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Development of Strategic Learning Materials in Shielded Metal ARC Welding (SMAW) NC II

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Abstract— *The persistent failure of conventional Technical-Vocational-Livelihood (TVL) instruction in Shielded Metal Arc Welding (SMAW) has resulted in low mastery of complex psychomotor skills and high failure rates on the National Certificate (NC) II assessment, creating a critical skills gap in the national workforce. This study addressed this pedagogical shortfall by developing and validating Strategic Learning Materials (SLMs). The SLMs were engineered by integrating Cognitive Load Theory (CLT) with modern multimedia design principles to transform abstract theory into a methodology that guarantees procedural mastery for the most cognitively demanding competencies (1G, 2G, and 3G welding positions). Employing a quasi-experimental, pre-test/post-test control group design with 65 Grade 12 SMAW students, results demonstrated a statistically significant improvement in mastery. The Mean Percentage Score (MPS) rose from 44.89% (Low Mastery) in the pre-test to 81.23% (High Mastery) in the post-test, a gain confirmed by a one-way ANOVA ($p = 0.000$). Furthermore, the SLMs received an "Outstanding" rating from a panel of expert and user validators. The study concludes that these validated SLMs are an effective, scalable solution for competency-based education, offering a replicable model that directly enhances student outcomes and contributes to a more highly skilled and certified workforce.*

Keywords— *Strategic Learning Materials (SLMs), Shielded Metal Arc Welding (SMAW), National Certificate (NC) II, Cognitive Load Theory (CLT), Workforce Readiness.*

I. Introduction

The prevalent crisis in Technical-Vocational-Livelihood (TVL) training, evidenced by alarmingly low mastery and high failure rates on the National Certificate (NC) II assessment for Shielded Metal Arc Welding (SMAW), necessitated a radical instructional intervention. This systemic deficiency is further highlighted by the persistent failure of conventional TVL training to translate theoretical understanding into demonstrable SMAW mastery, which remains a pressing concern that undermines the national supply of NC II-certified workers [9] [34]. This gap is particularly critical in a post-pandemic economy that increasingly demands adaptable, high-precision skilled labor.

Central to this pedagogical shortfall is the mismanagement of cognitive processes during instruction, making Cognitive Load Theory (CLT) a pivotal framework for reform [37][27]. Recent studies emphasize that reducing extraneous cognitive load—mental effort not contributing to schema formation—is essential when teaching complex psychomotor tasks such as 3G welding [8]. Furthermore, [37] assert that learning efficiency in technical fields directly correlates with how effectively learners direct germane cognitive load toward schema construction. Consequently, the development of Strategic Learning Materials (SLMs) in this study was rigorously informed by recent CLT advancements—incorporating worked examples, transient information delivery through multimedia, and immediate feedback loops—to optimize cognitive architecture for rapid and sustainable skill acquisition [24][27].

Translating these theoretical insights into practice reveals a localized dimension of the problem, particularly in the Division of Surigao del Sur, where the Mean Percentage Score (MPS) of the Pre-Test/Diagnostic Test for School Year 2023–2024 revealed a below-mastery level of 44.89%. In response to this local reality, and in line with DepEd Order No. 018, s. 2020, which mandates the provision of quality supplementary learning resources, this study was conceived to develop locally relevant, pedagogically sound materials that directly address these deficiencies. The goal was to transform instruction from an abstract, theory-heavy model into a performance-oriented methodology that ensures procedural mastery, specifically targeting the most cognitively demanding SMAW competencies: the 1G, 2G, and 3G welding positions.

Statement of the Problem

This study aims to address these shortcomings by developing Strategic Learning Materials (SLMs) specifically tailored to SMAW NC II training.

