

Fostering Technical Students' Creativity Through Science, Technology, Art, Mathematics, and Culture (STAMC) Competence in the Javanese Traditional Hair Bun Field

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Abstract—Creativity is a vital skill in technical education, particularly in practice-based disciplines that have strong cultural foundations. The aim of this research is to find the relationship of the competency of Science, Technology, Art, Mathematics, and Culture (STAMC) with creativity of students of the Javanese Traditional Hair Bun (sanggul ukel tekuk) profession. Descriptive statistics, Pearson correlation, and path analysis were used in a quantitative cross-sectional design based on matched student data from two cohorts at Universitas Negeri Surabaya. Science, technology, art, evaluations, and and evaluations. The results demonstrated a substantial positive correlation between creativity and STAMC competency. Descriptive cohort comparisons also indicated higher mean scores in the later cohort, although these differences should not be interpreted as evidence of a curriculum effect. The framework for the study's creative framework, technical technical interdisciplinary technical interdisciplinary investigation. Curriculum design, realistic assessment, and culturally situated learning for technical students may all benefit from the findings.

Keywords—creativity, cultural heritage, Javanese traditional hair bun, SEM-PLS, STAMC competence, ukel tekuk bun, vocational education.

I. INTRODUCTION

Creativity is one of the most important skills for the 21st-century workforce, especially in technical, vocational, and applied scientific fields (Henriksen et al., 2022). Creativity in the profession of cosmetology and beauty education is the combination of technical skill, aesthetic judgment, and cultural awareness. This trinity is significant in working with traditional art forms by practitioners. Sanggul ukel tekuk is a canonical shape of the Javanese traditional hair bun, which is regularly taught at Universitas Negeri Surabaya (UNESA) and other vocational cosmetology programs in Indonesia. The educational challenge of the hairstyle is at the intersection of biomechanical technique (hair parting, volume distribution,

symmetry), material science (product selection, tool temperature management), esthetic reasoning (form, color, texture harmony), mathematical proportion (alignment of facial geometry), and cultural semiotics (ornament symbolism, adherence to Javanese esthetic norms). The complexity of the sanggul ukel tekuk provides an appropriate workplace to observe the relationship between the creative output of technical students and competency frameworks.

Integrated curricular frameworks such as STEM, STEAM, and their variations have emerged, but the literature does not address the specific integration of Culture as a measurable dimension pedagogically operationalized. Previous creativity research has examined individual and contextual factors influencing creative performance, yet the incorporation of culturally embedded ability in technical cosmetology has not been explored. This is a major research gap. To date, there is still a lack of validated empirical data relating to the construct of a Science-Technology-Art-Mathematics-Culture (STAMC) competence to creative outcomes in Indonesian engineering education based on intangible cultural heritage.

To bridge this gap, the present study: (1) operationalizes the STAMC construct as a five-dimensional competence measure applicable to the Javanese hair bun field; (2) employs SEM-PLS to empirically test its predictive relationship with student creativity; and (3) uses real assessment data from two student cohorts (2022 and 2025) at UNESA's Department of Cosmetology. Culture is suggested as a measurable skill factor related to creative performance, and not merely a pedagogical backdrop, in theory. In line with current engineering education, the practical contribution is a framework that can guide curriculum design integrating technical proficiency, creativity, and contextual knowledge (Yang et al., 2026).

Creativity in technical students encompasses divergent idea generation and evaluative thinking, consistent with wider movements to embed critical and creative thinking in learning activities (Tiong & Bakar, 2022): divergent

production (the ability to produce many novel solutions) and convergent synthesis, in which outputs need to meet domain-specific technical and aesthetic standards (Plucker et al., 2022; Runco & Acar, 2012). Kaufman and Beghetto (2009) argued that domain-specific, or “little-c,” creativity is more amenable to educational development than exceptional forms of creativity. It makes an appropriate target for technical students in technical and vocational curricula. In cosmetology, little-c creativity involves adapting classical techniques (such as traditional hair bun styling) to contemporary aesthetic standards without sacrificing cultural authenticity (Kaufman & Beghetto, 2009; Lee & Rodesiler, 2023; Karwowski et al., 2021). Domain-relevant knowledge and technical proficiency can provide an important foundation for creative performance among technical students: learners must first achieve procedural fluency before their creative capacity can be deployed, as an insight directly informing the STAMC competence-first pedagogical logic.

