed correct entries of expenses, revenue, and remaining materials, showing early mastery of basic financial literacy. Examples of final product output should be placed in Figure 3. Documentation of booth activities and student–customer interactions belong in Figure 4.

Figure 3. Samples of finished student keychains

Figure 4. Student booth during APKRES 2025

Through pricing, packaging, and marketing decisions, students demonstrated an understanding of basic economic principles such as cost analysis, revenue generation, and market targeting [49], [50]. This aligns with entrepreneurship education research, which emphasizes that authentic, product-based activities foster opportunity recognition, pricing judgment, and business communication skills [31], [51], [52]. Students' ability to articulate why certain designs might appeal to specific customer groups, and their willingness to adjust prices or product bundles based on observed buyer behavior, indicates a developing sense of entrepreneurial adaptability [53]. The financial outcomes yielding RM 323 in revenue further suggest that the learning experience extended beyond simulation; students directly observed the real-world consequences of their design and production decisions.

3.4. Evolution of Creative Thinking Across Learning Sessions

Throughout the program, students' creative thinking developed visibly as they engaged in increasingly complex design decisions. At first, many relied on simple, existing templates with minimal modification. Over time, they became more willing to experiment with unique compositions, combining geometric shapes, layered textures, gradient backgrounds, and customized icons into more sophisticated visual arrangements.

This growth in creativity was partly driven by students' ability to articulate design problems and propose solutions. For instance, when a print-output color appeared faded, students tested different saturation settings, switched palettes, or adjusted contrast ratios. When designs looked cluttered, students reevaluated spacing, removed redundant elements, or reorganized the layout to improve visual balance. These problem-solving behaviors were noted frequently during observation sessions, where students were heard discussing alternative approaches and offering one another suggestions. Creativity also manifested through collaboration. Peer review became a natural part of the design cycle. Students often called classmates to evaluate their drafts and give feedback. This collaborative dynamic fostered greater confidence and encouraged students to take risks with their designs.

Creativity development emerged as another important outcome. The iterative design cycles, collaborative feedback exchanges, and problem-solving strategies observed during the program align with models of creative thinking that emphasize the interplay between generative and evaluative processes [54]. Students generated ideas through experimentation with digital features and refined those ideas through peer critique and technical adjustments. This study reinforces evidence that creativity is not a spontaneous talent but a skill that emerges through sustained engagement, reflection, and iterative refinement [55], [56]. The visibly improving quality of designs across sessions, supported by both visual artifacts and rubric data, demonstrates how creativity can develop in structured yet flexible learning environments [34], [57].

3.5. Integration of Mathematics, Technology, and Entrepreneurship in a Unified Practice

The final theme illustrates how students' mathematical reasoning, digital literacy, and entrepreneurial skills converged into a unified learning experience. The digital printing process served as a natural environment where these domains interacted continuously. Students used mathematics to set dimensions, apply proportions, and optimize printing layouts. Digital tools provided the technical means to visualize mathematical adjustments and experiment creatively. Entrepreneurship anchored these practices in real-world purpose, motivating students to consider usability, market preferences, and cost efficiency.

Interviews reveal that students developed an integrated understanding of the relationship between precision, design quality, and marketability. One student noted that "*Designs with the right size and bold colors are purchased more quickly*," indicating an awareness of the practical implications of mathematical and technological decisions. This integration was most visible during the exhibition, where students confidently explained their design logic, mathematical adjustments, and production steps while interacting with customers. A process map that visually traces the connection between mathematical planning, digital editing, printing, and sales presentation are shown in Figure 5.

