Empowering Creative Learning Through Visual Arts Integration in Steam Via Project-Based Learning: A Case Study in Sabah Secondary Schools

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ABSTRACT

The integration of visual arts into the traditional STEM framework, thereby transforming it into STEAM, has emerged as a significant pedagogical innovation aimed at fostering holistic, future-ready learners. This study examines the effectiveness of incorporating visual arts within a STEAM framework through Project-Based Learning (PBL) in selected secondary schools in Sabah, Malaysia. Employing a qualitative case study design, the research involved 30 students and five subject teachers from a rural secondary school. Data were collected through interviews, classroom observations and student project analyses. The findings revealed four key outcomes: enhanced creativity, improved problem-solving skills, increased student engagement and collaboration and heightened interest in STEM subjects. These results underscore the transformative potential of arts-integrated STEAM education in rural contexts, highlighting both pedagogical benefits and systemic challenges. The study concludes with policy recommendations for wider implementation and emphasizes the need for sustained teacher training and curriculum flexibility to support interdisciplinary learning.

Keywords: STEAM, Visual Arts, Project-Based Learning, Creativity, Rural Education, Secondary Schools, Sabah

INTRODUCTION

In the 21st-century educational landscape, there is growing consensus that conventional approaches to Science, Technology, Engineering and Mathematics (STEM) are insufficient for preparing students to navigate the complexities of modern life and the demands of the future workforce. As the global economy shifts toward creativity, innovation and interdisciplinary thinking, educators and policymakers are increasingly adopting the STEAM framework an educational model that integrates the Arts into traditional STEM disciplines. The "A" in STEAM, particularly the visual arts, serves not merely as an aesthetic addition but as a cognitive tool that nurtures creativity, self-expression and critical inquiry. As highlighted by Buruntong and Kindoyop (2023), the integration of visual arts into STEAM education not only enriches the learning experience but also fosters the development of innovative thinkers capable of addressing complex, real-world challenges.

In Malaysia, the implementation of STEAM is still evolving, especially in rural and under-resourced regions such as Sabah. These areas face various educational challenges, including limited access to teaching materials, a shortage of trained educators and minimal exposure to innovative pedagogical approaches. Despite these obstacles, rural schools hold great potential for educational transformation, provided that interventions are contextually relevant and pedagogically sound.

As noted by Talib et al. (2019), STEAM implementation in Malaysia remains in its early stages and lacks sufficient empirical

Data particularly regarding instructional strategies aligned with the new curriculum. This underscores the urgent need for enhanced teacher preparation and ongoing support, especially in less-developed areas, to enable meaningful and effective STEAM education that fosters student engagement and innovation.

Project-Based Learning (PBL) has proven to be an effective approach for delivering STEAM education, particularly in fostering student autonomy, collaborative inquiry and real-world problem-solving. PBL engages students in extended, meaningful tasks that require the application of interdisciplinary knowledge to create tangible outcomes (Baruah, J., Burch, G., & Burch, J., 2022). When visual arts are incorporated into such projects, students are encouraged not only to think critically but also to express their understanding in creative and personal ways.

As Hawari and Mohd Noor (2020) emphasize, PBL in a multidisciplinary art classroom promotes long-term learning and student-centered engagement while also enhancing communication, soft skills, leadership and creativity. Their findings indicate that the artistic process embedded in STEAM projects supports students through collaboration, exploration of real-world issues and critical reflection thus making learning experiences more impactful and meaningful.

This study is situated within the context of secondary education in Sabah and investigates the integration of visual arts into STEAM through PBL. The primary objective is to assess whether this integration improves student learning outcomes, particularly in the areas of creativity, engagement, problem-solving and attitudes toward STEM subjects. The research is guided by the following key questions:

1. How does integrating visual arts into STEAM via PBL affect students' creative thinking?
2. What are the impacts of this integration on students' problem-solving and collaboration skills?
3. Does the integration of visual arts influence students' attitudes toward and engagement in STEM learning?

This study contributes to the discourse on arts-integrated pedagogy by offering empirical evidence from a marginalized educational context. By focusing on Sabah a region often underrepresented in national educational research this work provides a nuanced understanding of how creative integration can foster transformative learning, even within resource-constrained environments.

