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Integrating Vietnam's Living Heritage into STEM Education: The Case of Vietnamese Conical Hat

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Abstract

This study presents an innovative integration of STEM education with the preservation of Vietnam's living heritage through the traditional craft of the Vietnamese conical hat at Gia Thanh Secondary School. The project aims to enhance student engagement in STEM by embedding the conical hat's cultural production process into Mathematics, Science, and Engineering lessons. Over 200 students participated in hands-on activities by applying geometric principles to design the conical hat, exploring material science using natural materials, and learning engineering concepts through traditional crafting methods. Overall, 85% of students reported that their interests had increased in STEM subjects, as measured by performance in geometry (95% success) and material science (80% engagement). Furthermore, the initiative connected students with local artisans, fostering cultural pride and raising awareness of the economic and cultural importance of the conical hat. By integrating heritage preservation with STEM education, this project demonstrates a replicable model for enriching STEM learning while maintaining local cultural traditions.

Keywords: Living Heritage; Nón Lá; STEM Education; Student Engagement; Vietnam

Introduction

Vietnam is renowned for its rich cultural heritage, with a diversity of practices and traditions that span centuries. Among its most iconic intangible cultural heritage is the traditional craft of *Nón Lá* (Vietnamese conical hat). However, like many traditional crafts in Vietnam, *Nón Lá* is at risk of decline due to the impacts of modernisation, urbanisation, and industrialisation (Nam & Thanh, 2024; Son, 2023). This has raised concerns about the preservation of such cultural practices and the need for new strategies that can sustain their relevance in contemporary society (Phan Ngoc, 1998).

The Convention for the Safeguarding of Intangible Cultural Heritage, adopted by UNESCO in 2003, underscores the importance of protecting such intangible heritage through education and the active involvement of local communities (UNESCO, 2003). Vietnam has been a signatory to this convention and has made significant efforts to safeguard its cultural heritage through initiatives that engage both communities and schools (Living Heritage

Entity, 2022). However, the challenges faced by communities such as Van Phuc Silk Village demonstrate that cultural heritage preservation requires more than just governmental support—it also necessitates the active participation of local artisans and innovative methods that integrate heritage into the educational system (Son, 2023).

Previous studies have shown that community involvement plays a vital role in the conservation of cultural heritage, particularly in preserving the knowledge and skills that are passed down through generations (Nam & Thanh, 2024). Despite these efforts, there is still a gap in integrating such heritage into formal academic subjects, particularly in STEM education (Nam & Thanh, 2024; Nguyen et al., 2020; Vuong et al., 2020).

The introduction of STEM education as a framework for cultural heritage preservation offers a unique solution to this gap (Wang Yuecheng, 2023). By integrating cultural heritage into STEM lessons, students can engage in hands-on learning experiences that not only teach scientific and engineering concepts but also foster an appreciation for their cultural identity(Bertoni & Peverada, 2023; Binbin et al., 2024; Sang & Yang, 2023).This approach aligns with the goals of the 2003 UNESCO Convention, which advocates for educational strategies that raise awareness of intangible cultural heritage among younger generations.

This study proposes an innovative model that integrates the traditional craft of *Nón Lá* into the STEM curriculum at Gia Thanh Secondary School. By using the craft as a medium for teaching geometry, engineering, and material science, this study aims to identify *Nón Lá* as a living heritage, investigate its STEM aspects, design STEM lessons centred around *Nón Lá* for secondary students, and foster cultural pride and awareness among the younger generation.

Methodology

The project involved over 200 students ages 12-15 at Gia Thanh Secondary School. The selection of students was voluntary, but their participation in cultural activities and prior knowledge of the conical hat craft was minimal. Teachers and local artisans from Gia Thanh, recognised for their expertise in crafting *Nón Lá*, were key collaborators.

The research was structured into five phases to explore the integration of Vietnam's *Nón Lá* into STEM education. The methodology followed a systematic approach to ensure that cultural preservation and effective STEM education were achieved.