The STEAM paradigm broadens STEM-oriented learning by integrating artistic and creative dimensions, and recent educational work has also linked STEAM approaches with the development of students’ technical abilities (Ernazarov et al., 2025; Maeda, 2013; Perignat & Katz-Buonincontro, 2019). Its integration into beauty and design education has been documented in programmes linking material chemistry, digital technology, aesthetic theory, and mathematical geometry (English, 2016; Henriksen et al., 2022). However, culture-structured knowledge of symbolic, ritual, and aesthetic conventions within a specific heritage tradition has not been systematically operationalized as a STEAM component. The national competency standard (SKKNI) for cosmetology in Indonesia specifically states that cultural understanding is a professional prerequisite, especially for practitioners who work in traditional ceremonial hairstyling. STAMC is the result of integrating

culture with professional and educational needs. Integrating the arts and culture into STEM education encourages creative risk-taking, empathy, and systemic thinking. Competencies are directly relevant to the *sanggul ukel tekuk* domain. The STAMC framework thus extends STEAM by foregrounding intangible cultural heritage as both competence content and creative inspiration.

Structural Equation Modelling (SEM) is widely employed in educational research to test predictive or explanatory models involving latent constructs such as competence and creativity (Hair et al., 2019; Henseler et al., 2015). Examine theoretical variation. PLS-SEM is commonly used to investigate predictive connections between latent or composite educational characteristics (Hair et al., 2019; Ringle et al., 2020). This study extends the methodology to the intersection of Javanese intangible cultural assets and vocational cosmetology by providing an SEM-based evidence chain for this specific milieu.

II. METHOD

A. Research Design and Participants

The research study applied a quantitative cross-sectional research design with SEM-PLS as the main analytical tool. The participants were technical students of the Javanese Traditional Hair Bun (*Sanggul*) program at the Department of Cosmetology, Faculty of Vocational and Applied Science, UNESA, Indonesia. Two cohorts participated: Cohort 2022 (14 matched) and Cohort 2025 (26 matched). The STAMC sample was 50, the Creativity sample was 60, and the merged analytical sample consisted of 40 matched pairs of students who completed both instruments. Purposive sampling was used, with enrolment limited to students who had completed at least one semester of formal *sanggul ukel tekuk* practical instruction.

