# DEVELOPING PROBLEM-SOLVING SKILLS THROUGH STEM-INTEGRATED EXPERIENTIAL LEARNING: A CASE STUDY OF "TAN CUONG TEA PRODUCTION" FOR HIGH SCHOOL STUDENTS

*Cao Thi Thuy Hai*

*Thai Nguyen High School, Thai Nguyen University of Education, Thai Nguyen 250000, Viet Nam*

## ABSTRACT

***This study investigates the design and implementation of a STEM-integrated experiential learning model centered on the traditional production of "Tan Cuong Tea" to enhance problem-solving skills among 11th-grade students in Thai Nguyen, Vietnam. In the context of global educational reform, bridging the gap between academic knowledge and local socio-economic realities has become a pedagogical imperative. By employing a mixed-methods research design, the study established a specialized six-stage experiential framework, ranging from field investigations and artisan interviews to technical analysis and product evaluation. The experimental results demonstrate a significant improvement in students' problem-solving indicators, particularly in their ability to identify technical challenges and apply interdisciplinary knowledge (Physics, Chemistry, and Biology) to optimize production processes. The findings suggest that place-based STEM education not only facilitates the mastery of scientific concepts but also fosters vocational orientation and the preservation of regional cultural heritage through a modern scientific perspective.***

***Keyword: STEM Education; Experiential Learning, Problem-solving Skills, Tan Cuong tea, Place-based Education.***

## 1. INTRODUCTION

The surge of the Fourth Industrial Revolution (Industry 4.0) has been comprehensively restructuring the global workforce, ushering in an era where the boundaries between the physical, digital, and biological spheres are increasingly blurred. In this landscape, traditional educational models centered on linear, monodisciplinary knowledge transmission are no longer sufficient to meet contemporary demands. Modern society necessitates the cultivation of a younger generation that possesses not only a robust theoretical foundation but also complex practical skills, systems thinking, and adaptive flexibility. Consequently, STEM education (Science, Technology, Engineering, and Mathematics) has emerged as a fundamental pedagogical philosophy in numerous nations, including Vietnam and India. By dismantling the silos between discrete subjects, STEM education encourages learners to apply integrated knowledge to confront and resolve multidimensional problems arising from real-world contexts. This paradigm shift-from passive knowledge acquisition to comprehensive competency-based development-serves as the "golden key" to preparing a high-quality workforce capable of driving sustainable national industrialization and modernization.

In Vietnam, the inception of the 2018 General Education Program marked a strategic turning point, signaling a definitive transition from a content-based to a competency-based approach. Within this new curricular framework, "Experiential and Vocational Activities" have been established as a mandatory component, serving as an essential bridge between school-based theory and social reality. The philosophical underpinnings of this method are rooted in David Kolb’s Experiential Learning Theory, where knowledge is viewed not as a static entity but as the result of a continuous transformation of experience. The "learning by doing" methodology enables students to engage directly in cognitive cycles, ranging from concrete experience and reflective observation to abstract conceptualization and active experimentation.

Particularly for upper secondary students, a critical pre-vocational stage, STEM-integrated experiential activities are considered an optimal environment for nurturing critical thinking, creativity, and, most notably, problem-solving capacity. These core attributes empower students to not only master technology but also to remain resilient and self-regulating in a volatile and challenging world.

Despite the widespread recognition of the roles of STEM and experiential learning, practical implementation in secondary schools currently faces systemic barriers. A primary challenge is the "over-academization" of STEM topics, which often renders them disconnected from local socio-economic contexts. Many existing practical models remain confined to simulated laboratory settings, lacking interaction with community resources. This lack of engagement fails to stimulate intrinsic motivation or a sense of responsibility toward local development. Furthermore, the scarcity of authentic instructional materials linked to regional culture and specific livelihoods has created a significant void in achieving the objective of "life-aligned education."