The first phase focused on recognising *Nón Lá* as a vital part of Vietnam's intangible cultural heritage. A survey was conducted among Gia Thanh School's students to assess their awareness and attitudes towards *Nón Lá*. The goal was to determine whether the students considered *Nón Lá* as a part of their cultural identity, understood its historical importance, and recognised its diminishing role in modern life. The second phase explored the scientific, technological, engineering, and mathematical elements in the making of *Nón Lá*. The objective was to uncover how traditional craftsmanship could be broken down into STEM-related topics, such as the geometry of the hat, the materials used, and the engineering principles involved in its design. Table 1 show the design of STEM activities in this study. Based on the STEM aspects identified, the third phase involved the design of STEM activities that incorporate *Nón Lá* craftsmanship into educational lessons. These activities were designed to engage the students on scientific and mathematical principles application in the production of *Nón Lá*. The performance of students was measured by the assessment questions. The fourth phase focused on gathering and analysing data from the implemented STEM activities and pedagogical experiments. Surveys, observational data, and student performance assessments were utilised to measure the success of integrating *Nón Lá* into STEM education. In the final phase, the research reflected on the overall outcomes of the study. This included an assessment of both the educational impact on students and the broader cultural impact in terms of raising

awareness about *Nón Lá* as an important element of Vietnamese heritage.

Table 1. Designing and Implementing STEM Activities

STEM lesson	Subject	Vietnamese Curriculum Objectives	NGSS DCI and SEP[1]	STEM Activity
Geometry and Measurement	Maths (Grades 6-9)	Maths: Focus on applying geometric formulas to real-world problems	DCI: 6. G.A. (Geometry: Solve real-world mathematical problems involving area, surface area, and volume); SEP: Using Mathematics and Computational Thinking	Calculate the surface area and volume of *Nón Lá* using cone formulas. Create models to visualize and compare surface areas and volumes.
Material Properties	Science (Grades 6-9)	Science (Grades 6-9): Investigate material properties like flexibility and durability.	DCI: PS1.A (Structure and Properties of Matter); SEP: Planning and Carrying Out Investigations	Investigate the properties of bamboo and palm leaves used for *Nón Lá* construction. Test the tensile strength and flexibility of different materials.
Design and Technology	Technology (Grades 6-9)	Technology (Grades 6-9): Apply engineering principles to construct items, understanding the tools used in traditional crafts	DCI: ETS1.B (Developing Possible Solutions); SEP: Constructing Explanations and Designing Solutions	Design and build a model *Nón Lá* using bamboo skewers and string, focusing on structural integrity and proposing design improvements.
Material Treatment	Science (Grades 6-9)	Science (Grades 6-9): Explore chemical reactions and material preservation	DCI: PS1.B (Chemical Reactions); SEP: Planning and Carrying Out Investigations	Experiment with different chemical treatments for leaves and observe changes in texture, colour, and durability.

[1] NGSS: Next Generation Science Standards, DCI: Disciplinary Core Ideas, SEP: Science and Engineering Practices (SEP)

Application of Technology in Craft	Technology (Grades 6-12)	Technology (Grades 6-12): Understand how to use tools and technology in traditional crafts	DCI: ETS1.A (Defining Engineering Problems); SEP: Using Mathematics and Computational Thinking	Explore traditional and modern tools for crafting *Nón Lá*. Compare traditional methods with modern technologies to enhance durability and efficiency.
Virtual Reality (VR)	Technology (Grades 6-12)	Use virtual platforms to simulate processes and enhance technological understanding	DCI: ETS1.A (Defining Engineering Problems); SEP: Using Mathematics and Computational Thinking	Use VR to explore *Nón Lá* construction. Apply coding skills to simulate robots performing tasks related to the geometry of *Nón Lá.*

Results and Discussion

Identifying *Nón Lá*–Conical Hat as a Living Heritage

The first phase of this research aimed to assess the current perceptions and awareness of *Nón Lá* as a cultural heritage element among students at Gia Thanh School. A structured survey was administered to 224 students to evaluate their awareness, interests, and practical use of *Nón Lá* in daily life. The survey revealed that nearly 70% of students expressed no interest or understanding of the traditional craft, whereas this was significant given the cultural importance of *Nón Lá* in their local community. In terms of practical usage, 90% of students reported not using *Nón Lá* at home for tasks like gardening or farming, opting instead for fabric hats or modern alternatives. Additionally, observations showed that 100% of students commuting by bicycle wore fabric hats or used umbrellas, indicating that *Nón Lá* no longer plays a role in their daily routines.

The data also revealed differences in interest levels across different grades, with Grade 6 students showing the highest level of disinterest (45 students). Overall, the findings discovered that *Nón Lá* became irrelevant to the younger generation in Gia Thanh, signalling a concerning decline in cultural engagement. The lack of practical use and emotional connection to *Nón Lá* was the cause of a diminishing cultural significance, raising concerns about the future of this traditional craft. To address this, an innovative method by integrating *Nón Lá* into STEM education should be explored to rekindle interest and ensure the preservation of this important cultural heritage for future generations.