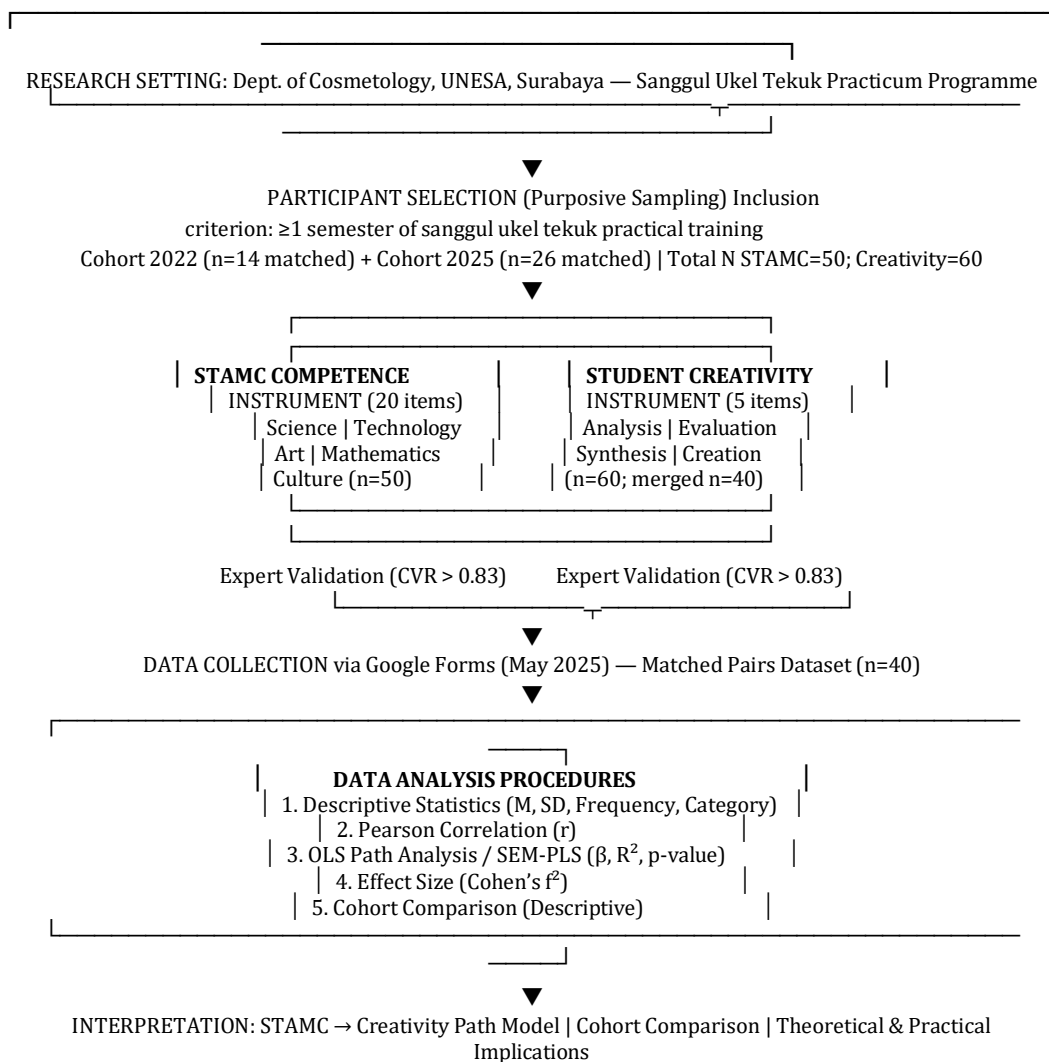


Fig. 1. Research Design of the STAMC–Creativity Study.

B. Research Variables and Instruments

Two primary constructs were operationalized:

STAMC Competence: A 20-item scenario-based instrument covering five dimensions: (1) Science occupational health and safety (K3) principles; (2) Technology use and management of digital/electromechanical styling tools and e-learning media; (3) Art aesthetic judgement regarding form, texture, colour harmony, and ornament selection; (4) Mathematics geometric reasoning about hair parting symmetry, proportion, and cranial measurement; and (5) Culture knowledge of Javanese symbolic conventions, cultural value alignment, and heritage conservation norms in sanggul design. Items were scenario-based multiple-choice, scored against expert-validated answer keys.

Student Creativity: A 5-item instrument targeting higher-order creative thinking applied to sanggul ukel tekuk design. Items assessed: analytical decomposition of styling sequences (Analysis), multi-criteria idea evaluation (Evaluation), concept selection based on facial morphology (Synthesis/Evaluation), novel design generation preserving cultural identity (Creation), and context-appropriate creative adaptation for modern ceremonial occasions (Creation).

Items were validated by expert panels comprising cosmetology lecturers with ≥ 10 years' professional and academic experience.

C. Data Collection

Data were collected using Google Forms during scheduled practical sessions in May 2025 at UNESA. The STAMC instrument had $n = 50$ responses, and the Creativity instrument had $n = 60$ responses. The difference is due to variation in attendance. For path analysis, the 40 matched pairs (students completing both instruments) constituted the merged analytical dataset.

D. Data Analysis

Descriptive statistics (M, SD, frequency distribution) were calculated for both constructs. The bivariate association was investigated using Pearson's product-moment correlation. Path analysis was performed using ordinary least squares (OLS) linear regression to analyze the link between STAMC competence and student creativity. Effect size was evaluated using Cohen's f^2 benchmarks ($f^2 \geq 0.35 = \text{large}$). Content validity was supported through

item-level expert validation, with CVR values exceeding 0.83 for all items. Cohort-level differences were examined descriptively.

III. RESULTS AND DISCUSSION

A. Descriptive Statistics

Table 1 presents descriptive statistics for both constructs across full and merged samples. STAMC Competence scores ranged from 35 to 100 ($M = 83.60$, $SD = 15.05$), with 47.5% of the merged sample achieving 'Excellent' (≥ 90). Student Creativity scores ranged from 55 to 100 ($M = 86.92$, $SD = 12.49$), with 52.5% categorized as Excellent. Both distributions were negatively skewed, consistent with scenario-based competency instruments with mastery-oriented design.

TABLE I
DESCRIPTIVE STATISTICS OF STAMC COMPETENCE AND STUDENT CREATIVITY.