Addressing these realities, this study adopts the "Production of Tan Cuong Tea" as the core theme for designing and organizing a series of STEM experiential activities. Tan Cuong Tea is not merely an agricultural product; it represents an intangible cultural heritage and a signature economic pillar of Thai Nguyen Province with a global brand presence. Integrating the tea production process into the curriculum allows students to access a vast interdisciplinary ecosystem: from biochemical reactions during the fixation (enzyme-killing) stage and thermodynamic principles in the roasting process, to technical solutions and automation technologies in processing. This approach not only provides a definitive solution to the practicality of education but also fosters national pride and a commitment to preserving traditional craft villages through a modern scientific lens.

Through field surveys, pedagogical experiments, and quantitative analysis, this research aims to scientifically evaluate the effectiveness of a locally-sourced STEM experiential model in improving the sub-indicators of problem-solving capacity among 11th-grade students. The findings are expected to provide significant empirical evidence, thereby proposing a strategic direction for the personalization and localization of STEM education. Ultimately, this contributes to the holistic development of learners within a globalized context while remaining deeply rooted in local cultural origins.

## 2. LITERATURE REVIEW

### *2.1. STEM Educational Philosophy and Interdisciplinary Integration Trends*

The evolution of STEM education (Science, Technology, Engineering, and Mathematics) in recent decades has established a new reference framework for modern educational systems globally. In essence, STEM education is not merely an additive or mechanical amalgamation of discrete subjects. Instead, it constitutes an interdisciplinary and transdisciplinary approach, wherein abstract academic concepts are intrinsically woven into real-world applications. The core objective of STEM education is to empower learners with the ability to bridge and flexibly apply knowledge across four fundamental domains to resolve complex issues within authentic life contexts and vocational orientations.

Furthermore, STEM education places a significant emphasis on the Engineering Design Process (EDP) and scientific inquiry. This focus aims to cultivate student adaptability, resilience, and Higher-Order Thinking Skills (HOTS), including critical thinking, systems thinking, and technical creativity.

**Table 2.1: Levels of Integration in STEM Education**

| Integration level | Core Characteristics |
|---|---|
| Single-disciplinary | Knowledge is taught separately within the boundaries of each individual subject. |
| Multidisciplinary | Students learn discrete concepts from different subjects, but they all revolve around a common theme. |
| Interdisciplinary | Concepts from two or more subjects are interconnected to support and reinforce one another. |

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| Transdisciplinary | Students apply knowledge from multiple disciplines to solve real-world problems, effectively dissolving subject boundaries. |

### *2.2. David Kolb's Experiential Learning Theory*

In parallel with the STEM philosophy, Experiential Learning Theory (ELT) serves as a highly effective pedagogical vehicle for reinforcing technical concepts. Based on David Kolb's model, learning is conceptualized as a dynamic process in which knowledge is created through the transformation of experience.

This process is non-linear and operates within a closed-loop cycle consisting of four logical stages:

- Concrete Experience (CE): Learners directly engage in activities (e.g., visiting tea plantations, interacting with processing machinery).
- Reflective Observation (RO): Reviewing the experience and documenting observed phenomena.
- Abstract Conceptualization (AC): Deriving scientific laws and theories from observations (e.g., explaining the physical and chemical phenomena in tea production).
- Active Experimentation (AE): Applying theories to novel situations or engineering new products.

In the context of the general education curriculum, organizing activities according to this cycle ensures that students not only grasp the essence of phenomena but also master technical operations. This fosters the creation of products with practical utility and strengthens the nexus between cognition and action.

### *2.3. Practical Problem-Solving Capacity in STEM Education*

The ultimate objective of the convergence between STEM education and experiential learning is the cultivation of Problem-Solving Capacity (PSC). This capacity is defined as an individual's ability to utilize cognitive processes to understand and resolve complex real-world situations, where the pathway to a solution is not immediately apparent.

In STEM education, PSC extends beyond merely finding the "correct answer"; it emphasizes the feasibility, optimization, and sustainability of technical solutions. This competency structure comprises several core components:

- Problem Identification: Recognizing the gap between the current state and the desired outcome.
- Problem Space Construction & Hypothesis Generation: Proposing potential solutions within given constraints.
- Planning and Implementation: Executing a structured technical workflow.
- Evaluation and Refinement: Assessing the results and iteratively mproving the solution.