The STEM Aspect of *Nón Lá*

The diagram depicts the mathematical dimensions of a traditional Vietnamese *Nón Lá*. In terms of geometry, the hat has a conical shape, and the key measurements include: (1) Bottom diameter (D): The diameter of the base is typically around 45 cm, which forms the circular base of the cone; (2) Height (H): The vertical height of the cone is approximately 25 cm; and (3) Slant height (L): The slant height, which is the distance from the tip of the cone to the edge of the base, is 33 cm. The base is represented as a circular arc with evenly distributed rims that emulate the real-life structure of a *Nón Lá*. In this geometric model, each rim is modelled as an ellipse section, simulating the horizontal bamboo rings. The conical hat leaves are made from *buông* leaves or palm leaves.

The materials and tools for making the conical hat include palm leaves, hat mould, hat rims, areca sheath, steel needles, and thread. The frame is made from bamboo, consisting of eight spokes and 16 grooves. The diameter of the largest hat rim is 40-50 cm, the length of the spokes is 24-27 cm, and the distance between each rim is 2 cm. The rims are sequentially arranged in the conical hat mould from the largest to the smallest, with each rim's connection point on the mould staggered. The largest rim is made from smooth, rounded diễn bamboo, which is thicker to ensure the hat is sturdy and durable. The rims must be flat, without rough or uneven surfaces, and there are a total of 15 rims.

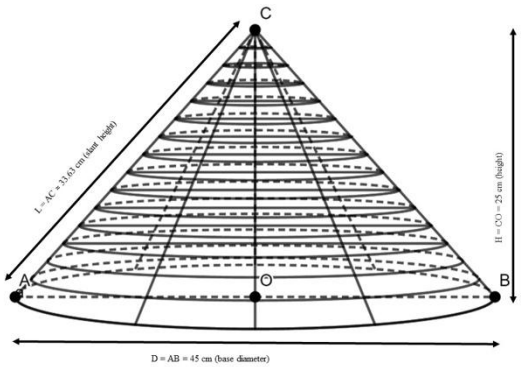

Figure 1: Geometric Model of the Traditional Vietnamese Conical Hat (Nón Lá)

The Process of Making a *Nón Lá*

Step 1: Selecting, Rolling, and Ironing the Leaves

The selected leaves must be flat, smooth, and not brittle or torn. While ironing the leaves, it was crucial to control the heat so the leaves did not burn or become too soft, ensuring they achieved the necessary durability and flexibility for making the hat.

Step 2: Assembling the Hat Frame - Making the Rims

The hat frame was made from bamboo or wood, consisting of eight spokes and 16 grooves. The diameter of the hat rim ranges from 40-50 cm, the length of the spokes is 24-27 cm, and the distance between the rims is 2 cm. The rims were split into small bamboo slats, shaved smooth and round. These rims were sequentially arranged in the conical hat frame from the largest to the smallest, with each rim's connection pointed on the mould and staggered to be more stable.

Step 3: Assembling the Hat

The hat was assembled in three layers: (1) The inner layer, with the right side of the leaf facing inward, was attached tightly to the frame; (2) A layer of dried mould tree bark (flattened and dried) was spread evenly over the frame; (3) The outer layer of beautiful leaves was spread over the mould layer, ensuring the frame is completely covered. To prevent the leaves from shifting, two strings were used to hold the leaves in place.

Step 4: Sewing the Hat

The hat was sewn using transparent white nylon thread, ensuring the thin and delicate stitching characteristic of the conical hat. The leaves must remain in place, and the stitches must be even and neat. The sewing process started from the third rim down to the bottom of the hat's brim.

Step 5: Securing the Hat

The securing process utilised red nylon thread and two bamboo steel wires, with one layer of tree bark placed between the two wires. Securing the hat helps reinforce the rim, making it stronger and more durable.

Step 6: Threading the Straps and Finishing the Tip

Threading the straps: The inner part of the hat (around the 3rd, 4th, and 5th rims from the largest rim up to the tip) is where the craftsman uses a large curved needle and yarn to symmetrically tie and attach the hat straps. The threading is usually done with colourful yarns like purple, peach pink, or light green to add a touch of vibrancy and help the hat sit securely on the head.

Finishing the tip: On the outside of the hat (at the smallest circle of the conical shape), the craftsman used white nylon thread to sew

neat, tight stitches up to the tip. This tight stitching ensures that water does not leak into the hat and strengthens the tip, making it firm and durable.

After the hat was completed, the craftsman applied a coat of resin mixed with gasoline, brushing it over the surface of the hat twice. This layer helps the hat become stronger, more durable, and more beautiful. A well-made conical hat is defined by even stitches, tight needlework, smooth leaves, as well as round, smooth rims.