LITERATURE REVIEW

The intersection of arts and STEM disciplines has gained significant scholarly attention over the past decade, catalyzing the development of the STEAM (Science, Technology, Engineering, Arts, Mathematics) educational paradigm. Rooted in constructivist and sociocultural theories of learning (Bonk & Reynolds, 1997; Buruntong, 2025), STEAM posits that integrating artistic modalities particularly visual arts enhances students' capacity for holistic thinking, empathy and creativity, thereby enabling deeper engagement with scientific concepts. This literature review synthesizes existing research across three interrelated domains, the pedagogical value of visual arts in STEM education, the effectiveness of Project-Based Learning (PBL) as a delivery model for STEAM and the relevance of these approaches in rural or underserved educational contexts.

Visual Arts in STEM Education

Visual arts are increasingly recognized not only for their aesthetic contributions but also for their capacity to foster cognitive flexibility, visualization skills and metaphorical thinking all of which are key attributes in scientific inquiry. Arts-integrated learning encourages students to interpret STEM content through various modalities such as drawing, sculpting and design, thereby accommodating diverse learning styles. As Bahrum, Wahid and Ibrahim (2017) explain, integrating visual arts into STEM transforms it into STEAM, enabling students to engage both hemispheres of the brain. This dual engagement enhances creativity, critical thinking, collaboration and problem-solving skills, ultimately making students more holistic and active participants in the learning process.

Research by Ayob et al. (2017) indicates that students who engage in arts-enriched STEM tasks demonstrate higher retention rates and improved conceptual understanding. In a study involving young children in Malaysia, it was found that STEAM project-based learning significantly enhanced their ability to inquire, explore, invent and reflect with particular strengths observed in invention and reflection. The arts provide students with tools to represent and process abstract STEM concepts through personal and cultural lenses, making learning more accessible and meaningful. Teachers also reported that children showed strong motivation and enthusiasm for STEAM activities, suggesting that early integration of the arts fosters deeper engagement and sustained interest in learning (Kashaka, Nyiramukama, & Extension, 2024).

Project-Based Learning as a STEAM Pedagogical Strategy

Project-Based Learning (PBL) aligns naturally with the STEAM framework, as it emphasizes active learning, real-world relevance and student autonomy. According to Hawari and Mohd Noor (2020), PBL supports interdisciplinary and student-centered art activities that enhance communication, soft skills, creativity and leadership. Their findings suggest that the artistic processes embedded within PBL-based STEAM projects help students navigate both analytical and creative domains, thereby strengthening their metacognitive abilities. Additional studies have highlighted how integrating visual arts into PBL provides authentic contexts for problem-solving and fosters collaboration and communication skills that are critical in both scientific and artistic communities (Chang et al., 2023).

Relevance in Rural and Underserved Contexts

Despite the documented benefits of STEAM education, its implementation in rural or resource-constrained settings remains limited. Schools in these areas often lack access to specialized arts educators, materials and interdisciplinary curricula. However, studies by Buruntong and Kindoyop (2023) suggest that when appropriately adapted to context, STEAM education can address systemic inequities by leveraging local culture and community knowledge. Their research shows that in Sabah where indigenous traditions and visual storytelling are deeply rooted the integration of visual arts through PBL enhances creativity and higher-order thinking among students.

This integration not only aids in understanding complex STEAM concepts but also aligns with the local socio-cultural context, making learning more meaningful and inclusive. Research by Sheik Dawood and Talib (2023) emphasizes the need for Malaysian education policies to recognize the transformative potential of STEAM, especially through community-driven and arts-inclusive strategies. Their analysis argues that successful implementation depends not only on curricular design but also on active involvement from local communities, creative industries and culturally relevant art practices.

See Too and Ng (2022) assert that for STEAM education to be implemented effectively, stakeholders must prioritize the development of diverse educational materials and promote collaboration among interdisciplinary educators. This collaborative model not only fosters innovation within teaching communities but also ensures that STEAM education becomes more inclusive, sustainable and impactful for Malaysia's diverse student population.