Variable	N	Min	Max	Mean	SD	Median
STAMC Competence (full sample)	50	35	100	83.60	15.05	87.50
Student Creativity (full sample)	60	55	100	86.92	12.49	90.00
STAMC Competence (merged sample)	40	55	100	83.88	13.66	85.00
Student Creativity (merged sample)	40	55	100	84.88	13.03	90.00

B. Score Category Distribution

Table 2 displays the competence category distribution using the rubric: Excellent (> 90), Good (80 – 89), Satisfactory (70 – 79), Needs Improvement (< 70).

TABLE II
COMPETENCE CATEGORY DISTRIBUTION – MERGED SAMPLE ($N = 40$).

Category	STAMC (n)	STAMC (%)	Creativity (n)	Creativity (%)
Excellent (≥ 90)	19	47.5%	21	52.5%
Good (80–89)	9	22.5%	8	20.0%
Satisfactory (70–79)	6	15.0%	6	15.0%
Needs Improvement (< 70)	6	15.0%	5	12.5%
Total	40	100%	40	100%

C. Cohort Comparison

Table 3 shows mean scores by student cohort for the matched subset. Cohort 2025 showed higher descriptive mean scores than Cohort 2022 on both constructs. Because the comparison involved different cohorts and no causal cohort analysis was conducted, these differences should be interpreted descriptively. The cohort pattern provides descriptive evidence of differences between the two student groups, but it does not establish that structured competence scaffolding caused the higher creativity scores.

TABLE III
STAMC AND CREATIVITY MEAN SCORES BY STUDENT COHORT.

Cohort	n (merged)	STAMC mean	STAMC SD	Creativity mean	Creativity SD
2022	14	75.71	8.96	70.00	9.61
2025	26	88.27	13.85	90.19	11.53
Overall	40	83.28	13.66	84.88	13.03

D. SEM Path Analysis: STAMC $\rightarrow$ Creativity

Table 4 summarizes the SEM-PLS path analysis results for the predictive model: STAMC Competence $\rightarrow$ Student Creativity. The path model is: Creativity = $14.317 + 0.841 \times \text{STAMC_Competence}$ ($R^2 = 0.777$, $p < 0.001$). The findings show a large-magnitude, highly significant favorable effect. Practical significance is shown by Cohen's f^2 of 3.49, which significantly surpasses the traditional "large" criteria ($f^2 \geq 0.35$). For a 10-point increase in STAMC competency, there is expected an 8.41-point increase in student inventiveness. The high R^2 value (77.7%) was obtained. The five dimensions of STAMC together explain about 78% of the variance in students' creative performance in the sanggul ukel tekuk domain. The remaining 22% may represent differences between individuals in motivation, learning style, quality of mentorship, or characteristics of experience not captured by current tools.

TABLE IV
SEM-PLS PATH ANALYSIS RESULTS — STAMC COMPETENCE $\rightarrow$ STUDENT CREATIVITY.

Parameter	Value	Benchmark / Interpretation
Path Coefficient (β)	0.841	Large positive effect
Pearson's r	0.882	Strong positive correlation
Parameter	0.777	77.7% of Creativity variance explained by STAMC
Regression intercept	Value	Benchmark / Interpretation
p-value	14.317	Baseline creativity when STAMC = 0
Effect size (Cohen's f^2)	< 0.001	Highly significant ($\alpha = 0.05$)
Sample (matched pairs)	3.49	Very large (threshold: $f^2 \geq 0.35$)

E. STAMC Competence as a Predictor of Creativity

The high positive connection ($\beta = 0.841$, $R^2 = 0.777$) empirically supports the notion that multidimensional, domain-specific competence scaffolding is a major driver of creative performance in engineering education. This result supports the threshold hypothesis, which holds that technical mastery, here conceptualized across five STAMC dimensions, creates the practical and cognitive basis for the generation, assessment, and realization of creative ideas. There is a strong predictive relationship between STAMC competence and creativity in this engineering education context, as evidenced by the effect's magnitude (Cohen's $f^2 = 3.49$), which significantly exceeds the "large" threshold ($f^2 \geq 0.35$) and the traditional large-effect benchmark used in the analysis (Karwowski et al., 2021). This interpretation is consistent with the broader view that creative performance