Pedagogical Experiments

Based on the pedagogical experiments conducted at Gia Thanh Secondary School, the results demonstrated a high level of student engagement and successful learning outcomes in the integration of STEM principles with the cultural heritage of *Nón Lá*. In the Geometry and Measurement lesson of the 224 students, 95% (213 students) successfully calculated the surface area and volume of the conical hat, with 90% showing high engagement in both mathematical and cultural aspects of the lesson. Only 5% of students required assistance, and another 5% struggled with the concepts, highlighting the overall effectiveness of the lesson.

In the Material Properties lesson, 80% of students successfully identified the properties of the materials used in *Nón Lá* making, with 95% engaging enthusiastically in material testing. This lesson sparked interest in applying traditional materials, like bamboo and palm leaves, to modern technologies. The Design and Technology lesson also showed positive results, with 75% of students successfully constructing a model conical hat and 85% deeply engaged in the design challenge. However, 20% of students required structural revisions to their models, and 5% were unable to complete the task, indicating room for further support and refinement of the lesson structure. Table 2 show the Summary of Pedagogical Experiment Results.

Table 2. Summary of Pedagogical Experiment Results

STEM Lesson	Key Learning Outcome	Student Performance
Geometry & Measurement	Calculated the surface area and volume of a cone	95% (213/224) were successful; 90% were highly engaged; 5% needed assistance; 5% struggled
Material Properties	Identified and tested traditional materials (bamboo, palm leaves)	80% correctly identified properties; 95% enthusiastically engaged in testing
Design & Technology	Constructed model of *Nón Lá*; applied engineering design principles	75% successfully built models; 85% were highly engaged; 20% needed revisions; 5% did not complete the task

These findings suggest that integrating cultural elements into STEM education can significantly enhance both student engagement and learning outcomes, while also fostering an appreciation for traditional craftsmanship.

Reflection and Cultural Impact

Based on the data from the pedagogical experiments and survey results, it is evident that integrating the *Nón Lá* into STEM education has had a notable impact on both cultural preservation and student engagement. According to the survey conducted with 224 students at Gia Thanh

Secondary School, approximately 70% of the students expressed little to no interest or understanding of the *Nón Lá*, indicating a significant decline in the connection between the younger generation and this cultural artifact. Only 10% of students occasionally used the *Nón Lá* for daily activities, such as helping with farming or gardening, while 90% preferred modern alternatives like fabric hats. This trend highlights the urgency of educational interventions to reconnect students with their cultural heritage.

In response, the STEM-based lessons demonstrated promising results. For example, in the geometry and measurement lesson, 95% of students accurately calculated the surface area and volume of the *Nón Lá*, and 90% were highly engaged in the activity, appreciating both its cultural and mathematical relevance. Similarly, 80% of students correctly identified the material properties of the bamboo and palm leaves used in *Nón Lá* making, with 95% showing high engagement in the hands-on testing. These findings suggest that integrating cultural elements like the *Nón Lá* into STEM education can significantly boost student interest in both STEM subjects and traditional crafts, thus ensuring the preservation of this important cultural heritage.

Discussion

The integration of local cultural artifacts, such as the Vietnamese *Nón Lá*, provides a meaningful context for STEM education. By connecting traditional knowledge systems with modern scientific thinking, students not only engage more deeply in mathematical reasoning but also develop a stronger appreciation for their cultural identity. This approach aligns with global educational trends that encourage culturally responsive pedagogy, particularly within the framework of the NGSS, DCI, and SEP. While the study is limited in scope, it offers a promising model for incorporating indigenous and local knowledge into formal STEM curricula. Future research should investigate the long-term effects of such integration on students' attitudes toward heritage preservation and their interdisciplinary competencies.

Conclusion

This study demonstrates the potential of integrating Vietnam's living heritage into STEM education, using the *Nón Lá* as a case study. Through a series of STEM-based lessons delivered to over 200 students at Gia Thanh Secondary School, the project effectively combined cultural preservation with the enhancement of STEM learning outcomes. The results showed that over 85% of students reported increased interest in both STEM subjects and the *Nón Lá* as a cultural artifact, following their engagement in hands-on activities involving geometry, material science, and engineering.

While the short-term data showed high levels of student interest and participation, particularly in relation to both STEM topics and the cultural artifact, these findings do not allow for definitive conclusions regarding the broader impact on cultural preservation. The project highlights a promising approach to embedding traditional knowledge into modern education. It is hoped that similar initiatives may contribute to raising cultural awareness and fostering appreciation for intangible heritage within contemporary STEM contexts.

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