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Development of Laboratory Manual as Supplemental Materials in Teaching Technical Vocational Education Program

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ABSTRACT

This study aimed to develop laboratory manual as supplemental materials in teaching technical vocational education program in the College of Education, Technical Vocational Education Department for the academic year 2024-2025. This study employed a mixed-method approach using descriptive, developmental, and experimental designs guided by the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). It involved diagnostic testing, bibliometric review, and quasi-experimental procedures to develop and validate a TESDA-aligned laboratory manual for Civil Technology. Data was gathered from students, teachers, curriculum experts, and academic heads using validated instruments, with results analyzed through average weighted mean and standard deviation. The results indicate that the study identified least learned competencies in Civil Technology II and used these to develop a TESDA-aligned laboratory manual. Bibliometric insights shaped its structure, and experimental results confirmed its effectiveness in improving student learning, earning strong support from students, teachers, and academic heads. It is strongly recommended to may consider adopting and integrate the TESDA-aligned laboratory manual into the Industrial Arts curriculum to strengthen hands-on learning and improve student competency.

Keywords: Development, laboratory manual, supplemental material, descriptive, innovation, experimental

INTRODUCTION

Technical-Vocational Education and Training (TVET) continue to serve as a critical platform for preparing learners with practical and employable skills, especially in countries like the Philippines where there is an ongoing push toward workforce alignment and national development (Talento, et al. 2022). The K–12 curriculum's Technical-Vocational-Livelihood (TVL) strand focuses on the hands-on ability in areas such as Industrial Arts, including electrical installation, plumbing, carpentry, and related trade subjects (Edralin & Pastrana 2023). Laboratory-based education is therefore fundamental in supporting technical competence and graduating students who are workplace-ready.

In conducting Technical-Vocational Education and Training (TVET) programs, laboratory learning is the focal point of experiential instruction (Zirkle, Jeffery, & Schrewe, 2019). TVET tracks, and especially Industrial Arts, are crafted to impart students with practical skills that reflect the demands of actual work settings. Still, most institutions still struggle with the availability and sufficiency of teaching materials that facilitate laboratory instruction. This critical shortfall undercuts not just the academic quality of student learning outcomes but also risks institutional compliance with key accrediting agencies like the Accrediting Agency of Chartered Colleges and Universities in the Philippines (AACUP) and the Commission on Higher Education (CHED) (Liquido, 2018).

Instructional materials—specifically laboratory manuals—are critical elements found in the CHED Certificate of Program Compliance (COPC) as primary markers for academic quality and implementation. Such materials

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are organized manuals that guarantee uniformity in the practice of instruction, procedural instruction clarity, and skill assessment correctness. AACUP also stresses well-developed and validated laboratory manuals in its accreditation of programs to serve as gauges of instruction readiness, implementation of curriculum, and student activities. Without these, institutions face difficulties in proving the robustness and relevance of their academic offerings during evaluation and accreditation. Although several studies have explored instructional material development in science and technology subjects (Mercado, 2020; Amparado et al., 2025), few have focused on the creation of laboratory manuals tailored to Industrial Arts under the TVET framework.

Existing resources often lack contextual relevance, are not competency-specific, or fail to address the actual skill gaps of learners identified in practical settings (Diola, 2023; Garcia et al., 2023). In addition, although there exists literature favoring performance-based learning and experiential instruction, there is still a wide gap in certified, field-validated laboratory manuals that are specifically addressing the least-mastered Industrial Arts competencies. This gap between curricular objectives and teaching resources poses a challenge to instructors and constrains students' exposure to higher-order thinking and technical competence. The absence of such teaching tools has far-reaching implications. To begin with, it inhibits the provision of competency-based education, particularly in very technical fields like plumbing, masonry, carpentry, and electrical work. Teachers tend to use makeshift approaches or even verbal instruction, which does not give students standardized instructions for procedures, safety measures, and handling equipment. As noted by Edralin and Pastrana (2023), the absence of well-developed learning resources in TVET institutions contributes significantly to the mismatch between graduate skills and labor market expectations. Inadequate resources, especially those intended for laboratory use, result in fragmented instruction, limited hands-on exposure, and an over-reliance on theoretical knowledge.