Gaps in the Literature

Although current literature supports integrating the arts into STEM through PBL, there is still a lack of empirical research focusing on rural Malaysian contexts particularly in Sabah. Much of the existing STEAM related research centers on urban or technologically advanced environments, which overlooks the unique challenges and opportunities faced by educators and students in rural regions. As noted by Buruntong et al. (2025), current STEAM practices in Malaysia rarely reflect the specific socio-cultural dynamics of rural communities. Their development of the ARTSCreaSTEAM LAB module seeks to address this gap by offering a culturally responsive and contextually grounded model of visual arts-based STEAM learning designed for students in rural Sabah. This study builds upon that foundation by presenting a case study that explores the intersection of visual arts, STEM and PBL within a culturally and economically diverse educational setting.

Theoretical Framework

This study is grounded in Lev Vygotsky's (1978) sociocultural theory of learning, which posits that knowledge is constructed through social interaction and guided support. Central to Vygotsky's framework is the concept of the Zone of Proximal Development (ZPD), which refers to the range of tasks a learner can perform with the assistance of a more knowledgeable other, such as a teacher or peer. Within this zone, learning is most effective when scaffolded that is, when support is provided to bridge the gap between what students can do independently and what they can achieve with guidance (Bonk & Reynolds, 1997).

This theory aligns closely with the Project-Based Learning (PBL) approach employed in the STEAM activities of this study. In a PBL environment, students engage in collaborative tasks that require inquiry, experimentation and iterative problem-solving processes that are enhanced when scaffolded appropriately by educators or peers. The social and interactive nature of PBL reflects Vygotsky's notion of learning as a mediated process, in which dialogue and collaboration play essential roles in cognitive development.

Therefore, Vygotsky's theoretical lens provides a foundation for understanding how the integration of visual arts within a STEAM framework, delivered through PBL, can support deeper cognitive engagement, skill development and personal growth among learners.

Conceptual Framework

The conceptual framework of this study illustrates how the integration of visual arts into STEAM through Project-Based Learning (PBL) enhances student learning outcomes, based on Vygotsky's sociocultural theory. The framework consists of four core components:

1. Inputs:

- Visual arts tools and techniques (e.g., drawing, modeling, designing)
- STEAM curriculum elements (Science, Technology, Engineering, Arts, Mathematics)
- Project-Based Learning pedagogy that emphasizes inquiry and collaboration

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2. Processes:

- Design and implementation of interdisciplinary STEAM projects
- Collaborative learning and guided support within the Zone of Proximal Development
- Artistic expression of scientific understanding through hands-on creation

⬇

3. Outputs (Student Learning Outcomes):

- Enhanced creativity and visual thinking skills
- Greater engagement and intrinsic motivation
- Improved critical thinking and problem-solving abilities
- More positive attitudes toward STEM subjects

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4. Moderating Factors:

- Teacher's ability to scaffold learning effectively
- Availability of resources and infrastructure
- Cultural relevance and alignment with local learning contexts

Figure 1 : Conceptual Framework Illustrating the Cyclical and Interactive Nature of Learning through Visual Arts Integration in STEAM via Project-Based Learning

Figure 1 illustrates a framework that reflects a cyclical and interactive model of learning. Grounded in Vygotsky's sociocultural theory, the model emphasizes that learning is most effective when it is socially mediated and contextually scaffolded. The integration of visual arts into STEAM through Project-Based Learning (PBL) activates this model by offering meaningful, supported and collaborative learning experiences that foster transformative educational outcomes.

METHODOLOGY

Research Design

This study adopts a qualitative case study design to examine the pedagogical impact of integrating visual arts into STEAM education through Project-Based Learning (PBL) in a rural secondary school in Sabah, Malaysia. A qualitative approach was deemed appropriate due to the exploratory nature of the research, the need for contextual depth and the aim to capture the lived experiences of both students and teachers engaged in arts-integrated STEAM learning (Yanto, 2023).

Research Context and Participants

The study was conducted in a government-funded secondary school located in a semi-rural district of Sabah, characterized by limited access to educational technology and specialized arts instruction. The school was selected based on its participation in a national pilot initiative promoting interdisciplinary STEAM projects. Thirty Form Two students (aged 13–14) and five teachers (representing Science, Mathematics and Visual Arts subjects) participated in the study. Participants were selected through purposive sampling to ensure active involvement in the STEAM-PBL initiative and the ability to provide rich, relevant insights.