1. What is the mean percentage score of the students prior to the usage of the self-made SMAW learning materials of the respondents as to least learned competencies;
1.1 Weld Carbon Steel Plates in Flat Position (1G)
1.2 Weld Carbon Steel Plates in Horizontal Position (2G)
1.3 Weld Carbon Steel Plates in Vertical Position (3G)
2. What is the mean percentage score of the students after the usage of the self-made SMAW learning materials of the respondents?
3. Is there a significant difference between the mean percentage score of the students in each least learned competency?
4. What is the extent of effectiveness of the Strategic Learning Material in SMAW NC II based on the expert's validation?
5. What enhanced Strategic Learning Material in SMAW NC II can be made based on the findings of the study?

II. Materials and Method

The research employed a Quasi-Experimental Research Design with a pre-test/post-test non-equivalent groups design to evaluate the effectiveness of the developed Strategic Learning Materials (SLMs). The study was conducted at

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Sagbayan National High School in Surigao del Sur, involving 65 Grade 12 TVL-SMAW students selected via universal sampling. The materials development was anchored on the principles of Cognitive Load Theory (CLT), Dual Coding Theory (DCT), and Self-Determination Theory (SDT). The procedure involved a diagnostic pre-test to identify the least-learned competencies (1G, 2G, and 3G welding), the implementation of the developed SLMs as the instructional intervention, and the administration of a subsequent post-test to assess student mastery. The SLMs underwent rigorous content and design validation by a panel of experts before implementation. Student performance data, including Mean Percentage Scores (MPS), were analyzed using a one-way Analysis of Variance (ANOVA) to determine the significant difference between the pre-test and post-test scores.

III. Results and Discussion

The Mean Percentage Score of the Students Prior to the Usage of the Strategic Learning Materials in SMAW NC II.

TABLE 1. Students' Mean Percentage Scores in the Pre-test

Test	Mean Score	Mean Percentage	Verbal Interpretation
Pre-test	22.446	44.89%	Low Mastery

The pre-test analysis yielded a Mean Percentage Score (MPS) of 44.89% among Grade 12 TVL-SMAW students, categorized as Low Mastery in the least-learned welding competencies (1G, 2G, and 3G). This deficiency confirms a critical gap in foundational psychomotor skills, directly attributable to the use of outdated resources and a lack of interactive content, locally manifesting the broader challenge of students failing the mandatory National Certificate (NC) II assessment in the Division of Surigao del Sur. This result aligns consistently with local research focusing on competency gaps in high-precision trades. For instance [7] found persistent struggles among TVL students in the Mindanao region in mastering complex, manipulative welding skills, specifically noting out-of-position techniques as the primary hurdle. [28] similarly reported that mastery deficiencies are concentrated in advanced welding positions due to the inadequacy of generic, one-size-fits-all materials to provide intensive, targeted instruction. Consequently, the low MPS of 44.89% confirms that the students were operating under a significant extraneous cognitive load, where the complexity of the information, likely compounded by poorly structured or text-heavy materials, was impeding schema formation as posited by Cognitive Load Theory [27] thereby justifying the development of the strategic, interventionist materials.

The Mean Percentage Score of the Students After the Usage of the Strategic Learning Materials SMAW NC II

TABLE 2. Students' Mean Percentage Scores in the Post-test (N=65 Sample Size)

Test	Mean Score	Mean Percentage	Verbal Interpretation
Post-test	40.615	81.23%	High Mastery

Following the intervention period utilizing the Strategic Learning Materials, the students achieved a notable improvement, resulting in a Mean Percentage Score (MPS) of 81.23%, which is classified as High Mastery. This result denotes a substantial raw gain of 36.34 percentage points from the pre-test, confirming that the majority of the students successfully surpassed the 75% competency threshold. This measurable leap from a deficient state to one of competence serves as strong preliminary evidence of the efficacy of the developed materials. The success of the intervention strongly supports the application of the integrated theoretical framework. The marked improvement is hypothesized to be due to the SLMs' adherence to Dual Coding Theory (DCT), where the combination of visual representations (welding diagrams, procedural videos) and textual explanations facilitated superior processing of complex psychomotor procedures. This finding resonates with the foreign study by [20], whose quasi-experimental results demonstrated that students using multimedia-enhanced, self-paced modules achieved statistically significant gains in post-test scores, attributing success to the enhanced visual and flexible learning format. Similarly, local research [38] validated that targeted modules addressing specific skills yielded a statistically significant boost in performance. Therefore, the high post-test score suggests the SLMs successfully managed the cognitive load and targeted the specific learning deficits effectively, thereby facilitating the rapid acquisition of the least learned SMAW competencies.