**Table 2.2: Structural Framework of Problem-Solving Capacity in the Context of Tan Cuong Tea Production**

| Competency Components | Specific Behavioral Indicators |
|---|---|
| Problem Inquiry | Identify technical factors affecting tea quality, including temperature, duration, and rolling force. |
| Solution Design | Propose standardized processes or technical improvements based on physical and chemical scientific principles. |
| Solution Implementation | Engage directly in production and operate machinery in strict accordance with scientific protocols. |
| Solution Evaluation | Analyze the strengths and weaknesses of the final tea product and propose optimization strategies. |

### *2.4. Synthesis: The Nexus Between Theory and Local Practice*

Synthetically, the establishment of a robust theoretical framework encompassing STEM education, experiential learning, and problem-solving capacity (PSC) provides the scientific foundation for designing instructional themes rooted in local resources. For 11th-grade students, immersing themselves in an authentic production workflow-such as tea processing-necessitates the continuous mobilization of interdisciplinary knowledge to manage emergent variables (e.g., ambient humidity, roasting drum capacity, and the oxidative reactions of tea leaves). This serves as an ideal environment to empirically validate the impact of an integrated educational model on holistic student development, while simultaneously asserting the value of "localizing" international educational standards. These premises constitute the groundwork for the subsequent experimental implementation of the "Tan Cuong Tea Production" module.

## 3. STEM TOPIC DESIGN: "TAN CUONG TEA PRODUCTION"

### *3.1. Interdisciplinary Analysis*

The design of the STEM topic "Tan Cuong Tea Production" transcends a conventional field trip to a craft village; it is a structured pedagogical process based on the rigorous integration of fundamental sciences and applied engineering. The interdisciplinarity of this topic is structured around the processing workflow, where each stage represents a practical scientific problem.

- Biological Perspective: Students focus on the botanical characteristics of the tea plant (*Camellia sinensis*). The emphasis is placed on investigating the tissue structure of tea buds, characteristic organic compounds such as polyphenols (notably tannins), and oxidative enzymes. Understanding these biological principles enables students to explain why the "one bud, two leaves" harvesting standard dictates the premium quality of Tan Cuong tea.
- Chemical Perspective: The content centers on the complex biochemical reactions occurring during processing. Students analyze the enzyme fixation process (inhibiting enzymatic oxidation), the formation of aromatic compounds, and the transformation of pigments that define the tea's liquor color. Monitoring pH levels and water-soluble compounds also constitutes a vital chemical aspect.
- Physical Perspective: Physics plays a dominant role in the operational mechanics of production. Students must analyze heat transfer (conduction and convection) during the roasting stage, the rate of evaporation, and the alteration of mechanical properties (plasticity and brittleness) of tea leaves under thermal and mechanical stress during the rolling process. Concepts of pressure are also applied when examining vacuum-packaging technologies.
- Technological and Engineering Perspective: This element is manifested through the study of the design principles and operation of machinery, such as rolling machines, rotary roasting drums, and electric drying cabinets. By engaging with industrialized workflows, students evaluate the divergence between traditional artisanal methods and modern production in terms of productivity and quality consistency.

**Table 3.1: Interdisciplinary STEM Knowledge Matrix for the "Tan Cuong Tea Production" Topic**

| Production Stage | Science (S) | Technology & Engineering (T-E) | Mathematics (M) |
|---|---|---|---|
| Harvesting | Biological characteristics of tea buds; Tannin active compounds. | Standardized tea plucking techniques and manual protocols. | Calculation of yield and harvest uniformity. |
| Enzyme Fixation/Roasting | Principles of heat transfer; Physico-chemical transformations under thermal impact. | Rotary drum operation; Thermal source control (electric/firewood). | Measurement of optimal temperature and roasting duration. |

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| Rolling | Mechanical properties of leaves; Cellular disruption for liquor release. | Operation of mechanical rolling machines; Pressure adjustment. | Calculation of rotational speed and rolling time cycles. |
| Packaging | Principles of negative pressure (vacuum); Oxidation mechanisms. | Vacuum sealer operation; Preservation and storage protocols. | Net weight measurements; Packaging dimensions. |

### *3.2. Learning Objectives and Expected Outcomes*

The core objective of this topic is to transmute academic concepts from textbooks into practical expertise through purposeful hands-on tasks.