Research Procedures

The study was structured over a 10-week intervention period during which students worked in small groups to complete a series of interdisciplinary projects. Each project required the integration of scientific principles (e.g., energy transformation, ecosystem modeling) with visual arts techniques (e.g., sculpture, painting, mixed media). Teachers collaboratively designed these projects to align with the national curriculum while fostering creativity and problem-solving.

The researcher maintained a non-intrusive observational role and employed multiple data sources to ensure triangulation. All procedures adhered to ethical research standards, including informed consent, confidentiality and participants' right to withdraw without consequence.

Data Collection Methods

Three primary data collection methods were employed:

1. Semi-Structured Interviews: Conducted with both students and teachers to elicit their perceptions, experiences and reflections on the STEAM-PBL process. Interview guides explored themes such as creativity, engagement, interdisciplinary learning and pedagogical challenges. Sessions were audio-recorded, transcribed verbatim and analyzed thematically.

2. Participant Observation: In-situ classroom observations were conducted during project work, focusing on student interactions, problem-solving behaviors and artistic expression. Detailed field notes were compiled, emphasizing behaviors indicative of engagement, innovation and collaboration.

3. Document Analysis: Students' final project artefacts, reflective journals and assessment rubrics were examined to assess scientific understanding, artistic execution and integrative thinking. Teachers' lesson plans and assessment records were also analyzed for alignment with STEAM and PBL principles.

Data Analysis

All qualitative data were analyzed using thematic analysis based on Braun and Clarke's (2006) six-phase framework: familiarization, generating initial codes, searching for themes, reviewing themes, defining and

naming themes and producing the report. Coding was both inductive and deductive, guided by the study's conceptual framework. NVivo software facilitated data organization and theme development.

To ensure trustworthiness, the study implemented several strategies: member checking to verify transcript accuracy, peer debriefing with fellow educators and maintenance of an audit trail documenting analytic decisions. Triangulation across data sources further strengthened the credibility and robustness of the findings.

RESULTS

The analysis of interview transcripts, classroom observations and student artefacts revealed four interrelated themes that illustrate the educational impact of integrating visual arts into STEAM through Project-Based Learning (PBL). These themes are: (1) enhanced creativity and imaginative expression, (2) development of problem-solving and design thinking skills, (3) increased student engagement and collaborative learning and (4) improved attitudes toward STEM subjects. Each theme is elaborated below with supporting evidence from the data.

Enhanced Creativity and Imaginative Expression

A prominent theme emerging from the data was the notable enhancement of students' creative abilities when visual arts were embedded in the learning process. Students reported feeling empowered to think beyond standard textbook responses, using artistic media to reinterpret and represent scientific concepts (Kong, 2021). One student reflected, "I never thought I could show what I know in Science by painting. It made the topic easier and more fun." This sentiment was echoed in multiple interviews, particularly among students who typically struggled with abstract scientific content.

Figure 2 presents Student Created 3D Respiratory System Model in a STEAM-PBL Project. The model incorporates visual arts elements such as color, form and symbolism to represent biological structures and airflow. This artefact illustrates students' ability to express scientific understanding through creative visual representation.

Figure 2 : Student Created 3D Respiratory System Model in a STEAM-PBL Project

Classroom observations further reinforced this theme. During a project on energy sources, students utilized recycled materials to construct functional models of solar panels and wind turbines, incorporating visual design elements to represent energy flow processes. These artefacts demonstrated not only scientific accuracy but also strong aesthetic judgment, including symmetry, color harmony and thematic symbolism, which enhanced their conceptual clarity.

Figure 3 illustrates students collaboratively engaged in hands-on design and prototyping during a STEAM-PBL energy project. The activity involved assembling recycled materials and electronic components to model renewable energy systems. This stage of the project allowed students to apply design thinking principles iterating, evaluating and constructing in real-time. Their collaborative effort exemplifies the integration of artistic creativity with scientific functionality.

Figure 3 : Students Collaboratively Engaged in Hands-On Design and Prototyping during a STEAM-PBL Energy Project

Teachers reported a noticeable improvement in students' ability to visualize and articulate scientific phenomena. A Visual Arts teacher observed, "They are making connections I haven't seen before between colors, systems and meaning. Their designs tell stories about science that a quiz never could." This observation suggests that visual arts function as a powerful cognitive bridge, enabling students to transform abstract scientific concepts into personalized and expressive representations (Morari, 2023).