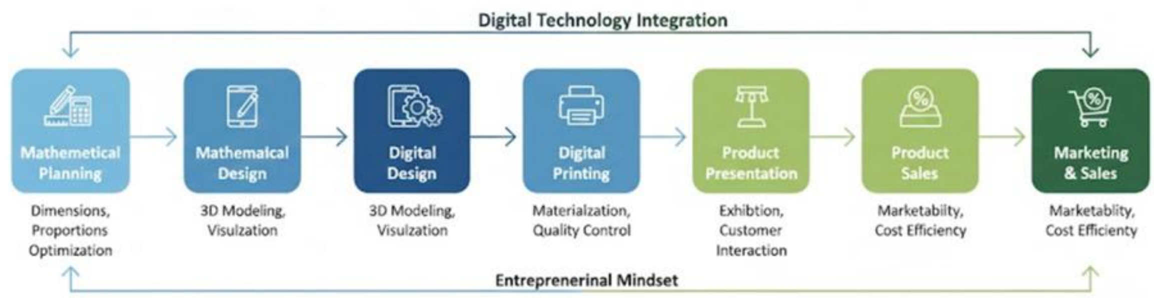

Figure 5. Integrated workflow from mathematics to product marketing

The integration of mathematics, technology, and entrepreneurship into a unified practice—offers an important pedagogical insight. In the context of this program, these three domains did not function as isolated learning objectives. Instead, they interacted organically as students moved between digital design, mathematical adjustment, and market-oriented decision-making. This aligns with integrated STEM and entrepreneurship frameworks, which argue that authentic tasks blur disciplinary boundaries and promote holistic skill development [58], [59]. The students' ability to explain their design measurements, justify color or layout choices, and discuss pricing decisions with exhibition visitors illustrates how knowledge from multiple domains blended seamlessly into a cohesive production process [60], [61]. The workflow observed in this study therefore embodies the kind of transdisciplinary learning environment that many contemporary educational models aim to achieve but rarely implement with such natural coherence.

The findings of this study align with and extend current literature in several important ways. In terms of digital literacy development, the rapid progression of students' abilities in navigating Canva mirrors what Muhajir et al. [62] and Fauziyah et al. [63] have documented regarding the role of iterative digital tasks in strengthening operational and critical digital literacy. However, the present study contributes a distinctive insight: most participants entered the program with very limited prior exposure to digital design tools, yet they demonstrated substantial competence within a relatively short period. This contrasts with existing research conducted predominantly in formal school environments, where baseline digital literacy levels are often higher. The results therefore affirm claims by Zervas and Stiakakis [64] and Vercruyssen et al. [65] that accessible, goal-oriented design tools can accelerate digital skill acquisition, but extend these findings by showing how this process unfolds within a non-formal CLC context.

In relation to mathematics learning, the findings diverge from studies that rely on teacher-designed STEM activities to embed mathematical concepts within project-based learning [66]. In this study, students' mathematical reasoning particularly in measuring, resizing, proportional scaling, and geometric manipulation was not intentionally directed by instructors. Instead, mathematical engagement emerged organically from the constraints of the production process itself, such as precise measurement requirements for shrink-film materials and the need to optimize layout efficiency. This spontaneous emergence of mathematics resonates with the work of Ariati and Aswin [67] and Angraini et al. [68], who argue that informal making environments can activate mathematical and computational thinking. The present study contributes an additional perspective by illustrating that such emergent reasoning can occur even among learners with minimal formal mathematical reinforcement when the learning task is anchored in authentic production goals.

The findings related to entrepreneurship likewise expand the existing literature. While previous studies often emphasize entrepreneurial intention, mindset, or perception [21], the present research documents actual economic outcomes through the successful sale of approximately ninety keychains. This provides concrete evidence of entrepreneurial competence manifested through real revenue-generating activity, aligning with [69] argument that authentic tasks and real-world transactions are essential for developing entrepreneurial awareness. Moreover, the integration of pricing strategies, cost calculations, and market appeal decisions within the production workflow demonstrates that entrepreneurial thinking in this context was not an abstract concept but an applied, iterative practice. This extends prior frameworks by showing how entrepreneurship can be meaningfully cultivated within non-formal learning environments such as CLCs, where traditional business education structures are typically absent.