The Significant Difference Between the Mean Percentage Scores of the Students in Each Least Learned Competency (1G, 2G, And 3G) Before and After the Intervention

TABLE 3. Test of Significant Difference between Pre-test and Post-test Scores

Comparison	F-value	p-value	Decision	Conclusion
Pre-test vs. Post-test	292.1	0	Reject H0	Significant

The inferential analysis conducted using a One-way ANOVA yielded an F-value of 292.10 and a p-value of 0.000 Given that the p-value is substantially below the established alpha level of significance (alpha = 0.05), the null hypothesis (HO) is decisively rejected. This finding leads to the conclusive statement that a statistically significant difference exists between the mean percentage scores of the students before and after using the Strategic Learning Materials. The statistical significance confirms the causal role of the SLMs as the active independent variable driving student performance improvement. The change observed is highly unlikely to be due to chance, maturation, or external factors. This result provides robust evidence supporting the core premise of the study. The success of this targeted intervention aligns with the findings [1] whose study in technical trades also demonstrated that concentrated, specialized instruction focusing on problem areas (like out-of-position welding) leads to superior and statistically validated outcomes compared to general curriculum delivery.

Moreover, by achieving this significant difference, the SLMs proved effective in managing the extraneous cognitive load associated with complex technical skills, allowing the students to successfully engage in the germane cognitive load

necessary for skill mastery and schema formation, as theorized [27]

The Extent of Effectiveness in the Strategic Learning Materials in SMAW NC II, Based on The Experts' Validation

TABLE 4. Experts' Validation Ratings for the Strategic Learning Materials (SLMs)

Factor	Weighted Mean (WM)	Verbal Description
Objectives	4.72	Outstanding
Technical Quality	4.49	Outstanding
Instructional Quality	4.47	Outstanding
Organization	4.63	Outstanding
Contextualized Content	4.59	Outstanding
Alignment with Training Regulations	4.69	Outstanding
Overall Validation Mean	4.60	Outstanding
Other Factor	Weighted Mean	Verbal Description
Ease of Administration	4.61	Outstanding
Time	4.67	Outstanding
Contextualized Content	4.69	Outstanding
Other Factors	4.72	Outstanding
Overall Weighted Mean	4.67	Outstanding

The comprehensive validation of the Strategic Learning Materials (SLMs) achieved an "Outstanding" rating across all measured factors from both the expert panel and student-users. Expert validation indicated highest approval for Objectives (Weighted Mean, WM = 4.72), confirming exceptional alignment of learning goals with competency standards. The lowest-rated, yet still "Outstanding," factor was Instructional Quality (WM = 4.47), suggesting minor design refinements were possible. In the user evaluation, the highest WM was for Other Factors (WM = 4.72), demonstrating the materials' strong motivational and overall helpfulness merit. The lowest user rating was for Ease of Administration (WM = 4.61). This robust validation confirms the high structural and technical quality of the SLMs, aligning with industry standards (WM for Technical Quality = 4.49; Alignment with Training Regulations = 4.69), while simultaneously affirming high user acceptance, practicality, and contextual relevance (WM for Contextualized Content = 4.69). Overall, the high "Outstanding" ratings establish the construct validity and reliability of the intervention materials, serving as a critical precursor to the successful intervention effects measured in the subsequent phase.