Figure 4 showcases a student's artistic depiction of environmental and atmospheric transformation through expressive colour gradients and symbolic elements. The sky transitions seamlessly from warm hues such as red, orange and yellow to cooler shades of purple and pink, symbolising the natural shift in atmospheric energy from day to dusk. Positioned at the centre is a lighthouse, radiating outward light to represent stability, guidance and the directional flow of energy amid changing environmental conditions. The surrounding mountains and the small boat on the sea introduce a narrative of human exploration within a dynamic natural world. The luminous reflection on the water further reinforces the connection between light, energy and movement. This artwork exemplifies how visual arts can serve as a powerful medium for students to express complex scientific themes such as energy flow and atmospheric dynamics through emotionally resonant and symbolically rich imagery.

Figure 4 : Visual Interpretation of Atmospheric Transformation and Guided Energy through Colour Symbolism

Development of Problem-Solving and Design Thinking Skills

Students demonstrated significant growth in problem-solving and design thinking through iterative project development and collaborative troubleshooting. As the projects required the integration of both scientific principles and artistic techniques, students were challenged to make informed decisions regarding material selection, structural stability and visual coherence.

For example, in a project simulating water filtration systems, student groups were tasked with designing models that combined both functional performance and aesthetic appeal. When initial prototypes failed to filter

effectively, students collaboratively tested alternative configurations, revised their models and documented their modifications. These cycles of trial, error and refinement reflect the key principles of design thinking a problem-solving approach that emphasizes iteration, prototyping and creativity (Kementerian Pendidikan Malaysia, 2013).

Figure 5 illustrates students engaged in collaborative problem-solving and design prototyping during a STEAM-PBL water filtration project. The group is shown constructing and refining a vertical filtration model using recycled materials such as cardboard and transparent containers. Students applied scientific understanding and aesthetic judgment to make decisions related to structural integrity, material layering and visual presentation. This moment captures a critical iterative phase in their project development, highlighting teamwork, creative reconfiguration and the pursuit of both functional effectiveness and visual appeal (Buruntong & Kindoyop, 2024).

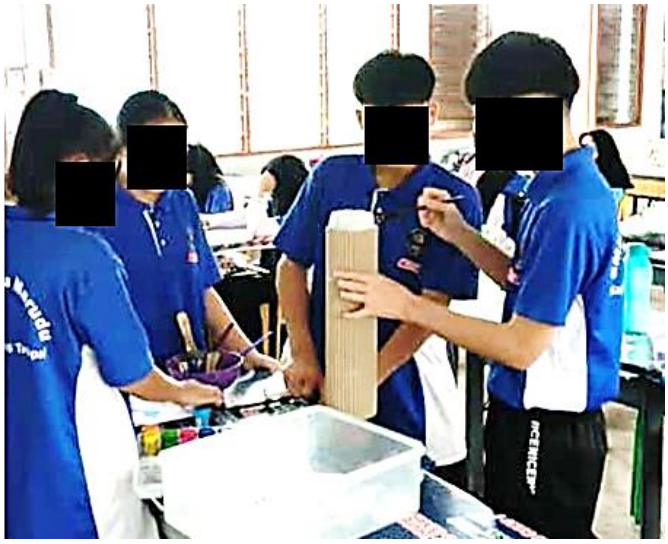

Figure 5 : Students Engaged in Collaborative Problem-Solving and Design Prototyping during a STEAM-PBL Water Filtration Project

Interview data revealed that students appreciated the real-world relevance of the STEAM-PBL projects. One student remarked, “It’s not like just solving equations we had to think like engineers and also like artists.” Teachers supported this observation, noting that students developed greater resilience and analytical thinking by navigating the challenges encountered during project implementation.

Increased Student Engagement and Collaborative Learning

Another salient outcome was the heightened level of student engagement and social collaboration. Observation notes indicated strong participation, with students voluntarily extending project work time and enthusiastically discussing their ideas. The open-ended nature of Project-Based Learning (PBL) empowered students to take ownership of their learning, while the integration of visual arts made the experience more enjoyable and less intimidating (Zhang & Jia, 2024).