The implications of these findings are significant for educational technology, mathematics education, and entrepreneurship education. From an educational technology perspective, the results illustrate how low-cost digital tools like Canva can serve as powerful entry points for novice learners, requiring minimal prerequisite knowledge while enabling high levels of creativity and precision. This supports broader discussions about democratizing access to digital creation tools and positions CLCs as viable sites for digital empowerment. In terms of mathematics education, the study demonstrates that authentic making experiences can elicit meaningful mathematical engagement without explicit instructional prompts. The production of digital souvenirs required students to employ measurement, proportion, and spatial reasoning in ways that were purposeful and contextually grounded, reinforcing literature on situated and embodied mathematical thinking [70]. For entrepreneurship education, the study suggests that product-based learning in a real marketplace setting can cultivate financial literacy, pricing strategies, and consumer awareness more effectively than simulated classroom tasks. Students' engagement with real customers and real sales provided an experiential foundation for understanding economic decision-making.

Taken together, these findings highlight the novelty of the present study. Unlike existing research that tends to address mathematics, digital literacy, or entrepreneurship in isolation, this investigation provides a holistic, process-oriented account of how these domains intersect throughout a complete design-to-market production cycle. The unique context of a non-formal CLC further distinguishes the study, offering insights into how integrated learning can occur among learners with diverse educational backgrounds and limited technological access. Moreover, the study contributes new empirical evidence showing that a simple, low-cost digital printing project can simultaneously foster mathematical precision, digital creativity, and entrepreneurial agency. Such organic integration represents a meaningful addition to the literature on transdisciplinary learning environments, demonstrating a model that is not only pedagogically effective but also feasible for communities with limited resources.

This study was conducted within a single CLC and involved a relatively small group of students, which limits the transferability of its findings to broader contexts. The qualitative case study design emphasizes depth rather than generalizability, and the absence of quantitative measures means that learning gains in mathematics, digital literacy, and entrepreneurship cannot be statistically verified. Although triangulation and member checking were employed, the interpretations remain subject to researcher perspectives, and the availability of digital tools in this particular setting may not reflect the realities of other low-resource environments.

Furthermore, the entrepreneurial outcomes observed particularly the successful sale of student products were shaped by the specific conditions of the exhibition and may not represent consistent market patterns. The project's dependence on certain materials and technologies also raises questions about scalability. Future research should explore multi-site implementations, incorporate mixed-methods evaluations, and examine long-term impacts to determine whether the competencies developed through this integrative approach are sustainable across varied CLC contexts.

4. CONCLUSION

This study examined how mathematics, digital technology, and entrepreneurship can be meaningfully integrated within a non-formal Community Learning Center through the production of digital souvenir keychains. The findings demonstrate that students engaged in authentic mathematical reasoning—particularly measurement, proportional scaling, and spatial optimization—while navigating iterative digital design processes using Canva. At the same time, students developed functional digital literacy, creative design capabilities, and practical entrepreneurial skills as they priced, produced, and successfully sold their products during a public exhibition. These outcomes illustrate that a simple, low-cost digital printing project can foster multidimensional learning that is relevant for the needs of 21st-century learners, especially those in non-formal and resource-limited environments. The study also highlights the pedagogical value of authentic, product-based learning experiences in promoting integrated competencies. Rather than being taught explicitly, students encountered mathematics, technology, and entrepreneurship organically as interdependent elements of a coherent workflow. The seamless alignment between design iteration, mathematical adjustment, and market-oriented decision-making underscores the potential of transdisciplinary learning models in CLC settings, where flexibility and contextual relevance are essential. By providing learners with real production goals and visible outcomes, the program enabled them to develop agency, creativity, and problem-solving abilities that extend beyond the boundaries of formal subject instruction. Future studies could adopt mixed-methods or longitudinal designs to measure shifts in mathematical understanding, digital literacy, and entrepreneurial competence over time. Multi-site research across different CLCs or community centers would allow comparisons of contextual factors that support or hinder integrated learning. It would also be valuable to investigate how similar digital production models could incorporate more advanced mathematical concepts such as geometric transformations, optimization strategies, or vector-based design to deepen STEM integration. Finally, partnerships with local industries or digital printing businesses may provide opportunities to explore how community-based collaborations enhance learners' authentic engagement, product innovation, and long-term entrepreneurial development.

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USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declare that no artificial intelligence (AI)-assisted technologies were used in the preparation, analysis, or writing of this manuscript. All stages of the research process, including data collection, data analysis, interpretation of results, and manuscript preparation, were conducted entirely by the authors without the assistance of any AI-based tools.

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