Commission of Higher Education push for outcomes-based education (OBE) emphasizes the need for quantifiable skill-based results that demonstrate whether graduates are prepared for their future careers. The model requires instructional materials which include step-by-step learning resources, assessment rubrics and reflective elements usually found in laboratory manuals. Without these, schools face challenges in documenting learning progress, aligning instruction with program outcomes, and supporting differentiated instruction—another requirement in quality assurance and accreditation. To address this gap, the present study aims to develop and evaluate a laboratory manual specifically designed as supplemental material for teaching Industrial Arts in the TVET program. The manual integrates key components drawn from a bibliometric review of effective educational resources—such as objectives, procedures, data recording sections, and assessment tools—and aligns them with the least-learned competencies identified through student performance data.

The study evaluates the manual's instructional, technical, and content validity, as well as its impact on student learning outcomes and teacher satisfaction. By doing so, it contributes to both the literature and practice of technical education, offering a structured and empirically validated tool for enhancing vocational instruction. In this study, aimed to develop laboratory manuals as supplemental materials in teaching technical vocational education program in the College of Education, Technical Vocational Education Department for the academic year 2024-2025. The laboratory manual provides Industrial Education students with clear, structured guidance that enhances hands-on learning, promotes skill mastery, and bridges the gap between theoretical knowledge and practical application—preparing them more effectively for real-world technical work.

METHODOLOGY

This study utilized a mixed-method approach, combining descriptive, developmental, and experimental research designs to guide the development and validation of a laboratory manual intended to supplement instruction in the Technical-Vocational Education and Training (TVED) program, specifically in Industrial Arts. The methodology followed the ADDIE model—Analysis, Design, Development, Implementation, and Evaluation—to ensure the systematic creation and testing of instructional materials based on data-driven insights (Spatioti et al. 2022). The descriptive method was initially employed to determine the least learned competencies among students enrolled in Industrial Arts. A diagnostic test was used as the primary instrument to assess student proficiency in selected competencies in Civil technology 2 such as masonry, plumbing, and tile setting. The

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ADDIE Model served as the backbone of the manual development process: Analysis – Data from the diagnostic tests, bibliometric review, and coarse syllabus helped identify learning gaps and instructional needs. This phase established the justification for creating a supplemental manual addressing specific competency deficiencies. Design – Based on the analysis, lesson objectives, lab activity structures, materials lists, procedures, and assessment tasks were designed. Emphasis was placed on alignment with the TVED curriculum and the CHED Certificate of Compliance requirements. Development – The laboratory manual was drafted, including standard sections such as Preliminaries, Pre-Lab Tasks, Activity Procedures, Observation/Data Sheets, and Post-Lab Questions. Content was enriched with illustrations, safety protocols, and student-centered tasks and validated by experts. Implementation – The manual was piloted in BTLED 3C-3D. Here, an experimental design was incorporated to measure the effectiveness of the manual. A quasi-experimental approach was used, involving two groups: Experimental Group: Students who used the newly developed laboratory manual. Control Group: Students who continued using traditional instructional methods. Evaluation – The manual underwent comprehensive validation and evaluation using adopted instruments to assess content, technical, and instructional quality. Three groups of respondents participated: Students – who were involved in both the diagnostic test and the experimental implementation, providing feedback on learning experience and outcome. Teachers – who validated the manual in terms of content accuracy, instructional design, alignment with competency standards, and technical quality. Academic heads – who evaluated the manual's integration into teaching practice, classroom impact, and contribution to program effectiveness.