Figure 6 illustrates a group of secondary school students presenting their constructed model as part of a STEAM-PBL activity. Each team member assumed specific roles such as designer, builder and presenter fostering an environment of shared responsibility and interdependence. The open-ended structure of the task encouraged students to lead discussions, make design decisions and reflect on their creative contributions.

Both observation notes and student reflections highlighted increases in confidence, enthusiasm and ownership of learning. One teacher remarked, “Students who rarely speak in class were suddenly leading group discussions and giving design feedback,” while a student journal entry captured the emotional impact: “Working with my group made me confident. We created something real.” The integration of visual arts further amplified participation, transforming the classroom into a more inclusive, expressive and student-centered environment.

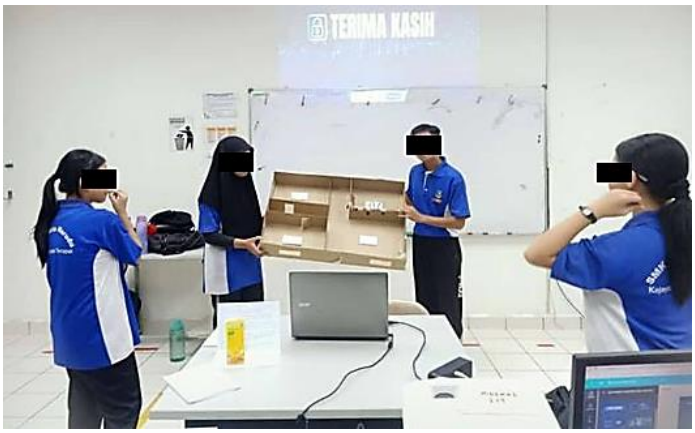

Figure 6 : A Group of Secondary School Students Presenting their Constructed Model as Part of a STEAM-PBL Activity.

Improved Attitudes Toward STEAM Subjects

A notable finding was the positive shift in students' attitudes toward traditionally challenging STEAM subjects. Prior to the intervention, many students expressed feelings of alienation or anxiety, particularly toward science and mathematics. However, the integration of visual arts recontextualized these subjects, rendering them more approachable and personally meaningful.

As illustrated in Figure 7, the act of visualizing scientific ideas through painting empowered students to interact with content in intuitive and engaging ways. One student reflected, “When we painted the layers of the atmosphere, I could remember them easily. It felt like learning through pictures, not just words.” These creative tasks offered alternative pathways for comprehension, reducing apprehension and increasing enthusiasm toward complex academic content.

Figure 7 : The Act of Visualizing Scientific Ideas through Painting Empowered Students to Interact with Content in Intuitive and Engaging ways

Teachers corroborated these observations by reporting improved classroom attendance, increased voluntary participation and a higher frequency of student-initiated questions in STEM classes. This affective transformation is particularly meaningful in rural school contexts, where STEM subjects are often perceived as intimidating or disconnected from students' lived experiences. The integration of visual arts not only enriched content delivery but also humanized STEAM learning making it more inclusive, experiential and emotionally resonant.

DISCUSSION

This study provides robust empirical evidence supporting the integration of visual arts into STEAM through Project-Based Learning (PBL) as a pedagogically sound and contextually relevant approach particularly in

under-resourced educational settings such as rural Sabah. The findings not only align with existing literature on the cognitive, emotional and social benefits of STEAM education but also offer new insights into how the arts can function as a transformative medium for interdisciplinary learning and inclusive pedagogy. Table 1 presents a summary of key findings and their theoretical implications arising from the STEAM-PBL integration.

Table 1 : Summary of Key Findings and Theoretical Implications from STEAM-PBL Integration

Theme	Key Findings	Theoretical Support	Implications
Arts as Cognitive Medium	Visual arts helped students visualize scientific concepts; improved spatial reasoning and personal expression.	Winner, E., Goldstein, T. R., & Vincent-Lancrin, S. (2013).	Strengthens justification for arts as core to STEM, not peripheral.
Higher-Order Thinking via PBL	Students engaged in analysis, synthesis and evaluation through design thinking and collaboration.	Bloom's Revised Taxonomy; Thomas, J. W. (2000).	PBL fosters deep learning and transforms passive classrooms into active, design-based environments.
Inclusive STEAM Identity	Marginalized students began to see themselves as capable learners and problem-solvers.	Vygotsky's ZPD and identity formation. Bonk, C. J., & Reynolds, T. H. (1997).	Arts-integrated PBL reshapes learner identity and broadens participation in STEAM.
Policy and Practice Implications	Need for systemic integration of arts, teacher training and assessment reform.	Curriculum innovation theory. Gear, R., Hurley, R., & Waters, M. (2023).	Calls for flexible curricula, interdisciplinary training and holistic assessment models.