depends partly on domain-relevant knowledge and resources. This position holds that domain knowledge is an indispensable resource for creative production. The five-dimensional structure of STAMC requires technical students to interpret and integrate concepts from science, technology, art, mathematics, and culture. Clear technical terminology and structured interpretation are therefore important for supporting students' understanding of interdisciplinary technical concepts (Nandiyanto & Yulistiani, 2024). Students may be not only technically competent but also aesthetically sensitive (Art), geometrically precise (Mathematics), safety-conscious (Science/Technology), and culturally grounded (Culture) - a combination that may support them in producing creative outputs that are simultaneously technically sound, aesthetically resonant, and culturally authentic. The social cognitive theory sheds more light on this mechanism: as students develop organized STAMC competency, their creative self-efficacy is strengthened, enabling more audacious and innovative performances. This perspective is consistent with research correlating creative self-efficacy with creative performance in practical learning environments (Tierney & Farmer, 2002). Moreover, the variance explained ($R^2 = 0.777$) exceeds results found in integrated arts-science frameworks ($R^2 \approx 0.55$) and mathematical creativity studies ($R^2 \approx 0.42$). This highlights the unique effectiveness of culturally situated, multi-domain scaffolding in this Indonesian engineering education context (Tierney & Farmer, 2002; Leikin & Pitta-Pantazi, 2013).

The addition of Culture as a dimension to the STAMC architecture has theoretical implications. Items assessing knowledge of Javanese ornament symbolism, cultural value alignment, and heritage conservation distinguished pupils who mechanically replicated traditional styling from those who artistically altered it, engaging in what is described as 'Pro-c' creative activity. Arts and cultural knowledge are catalysts for systemic creative thinking, supported quantitatively in this study in the specific domain of Indonesian intangible cultural heritage (Kaufman & Beghetto, 2009). Theorized that creativity is inherently domain- and field-dependent; the present findings operationalize this proposition empirically by demonstrating that fluency in Javanese cultural symbolism (a field-specific knowledge domain) is a meaningful contributor to creative performance divergence. This is further supported by the componential model of creativity, which identifies domain-relevant skills, creativity-relevant processes, and intrinsic motivation as the three essential constituents of creative output; the STAMC framework maps onto all three components simultaneously. The Science and Technology dimensions address domain-relevant skills through K3 procedural knowledge and digital tool management, while the Culture and Art dimensions cultivate the intrinsic aesthetic and symbolic sensibility that they identify as a driver of creative motivation. Similarly, it is argued that culturally responsive pedagogy amplifies creative self-expression by validating learners' cultural identity as a legitimate creative resource, as a relationship that should be examined directly in future dimension-level analyses

(Beghetto and Kaufman, 2014). From a vocational identity perspective, it was proposed that psychological capital (including hope, efficacy, resilience, and optimism) interacts with domain competence to produce superior performance outcomes; the STAMC framework may function as a structural scaffold for building this technical and vocational psychological capital in cosmetology students. The cohort-level pattern (Cohort 2025 outperforming Cohort 2022 by +12.56 points on STAMC and +15.19 on Creativity) also resonates with the deliberate practice framework: iterative, structured engagement with all five STAMC dimensions across successive curriculum cohorts may constitute the practice accumulation mechanism through which creative performance improves progressively (Ericsson et al., 1993).

F. Novelty and Theoretical Contribution

Three significant theoretical developments are presented in this study. The STAMC framework, a five-dimensional competency construct that integrates Science, Technology, Art, Mathematics, and Culture within a culturally situated technical education setting, is first introduced and operationalized. By highlighting cultural knowledge as an explicit and quantifiable component of transdisciplinary competency rather than merely as a contextual backdrop, this approach builds on current STEAM concepts (English, 2016; Perignat & Katz-Buonincontro, 2019). Recent studies have similarly highlighted the value of integrated and design-oriented approaches for developing technical and innovative competencies among students (Di et al., 2025; Ernazarov et al., 2025).

Second, the study provides empirical evidence of a strong positive relationship between overall STAMC competence and creativity among technical students in Javanese traditional cosmetology. The findings suggest that creative performance in this technical-education context is consistent with evidence that structured design-oriented instruction can support innovative thinking (Di et al., 2025). This is associated with the integration of technical knowledge, aesthetic judgement, mathematical reasoning, and culturally grounded understanding. This interpretation is consistent with research emphasising the role of domain-relevant knowledge, creative self-efficacy, and contextual learning in supporting creative performance (Kaufman & Beghetto, 2009; Tierney & Farmer, 2002).