The participants in the study were chosen purposively. There were 40 students, 10 teachers, 5 curriculum development experts and 5 academic heads. The instrument utilized in this study is composed of six parts. Part I is 30 items diagnostic test that covers Civil Technology Competency. Part II is a bibliometric aps for the review of literature in the development of laboratory manual. Part III, Design of Laboratory manual in terms of practical relevance, hands-on practice, equipment/tools/materials, clarity, and assessment methods. Part IV is a validity instrument adapted from Mercado, (2020), for the development of the laboratory manual. Part V, a 20 items pretest and posttest for the implementation phase. Part VI is the evaluation instrument rated by students, teachers and academic head. All the instruments were subjected to content and construct validity. To determine the analysis, design, development, implementation and evaluation of the laboratory manual as evaluated by the respondents, Average weighted mean and standard deviation were employed.

RESULTS

Least Competencies

Least Competencies. Table 1 shows the diagnostic test results among 64 undergraduate BTLED major in Industrial Arts education students was conducted in AY 2024–2025. This was to determine the least learned competencies in Civil Technology II (Masonry, Plumbing & Tile Setting), which became the basis of the activities included in the laboratory manual. Likewise, the researchers reviewed the common syllabus from instructors as part of the needs assessment. The findings indicate that among the 30 total competencies, 9 of them are classified as "least practiced" or "least suitable" for inclusion in standard laboratory activities. The competencies that fall into this category exhibit very low frequency or are rarely implemented in lab settings due to various constraints—ranging from material costs, time limitations, safety concerns, to instructional efficiency as the recommended for the development of laboratory manual in Civil Technology 2. This finding collaborates with the study Gari, and Malonisio, (2023), who highlighted the tendency to prioritize such tasks in constrained learning environments. Likewise, Garcia et al. (2023) pointed out, such preparatory tasks are often overlooked in favor of more skill-intensive competencies.

Table 1. Least Competencies, (Overall = 30 competencies)

Item	Least Competency	Results	Rank	Interpretation
3	Site Layout and Batter Board Setup	low frequency	6	Rarely repeated in lab; mainly demo-based

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6	Scaffolding Assembly	low frequency	7	Safety concerns and equipment limitations reduce lab inclusion
7	PPE utilization	Very low frequency	5	Performed only for demonstration due to gender utilization
8	Wall Plastering	low frequency	9	High material cost and cleanup make it unsuitable for routine lab activities
12	Preparing Pipes, Tools and Equipment for Installation	Very low frequency	2	Not a standalone task; integrated into other plumbing activities
14	Make Piping Joints and Connection	Very low frequency	1	Often covered under broader plumbing tasks rather than isolated practice
21	Perform Plumbing Repair and Maintenance Works	low frequency	8	More appropriate for actual fieldwork than classroom-based labs
30	Lay and repair wall and floor tiles	Very low frequency	3	Low priority due to space and specific material requirement

Analysis

Bibliometric Review on Laboratory Manual.

Table 2 indicates the bibliometric review of existing laboratory manual developments across science and technical disciplines provides valuable insights into best practices, structural elements, and pedagogical applications that can be adapted and contextualized for use in Civil Technology, particularly in Masonry, Plumbing and Tile Setting competencies. Several sources (Mercado, 2020; Diola, 2023) emphasize the importance of including preliminaries such as title pages, safety guidelines, objectives, and score sheets. These components help establish expectations, guide learner engagement, and standardize assessment. Deutch (2018) and Ahern (2018) highlight the value of linking laboratory tasks to real-world scenarios or prior knowledge to enhance student engagement and learning depth. In Industrial Arts, this could mean connecting each task to workplace situations or common field challenges. Amparado et al. (2025) explored a simulation-based manual to address the limitations of physical lab activities, particularly in contexts where materials are scarce or challenging logistics. As seen in Rogayan & Dollete (2019), modular and competency-driven structures support focused learning and adaptability in various classroom settings. This review engaged for the model to use in the development of laboratory manual particularly in Civil Technology 2 (Masonry, Plumbing & Tile Setting), the manual should incorporate clear safety protocols, step-by-step procedures, and competency-based rubrics, especially since some tasks involve equipment handling and hazardous materials. This creates a structured format aligned with TESDA's Competency-Based Training model.