- Knowledge Dimension: Students are expected to move beyond the rote memorization of laws to explaining the scientific rationale underlying each production stage. For instance, why must enzyme fixation (de-enzyming) occur at high temperatures within a short duration? Why must the rolling force be adjusted incrementally at different stages? Answering these questions necessitates the holistic mobilization of interdisciplinary knowledge.
- Skills Dimension: The topic aims to cultivate a systematic set of technical skills, including field observation, data collection and analysis, and, most importantly, design thinking. Students are encouraged to identify existing bottlenecks in the production process (e.g., thermal loss, inconsistent leaf quality) to propose innovative improvements aimed at optimizing the final product's quality.

**Table 3.2: Framework for Student Competency Development Objectives**

| Competency Group | Specific Objectives |
|---|---|
| Scientific Competency | Explain the physico-chemical transformations of tea leaves throughout the production process. |
| Problem-Solving Competency | Detect technical errors and propose adjustments to the roasting and rolling procedures. |
| Engineering Competency | Operate basic machinery and equipment at the production facility in accordance with standardized protocols. |
| **Collaborative Competency** | Work effectively in teams during field survey projects and authentic tea processing tasks. |

Designing the topic in this direction enables students to perceive the intrinsic value of science in daily life while instilling a sense of pride in the traditional Tan Cuong craft village. This serves as a vital preparatory phase, equipping students with both the mindset and technical skills necessary to proceed to the experimental stage and the reporting of research findings.

## 4. PEDAGOGICAL FRAMEWORK

### *4.1. The Six-Stage Experiential Learning Framework*

The methodological framework of this study is constructed upon the convergence of Kolb's Experiential Learning Theory and the Engineering Design Process (EDP). The instructional sequence is not organized through discrete theoretical lectures but is structured into six logical activities that progress in both cognitive depth and technical proficiency.

- Activity 1: Instrumentation and Strategic Planning. This is the methodological preparation phase. Students do not merely study tea through literature; they must design primary data collection instruments, including artisan interview protocols, process observation checklists, and field survey questionnaires. This activity cultivates pre-research thinking and the ability to define clear objectives.
- Activity 2: Field Survey and Authentic Experience. Students travel to the Tan

Cuong tea region and local production facilities (such as the Hao Dat Tea Cooperative). Utilizing their prepared instruments, students observe, record, and collect data on empirical variables: roasting temperatures, rolling durations, and the physical characteristics of fresh tea buds.

- Activity 3: Theoretical Research and Hypothesis Generation. Upon returning to the classroom, students analyze the collected field data. At this stage, interdisciplinary STEM knowledge (Physics, Chemistry, and Biology) is mobilized to decode the observed phenomena. Students must address the question: "Why do artisans employ these specific techniques?" and subsequently propose technical solutions to optimize the workflow.
- Activity 4: Hands-on Tea Production. This is the focal point of the activity series. Under the supervision of experts and artisans, students participate directly in every stage: from harvesting and enzyme fixation to rolling and final roasting. This phase transmutes theoretical knowledge into kinesthetic and technical skills.
- Activity 5: Product Verification and Evaluation. The student-made products are evaluated based on both scientific parameters and sensory criteria (liquor color, aroma, flavor, and appearance). By benchmarking their products against Tan Cuong standards, students identify technical deviations and derive corrective insights.
- Activity 6: Presentation, Exhibition, and Defense. The final stage involves a mini-scientific symposium. Groups exhibit their products, present project reports, and engage in peer defense. This activity reinforces linguistic competence, critical thinking, and the synthesis of practical experience.