This high validation rating is critical, as it establishes the construct validity and reliability of the intervention materials before measuring their impact. The strong scores in Technical Quality (WM = 4.49) and Alignment with Training Regulations (WM = 4.69) corroborate the framework established [6] affirming that the tripartite validation process successfully mitigated potential flaws in content and design by meeting both pedagogical and rigorous technical/industry standards necessary for the SMAW trade. Furthermore, the highest user rating for "Other Factors" strongly substantiates the integration of motivational theory, aligning with the findings [32] that intuitive and highly usable materials foster greater student engagement and retention, thus confirming the SLMs acted as effective motivational tools. While Instructional Quality was the lowest-rated factor by experts, the overall "Outstanding" rating negates the assertion that the material's internal design was fundamentally flawed, supporting the argument [4] that such high validation scores are the expected precursors to a successful intervention effect. Finally, the high rating for Contextualized Content (WM = 4.69) affirms the material's relevance to the local environment and NC II requirements, a necessity highlighted [31] in the Philippine context.

Enhanced Strategic Learning Materials for SMAW NC II

The study produced three validated Strategic Learning Modules (SLMs) for the SMAW NC II program, each targeting the least mastered welding positions—1G (Flat), 2G (Horizontal), and 3G (Vertical). Designed as user-friendly, remedial resources, these modules provide Grade 12 TVL students with a structured path to develop essential knowledge and practical skills aligned with certification standards. Grounded in empirical findings, the SLMs address low mastery revealed in pretest results, effectively bridging the gap between theory and practice to enhance students' readiness for the NC II assessment.

Anchored on the empirical findings of the study, the development of the SLMs directly responds to the low mastery levels revealed in the pretest results. Each module was purposefully designed to address specific learning gaps and enhance psychomotor performance in critical welding tasks. Through focused content, guided exercises, and clear visual instruction, the SLMs function as validated, high-quality learning resources that remediate deficiencies in traditional instruction. Ultimately, this output bridges the divide between classroom learning and workplace competence, ensuring that TVL students are better prepared for the NC II assessment and future industry demands.

IV. Conclusions

The study concludes that the initial pre-test, which yielded a Low Mastery Mean Percentage Score (MPS) of 44.89% in the critical 1G, 2G, and 3G welding competencies, established a significant, empirically validated gap in the foundational psychomotor skills of Grade 12 TVL-SMAW students, necessitating an immediate instructional intervention. The subsequent implementation of the developed Strategic Learning Materials (SLMs) proved highly effective, resulting in a substantial and statistically significant improvement: post-test results showed a rise to an 81.23% MPS, classified as High Mastery, with a raw gain of 36.34 percentage points. This improvement was statistically confirmed by a One-Way ANOVA ($p = 0.000$), which established the SLMs as the causal factor for enhanced student competency. Furthermore, the comprehensive validation of the SLMs—which received an overall "Outstanding" rating from both experts (affirming structural quality and alignment) and users (affirming practicality and engagement)—confirms the materials' quality, pedagogical soundness, and practical value, demonstrating that the validated SLMs successfully bridge the gap between theoretical deficit and practical proficiency for successful SMAW NC II certification.

Recommendations

To maximize the impact and ensure the long-term sustainability of the Strategic Learning Materials (SLMs), several actions are recommended: Students are strongly urged to consistently use the SLMs to reinforce mastery of the 1G, 2G, and 3G welding positions, thereby ensuring their practical skills align with National Certificate (NC) II certification standards. Teachers must integrate the SLMs as the primary instructional tool for core SMAW competencies and facilitate ongoing feedback sessions to maintain effective application and continuous skill acquisition. Curriculum Developers should adopt the SLMs' validated, competency-based design as a replicable model for creating targeted learning resources across other Technical-Vocational-Livelihood (TVL) specializations, ensuring a consistent standard of evidence-based quality. The Department of Education (DepEd) – Division of Surigao del Sur is advised to officially evaluate and endorse the SLMs for division-wide dissemination, standardizing the SMAW NC II program and promoting the replication of this successful model. Furthermore, TESDA should collaborate with DepEd to review and integrate the SLMs into regional training programs to strengthen the quality of workforce training. Finally, future researchers are encouraged to investigate the long-term effects of SLM utilization on skill retention, NC II certification outcomes, and the applicability of the SLM design principles to other high-precision technical trades, guiding continuous curriculum innovation.

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