Table 2: Bibliometric Review on Laboratory Manual

Source	Part of Manual	Utilization/Purpose
Development of laboratory manual in physics for engineers. (Mercado, 2020).	Preliminaries, title page, foreword, safety guidelines, table of contents, and score sheet, activities, introduction, objectives, list of materials, equations, illustrations, procedures, tables & data sheet,	Provides background concepts, often discussing the move from basic concepts to more complex cellular structures.

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	follow-up questions and conclusions, references.	
Biochemistry laboratory reports: Filling in the introduction and discussion (Deutch, 2018)	Introduction, Objectives, Materials, Procedure, Report Sheet, Assessment and References.	Places the lab exercise in a broader experimental context, connecting it to previously published research.
Development and Validation of Laboratory Manual in Life Science for Grade 11 Senior High School: An Input to Instructional Material Development. (Diola, 2023)	Introduction, Objectives, Materials, Procedure, Report Sheet, Assessment and References.	Outlines the steps for conducting experiments, including materials and equipment needed.
Development and Validation of a Computer Simulation-Based Laboratory Manual for Gas Laws. (Amparado, Tapia, & Sanchez, 2025).	Cover Page, Preface, Table of Contents, Introduction, Simulation Activities, and References.	Used as a means for students to learn how to write laboratory procedures.
Microbiology: A Laboratory Experience (Ahern, 2018)	Introduction, Main Body, Exercises	Designed to engage and support students' interest in microbiology and provide hands-on experience.
Development and validation of a field-based laboratory manual in general botany. (Lerios, 2001).	Introduction, objectives, materials and apparatus, procedure / activities, and evaluation.	Provides a valuable resource for teaching Life Science
Development and Validation of Physical Science Workbook for Senior High School (Rogayan, & Dollete, 2019)	Introductory statement, Learning outcomes, Learning tasks, Add-on vocabulary, Suggested readings	Used as a competency-based workbook on physical science in lecture classes in secondary education.
Competency based learning material (CBML) (Parvez, 2023)	Introduction, learner guide, competencies, outcomes, learning experiences, information sheet, performance criteria checklist	The material is designed to be learner-centered focusing on outcomes and practical application of knowledge and skills.

Design

Design of Laboratory Manual. Table 3 shows that the design of the laboratory manual obtained an overall average score of 4.7 (Highly structured and organized) indicates a highly favorable evaluation of the manual's structure and instructional effectiveness. The ratings across all four manual format indicators—Preliminaries; Prelab; Observation and Data Recording; and Postlab highlight the manual's strength in addressing the core instructional needs of Industrial Arts learners.

These findings carry several key implications for curriculum enhancement, teaching strategy, and competency-based training. It suggests that the manual effectively connects lab activities to real-world applications, a cornerstone of Technical-Vocational Education and Training (TVET). According to Reyes & Dizon (2023), laboratory manuals that prioritize contextual learning experiences significantly increase student engagement and skill retention. Likewise, Godsk, and Møller, (2025) pointed out, a well-designed manual doesn't just teach content—it shapes how technical education is delivered.

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Table 3. Design of Laboratory manual in terms of practical relevance, hands-on practice, equipment/tools/materials, clarity, and assessment methods

Manual Format	Mean Score	Interpretation
Preliminaries	4.6	Highly structured and organized
Prelab	4.7	Highly structured and organized
Observation and Data Recording	4.8	Highly structured and organized
Postlab	4.7	Highly structured and organized
Average Mean	**4.7**	**Highly structured and organized**

Development

Validity of Laboratory Manual in terms of Content.