Arts as a Medium for Cognitive Transformation

The enhancement of student creativity observed in this study reinforces Eisner's (2002) assertion that the arts function as cognitive tools, fostering perceptual sensitivity and divergent thinking. Within the STEAM-PBL context, visual arts enabled students to externalize and reconfigure abstract scientific concepts into tangible, meaningful forms. This transformation bridged the gap between conceptual knowledge and lived understanding an especially critical shift in STEM education, which often emphasizes rote memorization and abstract instruction.

Furthermore, the data suggest that visual arts integration supported the development of spatial reasoning and symbolic representation skills positively correlated with higher achievement in mathematics and science (Winner et al., 2013). The interplay of creative expression and scientific inquiry created a learning environment where imagination, visualization and critical analysis coexisted. This synergy affirms the arts as an essential dimension of STEM, contributing to deeper learning, greater retention and enhanced cognitive flexibility.

PBL as a Conduit for Higher-Order Thinking

The structure of Project-Based Learning (PBL) offered iterative opportunities for students to engage in authentic problem-solving, design thinking and the construction of knowledge. These projects pushed students beyond procedural tasks, prompting the application of analytical, synthetic and evaluative thinking key levels in Bloom's revised taxonomy (Anderson & Krathwohl, 2001). Through collaborative inquiry and peer negotiation, students co-constructed understanding, tested ideas and refined their work.

These findings align with Thomas (2000), who argues that PBL cultivates a dynamic learning environment conducive to deep, applied understanding. In this study, classrooms evolved into creative laboratories where students assumed the roles of designers, engineers and critical thinkers. The social interaction and scaffolding inherent in PBL supported cognitive growth within Vygotsky's Zone of Proximal Development, enabling students to attain outcomes beyond their individual capabilities.

Reframing STEM for Marginalized Learners

One of the most compelling outcomes of this study is its potential to reframe STEM education for learners who have historically felt alienated from it. The integration of visual arts made scientific content more accessible, relatable and culturally resonant, particularly for students with limited exposure to science outside the classroom. For many, it was the first time they felt seen as capable contributors within STEM learning spaces an identity shift of significant educational value (Bonk & Reynolds, 1997; Buruntong, 2025).

This affective transformation underscores the capacity of arts based pedagogy to foster belonging and promote educational equity. Students who previously perceived STEM as inaccessible became active participants in constructing knowledge. In contexts such as Sabah, where geographic and socioeconomic barriers often inhibit STEM engagement, STEAM-PBL approaches are not merely innovative they are essential for equitable education and inclusive national development.

IMPLICATIONS FOR POLICY AND PRACTICE

The findings of this study yield several key implications. First, there is a need for the systemic incorporation of arts-integrated pedagogies into national STEM frameworks. Such integration must be contextually adaptable to reflect diverse educational realities, especially in under-resourced rural schools. Policymakers should recognize the arts as a legitimate and integral component of STEM, rather than as supplementary enrichment (Gear, Hurley, & Waters, 2023).

Second, teacher education must evolve to prepare educators for interdisciplinary practice. Effective STEAM instruction requires confidence and competence in both scientific and artistic domains. Professional development programs should therefore include training in collaborative planning, visual literacy and PBL facilitation.

Finally, assessment systems must be reimagined to value process, creativity and student voice alongside content mastery. Conventional examinations often fail to capture the complexity and richness of learning in STEAM-PBL contexts. Alternative assessments such as portfolios, presentations and reflective journals can better reflect the multifaceted nature of student growth in this educational model.

LIMITATIONS OF THE STUDY

While the study provides significant insights into the integration of visual arts within a STEAM framework through Project-Based Learning (PBL) in rural Sabah, several limitations should be acknowledged. Firstly, the research was confined to a single secondary school with a relatively small sample of 30 students and five teachers. Although this aligns with the goals of qualitative research that prioritizes depth over breadth, it limits the generalizability of the findings to broader educational settings, particularly urban schools or those equipped with advanced digital infrastructure.