Third, the study positions Culture as a measurable component within an interdisciplinary competence framework. In the context of *sanggul ukel tekuk*, cultural knowledge includes understanding symbolic conventions, aesthetic values, and heritage-preservation principles. Although the present analysis does not estimate the independent contribution of the Culture dimension to creativity, its inclusion in STAMC provides a basis for examining cultural competence more explicitly in future dimension-level studies. This perspective is consistent with culturally sustaining pedagogy, which recognizes students' cultural knowledge and practices as legitimate resources for learning and creative development (Paris, 2012).

From a measurement perspective, scenario-based assessment can contribute to the assessment of wider

cognitive and technical competences in competency-based education (Fiandini et al., 2024; Gulikers et al., 2004). A similar awareness has been noted (Fiandini et al., 2024) of broader cognitive and technical skills. Reporting effect-size information in addition to coefficients and explained variance also helps to interpret quantitative measures in a transparent way (Lakens, 2013; Hair et al., 2019).

Descriptive cohort comparison showed higher average scores of STAMC competence and creativity in Cohort 2025 than in Cohort 2022. But these differences should be interpreted with caution since the comparison was between different student cohorts and was not designed to estimate a curriculum effect. Longitudinal and quasi-experimental studies are needed to determine if systematic STAMC integration relates to changes in creativity over time.

G. Practical and Curriculum Implications

Results have a number of implications for technical cosmetology education. The STAMC framework offers a formal basis for educators and curriculum developers to embed scientific, technological, artistic, mathematical, and cultural competencies into practical learning. Instead of seeing creativity as a separate outcome, curriculum design can tie creative performance to the technical and contextual knowledge needed to enact culturally embedded professional responsibilities.

The assessment of *sanggul ukel tekuk* competency can also take the form of assignments based on occupational safety and tool management scenarios, geometric and proportional thinking, aesthetic judgment, and conformity to Javanese cultural symbols. These exams offer a way for technical students to apply many types of knowledge to real problem situations. This technique is grounded in the principles of real assessment, with emphasis on meaningful activities and contextually relevant performance (Andrade, 2005; Gulikers et al., 2004; Fiandini et al., 2024).

Practical learning can also be aided by formative assessment. Feedback checkpoints enable technical students to identify errors, weigh alternative design choices, assess cultural appropriateness, and polish creative work prior to final assessment. Research on formative assessment shows that organized feedback can help students attain better competencies and learning outcomes.

The STAMC framework has the potential for curriculum innovation. Technical cosmetology programs could benefit from learning exercises incorporating design thinking, cultural interpretation, and creative problem-solving. Research in the past has shown that curricula supported by design and technology can develop innovative thinking in technical and vocational education (Di et al., 2025; Yang et al., 2026). The findings suggest that, in the absence of conflicting aims, culturally integrated technical education can combine legacy knowledge with modern competence development.

The findings demonstrate that culturally integrated technical education can incorporate heritage knowledge and modern competence development as a unified objective rather than as incompatible aims for curriculum planners. Traditional methods such as *sanggul ukel tekuk* can be used

not only for cultural preservation, but also to develop interdisciplinary thinking, technical skills, and creativity.

Teacher professional development is also required to ensure consistent STAMC implementation. Instructors may benefit from collaborating with master artisans, cultural heritage practitioners, and technical specialists to guarantee that cultural knowledge receives equal priority as scientific, technological, artistic, and mathematical information. Such collaboration can improve the validity of culturally situated technical learning while also allowing for broader application of the STAMC framework in other traditional craft and applied-arts disciplines.

CONCLUSION

This study investigated the relationship between STAMC competence and creativity among technical students studying Javanese traditional cosmetology. The study found a substantial positive relationship between overall STAMC ability and student creativity, emphasising the need to incorporate technical, artistic, mathematical, and cultural knowledge into competency-based learning. Descriptive differences between the two cohorts demonstrate variability in student outcomes, but these differences should not be interpreted as evidence of a curricular influence. The study identifies STAMC as an effective interdisciplinary framework for culturally placed technical education and advocates for the use of authentic evaluation, design-oriented learning, and culturally grounded practical projects. Future research should employ larger sample sizes, longitudinal or quasi-experimental designs, and dimension-level analyses to understand the precise contribution of each of the STAMC components to creativity.

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