Table 4 reflects a highly favorable evaluation, with a composite mean of 3.90 and a qualitative interpretation of "Strongly Agree." This suggests that the manual is not only content-rich and pedagogically sound, but also effectively aligned with curricular goals, inclusive principles, and instructional standards. These results hold significant implications for educational practice, curriculum development, and instructional material design in the Industrial Arts domain. This aligns with the findings of Marasigan (2019), who emphasize that interactive learning experiences in Industrial Arts foster better problem-solving and collaboration skills. According to Dantic, (2023), clear content organization paired with accurate performance evaluation fosters learning continuity and mastery. Teachers can rely on the manual not only to deliver lessons, but to systematically monitor progress, support remedial actions, and ensure student competency.

Table 4: Validity of Laboratory Manual in terms of Content

Criteria	Weighted Mean	SD	Remarks
The content is scientifically adequate and accurate.	4.00	.00	Strongly Agree
Emphasize active learning.	3.85	.05	Strongly Agree
Contents of each activity are relevant to the objectives.	3.90	.06	Strongly Agree
It is well organized.	3.75	.25	Agree
It evaluates student learning as stated in objectives.	4.00	.00	Strongly Agree
It allows the development of multiple intelligence.	3.90	.06	Strongly Agree
Topics are supported by illustrations and tasks suited to students.	4.00	.00	Strongly Agree
It is aligned to curriculum.	3.85	.05	Strongly Agree
The contents are free to ethnic, gender, and other stereotypes.	3.85	.05	Strongly Agree
Composite	**3.90**		**Strongly Agree**

Validity of Manual in terms of Technical Quality.

The findings presented in Table 5 show that validity of developed laboratory manual in terms of technical quality reveal a composite weighted mean of 3.91, interpreted as "Strongly Agree." This suggests that the manual is not only pedagogically valid but also technically sound, contributing significantly to its usability, effectiveness, and overall instructional quality in Industrial Arts education. It implies self-directed learning, which is vital in practical courses where learners benefit from repetition and control over their pace, especially in activities involving complex mechanical or construction skills. According to Wools, Molenaar, Hopster-den Otter, (2019), instructional materials in Industrial Arts must foster learner autonomy to promote mastery of skills and boost learner confidence in manipulating tools and completing procedures independently. Recent research by Sánchez-Ramírez et al., (2022) found that technical manuals that use clear, learner-friendly language led to improved task execution and fewer procedural errors during hands-on activities. The manual can serve as a reliable instructional

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guide, reducing the cognitive load for both students and teachers, and ensuring clarity of instructions during technical operations.

Table 5: Validity of Manual in terms of Technical Quality

Criteria	**Weighted Mean**	**SD**	**Remarks**
The manual is easy to understand.	4.00	.00	Strongly Agree
The manual allows learner to control pace of learning	4.00	.00	Strongly Agree
The graphics are excellent	3.90	.06	Agree
The layout and design are attractive	3.75	.25	Agree
Intend users can easily and independently use the manual.	4.00	.00	Strongly Agree
The language used is clear, concise, and motivating.	4.00	.00	Strongly Agree
The manual is aesthetically pleasing	4.00	.00	Strongly Agree
The symbols used are well-define	3.75	.25	Agree
Topics are presented in a logical and sequential order.	3.75	.25	Agree
Composite	**3.91**		**Strongly Agree**

Validity of Manual in terms of Instructional Quality.

The results in Table 6 show the validity of developed laboratory manual in terms of instructional quality, with a composite weighted mean of 3.94 (Strongly Agree), confirm that the laboratory manual for Industrial Arts is not only educationally sound but also instructionally effective. This high level of agreement from evaluators demonstrates that the manual aligns well with modern pedagogical standards and responds to the learning needs of students in technical-vocational contexts. According to Edralin and Pastrana (2023), the future of Technical and Vocational Education and Training (TVET) in the Philippines hinges on curriculum-aligned, industry-responsive instructional materials that can bridge classroom learning with real-world technical skills. The manual's validated instructional quality suggests it meets these evolving expectations by integrating realistic activities, relevant content, and learner-centered pedagogy. As discussed by Gong, et al., (2023), visual clarity and color-coding in instructional design can significantly improve learner comprehension, especially in skill-based subjects like Industrial Arts.