Secondly, the dual role of the teachers as both facilitators and data contributors may have introduced bias, potentially influencing student behavior and responses. The reliance on self-reported data from students such as reflective journals and interviews also raises the possibility of social desirability bias, where responses may reflect what participants perceive as favorable rather than their genuine thoughts or experiences.

Thirdly, although student artefacts were referenced and described, the study lacked consistent inclusion of visual documentation, such as photographs or step-by-step design sketches. This absence reduces the reader's ability to visualize the learning context and evaluate the artefacts' educational value independently. Incorporating such visuals would have provided a richer, more immersive understanding of the learning processes and outcomes.

Lastly, the study does not include a comparative analysis between rural and urban implementations of STEAM-PBL. Such comparisons could offer valuable insights into how differing access to technology, teacher training and cultural capital influence learning outcomes. Future research should consider longitudinal

methods, more diverse school contexts and a combination of qualitative and quantitative data to enhance the robustness and applicability of the findings.

FUTURE RESEARCH AND SCALABILITY RECOMMENDATIONS

To strengthen the evidence base and broaden the applicability of arts-integrated STEAM education, future research should adopt a wider scope and extended timeframe. A longitudinal study would offer critical insight into the long-term effects of STEAM-PBL on students' academic performance, creative development and attitudes toward STEM subjects. Monitoring these impacts over time could determine whether initial gains are sustained or diminish without continued support.

In addition, comparative studies between rural and urban school environments are strongly recommended. Such research would highlight context-specific challenges and advantages, offering a clearer understanding of how geographical, technological and socio-economic factors shape the implementation and effectiveness of STEAM-PBL. These insights would assist policymakers and stakeholders in designing equitable, targeted interventions that bridge the urban-rural education divide.

Scalability is another key area for investigation. While this study focused on a single school, its approach integrating visual arts through collaborative, project-based activities can serve as a model for wider application. Future research should test this approach across multiple regions, educational levels and resource settings to evaluate its adaptability and impact. Developing a modular, flexible STEAM curriculum with integrated visual arts guidelines could facilitate broader implementation.

Moreover, sustainable teacher professional development must be embedded within any scaling efforts. Continuous training in interdisciplinary pedagogy, visual arts techniques and student-centered practices will be essential to ensure consistency and quality in STEAM-PBL delivery. As STEAM education evolves, research must also address the support systems and institutional structures required to sustain meaningful, cross-disciplinary learning experiences for diverse student populations.

CONCLUSION

This study presents compelling evidence that integrating visual arts within a STEAM framework through Project-Based Learning (PBL) constitutes a transformative pedagogical approach particularly in underserved educational settings such as rural secondary schools in Sabah. The findings demonstrate that this integration fosters meaningful gains in student creativity, engagement, problem-solving skills and attitudes toward STEM learning.

Visual arts functioned not merely as an aesthetic supplement but as a powerful cognitive and emotional tool, enabling students to internalize, personalize and apply complex scientific concepts. Through collaborative, hands-on projects, students addressed real-world problems using design thinking and produced artefacts that reflected both deep conceptual understanding and imaginative expression. The interdisciplinary nature of this approach facilitated enriched learning experiences and empowered students to view themselves as competent contributors in both scientific and artistic domains.

The observed shifts in cognitive competencies and learner dispositions underscore the urgency of reimagining conventional STEM education, particularly in marginalized contexts. This study highlights the importance of educational policies that support arts-integrated pedagogies, curricular flexibility and sustained teacher professional development. In a global landscape increasingly defined by the need for creative, adaptive and interdisciplinary thinkers, STEAM education delivered through contextually grounded PBL models represents not merely a pedagogical innovation but an educational imperative.

Future research should extend these findings by examining the longitudinal impacts of STEAM-PBL programs and assessing their scalability across varied educational settings. Comparative studies between urban and rural schools may further clarify context-specific enablers and barriers. With strategic investment and institutional commitment, arts-integrated STEAM has the potential to democratize STEM education and cultivate the full spectrum of student intelligence and creativity.

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