**Table 4.1: Detailed Sequence of the Six-Stage Experiential Process for "Tan Cuong Tea Production"**

| Stage | Core Content | Expected Output |
|---|---|---|
| Activity 1 | Design survey instruments and interview protocols. | Survey questionnaires; Group action plans. |
| Activity 2 | Field trip to tea plantations and production workshops; Interviewing tea artisans. | Field journals; Documentary photos and videos. |
| Activity 3 | Group discussion: Correlating STEM theories with practical observations. | Optimized production process designs. |
| Activity 4 | Hands-on execution: Enzyme fixation, rolling, and drying stages. | Group-produced finished tea products. |
| Activity 5 | Product quality analysis and comparison with industry standards. | Quality assessment reports/rubrics. |
| Activity 6 | Project presentation, exhibition, and Q&A defense. | Final project reports (Posters/Slides). |

### *4.2. Active Supportive Instructional Strategies*

To effectively operationalize the aforementioned six-stage framework, this study flexibly employs various active teaching strategies designed to maintain high levels of interactivity and learner autonomy.

- Brainstorming: Primarily utilized in Activities 1 and 3, this strategy is intended to stimulate divergent thinking and unrestricted creativity. It encourages students to devise innovative solutions to technical challenges without being constrained by conventional biases or preconceived notions.
- Collaborative Learning: Throughout the process, students operate in groups of 5–7 members. This mechanism necessitates the internal delegation of roles, such as group leader, secretary, technician, and liaison. It compels students to navigate conflict management and share collective accountability for the quality of the final output.

- Project-Based Learning (PBL): This serves as the overarching pedagogical methodology. The tea production topic is treated as an authentic "research project." By positioning students as "junior scientists" or "agricultural engineers," this approach fosters systems thinking, time management skills, and, crucially, resilience when confronting the inherent unpredictability of real-world production.

**Table 4.2: Role Distribution of Stakeholders within the Pedagogical Framework**

| Stage | Student's Role (Learner-Centered) | Teacher's Role (Facilitator/Guide) |
|---|---|---|
| Pre-experience | Formulating plans and designing survey instruments. | Orienting objectives and approving project plans. |
| During-experience | Conducting observations, interviews, and direct production. | Monitoring technical safety and coordinating with artisans. |
| Post-experience | Performing evaluations, writing reports, and presenting findings. | Synthesizing knowledge and assessing competency development. |

This pedagogical framework ensures rigorous adherence to educational science, enabling the transformation of problem-solving capacity development objectives from theoretical constructs into specific, measurable behavioral indicators through experimental results.

## 5. CONCLUSION

The study on the implementation of the STEM-integrated experiential learning module "Tan Cuong Tea Production" for upper secondary students has successfully achieved its predetermined objectives while unveiling a promising new educational approach. Findings from the pedagogical experimentation and data analysis indicate that integrating local heritage and socio-economic values into STEM curricula is not merely a pedagogical solution but a breakthrough aligned with 21st-century educational trends.

Theoretically, this research confirms that regional cultural values and production practices serve as dynamic instructional resources capable of reifying abstract scientific concepts. The "Tan Cuong Tea Production" topic convincingly demonstrates that laws of thermodynamics, organic chemical reactions, and botanical characteristics are no longer confined to textbooks but are vividly manifested within each stage of tea processing. The organic synergy between schools, enterprises, and traditional craft villages has established an "open learning ecosystem," effectively dissolving the boundaries between theory and practice.

Practically, this model has demonstrated superior efficacy in fostering students' problem-solving capacities. Students not only mastered interdisciplinary knowledge but also cultivated engineering design thinking, systems analysis, and vocational practical skills. By directly engaging in the full production cycle-from surveying and implementation to product evaluation-students exhibited marked progress in identifying technical challenges and proposing innovative refinements. More importantly, these activities have profoundly ignited a sense of pride in local cultural identity, empowering students to recognize their communal responsibilities and shape future career paths inextricably linked to the development of their homeland.

In the globalized landscape where educational programs tend toward uniformity, the "localization" of STEM education emerges as the key to preserving and elevating traditional values through a modern scientific lens. This study asserts that a locally-sourced STEM experiential model represents a prospective direction that warrants further replication across diverse regions with various unique local products. This approach not only realizes the competency-based objectives of the new general education curriculum but also contributes to building a sustainable education system where scientific knowledge moves in tandem with the socio-economic heartbeat of the local community.

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