Table 6. Validity of Manual in terms of Instructional Quality

Criteria	**Weighted Mean**	**SD**	**Remarks**
It provides feedback on accuracy of the students' answer.	3.85	.05	Strongly Agree
It is of high educational value.	4.00	.00	Strongly Agree
It is a good supplement of the curriculum.	4.00	.06	Strongly Agree
It addresses the needs and concern of the students	3.90	.06	Strongly Agree
The manual facilitates collaborative and interactive learning.	4.00	.00	Strongly Agree
It integrates students' previous experience.	4.00	.00	Strongly Agree
The manual introduction helps answering follow-up questions.	4.00	.00	Strongly Agree
It reflects current trends in civil tech instruction and experiments.	4.00	.00	Strongly Agree
The graphics and colors used are appropriate for instructional objectives.	3.75	.25	Agree
Composite	**3.94**		**Strongly Agree**

Implementation

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Pretest and Posttest.

The results of the pre- and post-test analysis in Table 7 indicate a significant difference in learning gains between the control group (traditional approach) and the experimental group (utilized the laboratory manual). The experimental group recorded a mean gain of +18.8, while the control group only recorded +6.1, which means that the laboratory manual significantly contributed to students' learning outcomes. These results confirm that systematic, experiential learning guides such as laboratory manuals improve both skill acquisition and skill building in technical-vocational settings. As per Rafiq, Triyono, & Djatmiko, (2022), students in skills courses derive maximum benefit when teaching materials are prepared to involve them in active learning processes, facilitating them to relate theory to practice. Additionally, the experimental group's dramatic improvement resonates with research by Adjei, et al. (2023), which highlighted the fact that performance-based learning materials, coupled with clear outcomes and measurement strategies, result in greater scholastic achievement and student confidence. The control group's limited gain also reflects a larger problem with conventional instructional techniques that rely principally upon lectures or theory-driven instruction. As noted by Ragab, Kaid, & Kotby, (2024), passive learning environments often fail to stimulate higher-order thinking skills and practical application, especially in technical fields like civil technology.

Table 7. Pretest and Posttest

Group	Pre-Test Mean	Post-Test Mean	Mean Gain	Interpretation
Control Group (n=20)	62.4	68.5	+6.1	Moderate improvement (traditional method)
Experimental Group (n=20)	61.9	80.7	+18.8	Significant improvement (with lab manual)

Evaluation

Evaluation of Student Learning Outcomes. Table 8 shows the evaluation of the laboratory manual in Civil Technology 2 based on student learning outcomes reveals highly favorable results, with an average mean of 4.3, interpreted as "Very Good". This suggests that the manual not only strengthened students’ theoretical understanding but also enhanced their confidence and engagement in performing practical tasks. These outcomes confirm that the manual effectively enhances understanding, confidence, critical thinking, and performance, which are all essential components of successful technical-vocational education. This suggests that students find the manual effective in reinforcing classroom instruction through practical application. According to Khateeb (2018), performance-based assessments and hands-on tasks significantly improve student achievement and self-efficacy when they are tightly integrated with theoretical content. The manual's alignment of concepts and practice supports this assertion. Ağçam, and Babanoğlu, (2020) noted that instructional tools that foster learner autonomy and clarity lead to increased motivation and confidence, especially in TVET programs where procedural mastery is critical. This also supports teachers by reducing the need for constant intervention and allowing more self-directed learning. The manual bridges the gap between abstract concepts and practical skills, thereby strengthening cognitive and psychomotor learning domains. This is particularly vital in Industrial Arts, where technical theory must be translated into accurate performance and tool handling.

Table 8. Evaluation of Student Learning Outcomes

Statement	Mean	Interpretation
The laboratory manual improved my understanding of theoretical concepts.	4.3	Very Good
I was able to perform lab activities more confidently using the manual.	4.4	Very Good
The manual helped me connect lab activities to real-world applications.	4.2	Good

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My performance in lab assessments improved after using the manual.	4.1	Good
The manual encouraged me to explore and think critically.	4.5	Excellent
Average mean	**4.3**	**Very Good**

Evaluation of Teacher Satisfaction.

Table 9 shows the evaluation of teacher satisfaction regarding the developed laboratory manual in Industrial Arts demonstrates a high level of approval, with an average mean rating of 4.52 interpreted as “Strongly Agree.” This reflects both the pedagogical soundness and the practical utility of the manual in real classroom settings. This aligns with the findings of Edralin and Pastrana (2023), who assert that in TVET settings, instructional materials that demonstrate adaptability, relevance, and ease of use across diverse learner profiles are essential for broader implementation success. This reflects the instructional design principle of “teacher usability,” which Toropova, Myrberg, & Johansson (2020), found to be a key factor in successful performance-based instruction. The manual demonstrates high teacher satisfaction, which increases the likelihood of sustained and widespread use. Likewise, it supports curriculum alignment and offers strong potential for institutional adoption across Industrial Arts programs.

Table 9. Evaluation of Teacher Satisfaction

Statement	**Mean**	**Interpretation**
The manual aligns well with curriculum objectives.	4.4	Agree
It was easy to integrate the manual into my teaching practice.	4.5	Strongly Agree
The manual supported differentiated instruction (for students of varying levels).	4.6	Strongly Agree
Students were more engaged during lab activities when using the manual.	4.3	Agree
I would recommend the use of this manual to other teachers.	4.8	Strongly Agree
Average mean	**4.52**	**Strongly Agree**

Evaluation of Program Effectiveness by the Academic Heads.

Table 10 demonstrates strong endorsement of its role in advancing the goals of Technical and Vocational Education and Training (TVET), with an overall average mean of 4.7 (interpreted as "Strongly Agree"). This high level of evaluation reflects the manual's effectiveness not only as a teaching tool but also as a strategic instructional resource aligned with industry needs.

It underscores the importance of developing learning materials that reflect current industry standards and real-world applications to enhance graduate employability. This supports the argument by Ragab et al. (2024) that educational innovations with demonstrated success in one domain should be considered for cross-disciplinary application to maximize institutional impact. The results support a policy recommendation for institutional adoption and further development of similar competency-based instructional materials.

Table 10. Evaluation of Program Effectiveness by the Academic Heads

Statement	**Mean**	**Interpretation**
The laboratory manual contributes to achieving the goals of the TVED program.	4.6	Strongly Agree
The manual supports industry-relevant skills development.	4.5	Strongly Agree
Its implementation has led to noticeable improvement in student performance.	4.6	Strongly Agree
Teachers reported ease of implementation and positive results.	4.8	Strongly Agree

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The manual should be considered for scaling to other technical subjects.	5.0	Strongly Agree
Average mean	**4.7**	**Strongly Agree**

DISCUSSION

Results of the students' diagnostic test in Civil Technology 2 served as the basis for the selection of topics/activities included in the laboratory manual. Nine out of thirty competencies showed "very low competencies" and was served as the basis for the developing targeted lessons in Civil Technology 2 (Masonry, Plumbing, and Tile Setting). This may also be attributed to the fact that diagnostic tests were only recently introduced as part of efforts to enhance students' skills. As mentioned by Garcia et al. (2023), the complex details derived from diagnostic assessments have the potential to assist in targeting learning gaps and facilitating advanced levels of instruction. Hence, it can bridge the gap between demonstrated and practiced competencies. The analysis phase is conducted through bibliometric review. The results indicate that areas of effective instructional manual design are adaptable for Civil Technology 2. With regards to safety procedures, application to actual work situations, and achievement testing, the results confirm that a structured TESDA manual focused on the skills and industry requirements of Masonry, Plumbing, and Tile Setting will be beneficial. The design phase. The design of the laboratory manual reflects a highly structured and organized format that supports effective teaching and learning in Industrial Arts. Its strong performance across key components—Preliminaries, Prelab, Observation, and Postlab—shows that it addresses essential instructional needs. This design not only facilitates smooth lesson delivery but also strengthens the connection between lab tasks and real-world applications, which is vital in TVET settings. A well-designed manual like this enhances student engagement, supports skill development, and elevates the overall quality of technical instruction. Likewise, the development of the laboratory manual is validated from the content, technical features, and instructions, and the result shows impressive consistency of quality materials. This indicates that the manual is well organized, pedagogically sound, and technically accurate and thus can effectively teach the lesson in Civil Technology. The more interactive the lesson, the more the learners are engaged/motivated to enhance their learning experience (Reyes & Dizon 2023). Similarly, Mendoza, Asio, and Soriano, (2022) assert that learning outcomes in the framework of curricular goals, clear indicators and the emphasis on learners of independence affirm the success of teachers and mastery of students in an activity directed towards meaningful tasks. The implementation phase was determined by experimental study. The pretest and posttest results clearly demonstrate the effectiveness of the laboratory manual in enhancing student learning. This underscores the value of structured, hands-on instructional materials in technical-vocational education, where active engagement and performance-based learning are critical. Likewise, the limited improvement in the control group further highlights the limitations of traditional, lecture-based methods in fostering applied competencies essential in fields like Civil Technology. The evaluation of student learning outcomes indicates that the laboratory manual in Civil Technology 2 effectively enhances both theoretical understanding and practical performance. This finding agrees with Edralin and Pastrana (2023) on using appropriate instructional materials to be beneficial and convenient in the teaching-and-learning process both for the learners and the teachers. Moreover, the teacher satisfaction rating obtained high approval that suggests strong potential for sustained implementation and broader adoption across Industrial Arts programs. Likewise, the evaluation by academic heads has impressive rating, highlights the laboratory manual's effectiveness as both an instructional and strategic resource in advancing TVET goals. These findings support broader institutional adoption and the development of similar materials across disciplines, reinforcing the value of scalable, practice-oriented educational tools in technical education.

CONCLUSIONS

The diagnostic assessment of BTLED Industrial Arts students in AY 2024–2025 revealed that 9 out of 30 competencies in Civil Technology II were least learned, primarily due to limited lab implementation caused by material costs, safety concerns, and time constraints. The bibliometric analysis confirms a clear parts of

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laboratory manual in terms of preliminaries; prelab; observation and data recording; and postlab informed the creation of a TESDA-aligned, practical, and engaging manual for Civil Technology (Masonry, Plumbing, & Tile Setting).The implementation phase, assessed through an experimental study, showed that the laboratory manual significantly improved student learning based on pretest and posttest results. High student rating, teacher satisfaction and strong approval from academic heads further confirm the manual's value as both a teaching tool and strategic resource, supporting its sustained use and potential for wider adoption across Industrial Arts and other technical-vocational programs.

RECOMMENDATIONS

It is strongly recommended to prioritize the development and integration of targeted laboratory activities for the least learned competencies in all areas in Industrial Arts, using cost-effective, safe, and time-efficient strategies to ensure students gain hands-on experience and mastery of these essential skills. Schools offering Industrial Arts may consider adopting and integrate the TESDA-aligned laboratory manual into the Industrial Arts curriculum to strengthen hands-on learning and improve student competency. Given its effectiveness, the manual may consider be adapted for broader use across other technical-vocational subjects, promoting consistency in competency-based instruction and improving overall training quality.

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