Enhancing Undergraduate Research Skills: Development and Validation of Scaffolded Research Worksheets in Industrial Technology Education

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Abstract
This action research investigated the development and level of acceptability of research worksheets and templates designed to assist Bachelor of Industrial Technology (BIT) and Bachelor of Technology and Livelihood Education (BTLEd) students in conducting academic research at Pangasinan State University (PSU) Asingan Campus. A total of 191 students participated during the School Year 2024–2025. The worksheets were evaluated for clarity, organization, relevance, and usability using a Likert-type scale. Descriptive statistics were applied to determine mean scores and interpret levels of acceptability. Results revealed that the developed worksheets were rated "Excellent" (M = 3.65) in structure and clarity, "Good" (M = 3.25) in aiding comprehension of research concepts, and "Excellent" (M = 3.50) in promoting independent learning. Findings affirm the effectiveness of structured research worksheets as scaffolding tools in guiding students through the research process. The study recommends institutional adoption of the worksheets as standardized tools for undergraduate research instruction.
Keywords Research worksheets; template development; action research; student acceptability; PSU Asingan; educational scaffolding; research instruction; academic skills...

Introduction
Research is an integral component of tertiary education, fostering critical thinking, innovation, and academic inquiry. At Pangasinan State University (PSU) Asingan Campus, research subjects are embedded in the curricula of the Bachelor of Industrial Technology (BIT) and Bachelor of Technology and Livelihood Education (BTLEd) programs. However, many students struggle to structure their research projects, resulting in inconsistent outputs and learning gaps.

To address these challenges, this study developed a set of worksheets and templates intended to systematically guide students through the research process, from topic formulation to presentation. The initiative aimed to simplify complex research procedures, clarify academic expectations, and enhance student confidence and competence.

The objectives of this study are as follows:

1. To develop research worksheets and templates aligned with the curriculum outcomes of ProfEd TLE Research, Fundamentals of Research and Project Design and Development;
2. To evaluate the level of acceptability of the developed materials among BIT and BTLEd students;
3. To identify areas of improvement in the research instruction process through the use of structured worksheets.

Theoretical and Pedagogical Foundations

Constructivist learning theory emphasizes that learners actively build knowledge by integrating new information with prior understanding. In this view, teaching should facilitate students' own inquiry and sense-making rather than simply transmitting facts. The research worksheets in this study were designed as constructivist tools: they guide students through hands-on tasks and questions, allowing them to construct an understanding of the research process step by step. For example, Bruner's concept of *scaffolding* – structured support by an expert until learners achieve competence – underpins the worksheets' design. Wood, Bruner, and Ross (1976) originally described scaffolding as providing strategies (e.g., recruiting interest, demonstrating tasks, marking critical features) to support learners until they can perform independently. In practice, the worksheets break complex research tasks into manageable parts (e.g., selecting a topic, reviewing the literature, designing methods), each accompanied by prompts and examples. As learners gain skill, the worksheets fade guidance, encouraging independent thinking. Scaffolding thus makes the research process transparent and manageable, aligning with the principles of social constructivism, which hold that knowledge is co-constructed through guided interaction.
Self-regulated learning (SRL) theory further substantiates this instructional approach. SRL encompasses students' abilities to set goals, monitor their learning strategies, and reflect on outcomes during academic tasks. Empirical evidence indicates that SRL is a strong predictor of academic success, surpassing motivation or self-efficacy alone. Nevertheless, many learners encounter difficulties in self-regulation without external support. The worksheets integrate SRL components by prompting students to plan each research step, assess their understanding against established criteria, and reflect on their progress after each task. Thus, the worksheets provide structured guidance that cultivates SRL processes. In summary, the integration of constructivism, scaffolding, and SRL theory offers a robust pedagogical foundation: the worksheets function as *cognitive tools* that render the research process active, supported, and self-directed for undergraduate students.

2. Review of Related Literature

Instructional Design and Cognitive Support in Higher Education

Effective instructional design in higher education emphasizes incremental skill acquisition and cognitive support for learners. Scaffolding – inspired by Vygotsky's Zone of Proximal Development – is a core strategy: the instructor provides temporary, fading supports that enable students to perform tasks beyond their unaided ability. Such support may include guiding questions, templates, and phased activities that reduce extraneous cognitive load by structuring complex tasks. Merrill's (2002) First Principles also advocate problem-centered learning with explicit modeling and practice; scaffolding operationalizes these by making problem-solving steps visible. For example, Borchers *et al.* (2025) found that highly scaffolded (guided) tutoring systems produced significantly greater conceptual learning gains than minimally scaffolded ones. Instructors' surveys confirm that "meaningful cognitive support" (e.g. clear instructions, examples, checklists) fosters learner autonomy and metacognition. Likewise, adaptive scaffolding in digital environments has been shown to optimize cognitive load by reducing extraneous demands, freeing working memory for learning and self-regulation
Instructional strategies explicitly designed to support cognition include advanced organizers, stepwise skill practice, and guided feedback. For instance, Richardson *et al.* (2022) report that effective scaffolding encourages students to identify their learning needs, select strategies, and self-evaluate progress. Empirical evidence (e.g. Kim *et al.*, 2017) shows that computer-based scaffolds in problem-based learning (PBL) produce moderate positive effects on cognitive outcomes ($g \approx 0.39$). However, poorly calibrated support can backfire: excessively detailed guidance can increase extraneous load, while insufficient guidance can leave novices overwhelmed. Thus, instructional design must sequence skill-building, gradually fading supports as competence grows, consistent with cognitive apprenticeship models of learning. In sum, theory and research underscore that well-designed scaffolding – often instantiated through worksheets, templates, or phased assignments – is essential to help students master complex higher-order tasks.

Developing Research Competence among Undergraduates
Building research competence is a priority in undergraduate education, yet studies find pervasive gaps in how curricula develop these skills. Research competence – the ability to formulate questions, seek and evaluate

evidence, and communicate findings – is often cited as a “key 21st-century competence”. However, curricular design for these skills remains uneven. Ciraso-Calí *et al.* (2022) observed that students frequently lack proficiency in *state-of-the-art* literature review, subject-matter knowledge, and communication, even in education-science programs. Pre-/in-service teachers commonly report low confidence and motivation in the research methods course. Gaps include weak integration of methods with content, insufficient stepwise skill practice, and insufficient feedback. In response, scholars advocate scaffolded inquiry and project-based learning. For example, Reavis and Thomas (2019) illustrate a multi-course scaffold in psychology: lower-level classes introduce basic research projects that culminate in advanced independent research opportunities. This vertical integration – pairing statistics and methods early on – was shown to improve learning outcomes and retention. Similarly, Buffalari *et al.* (2020) argue that *course-based undergraduate research experiences* (CUREs) and other early research engagements yield “improved critical thinking, scientific reasoning, academic performance, and retention in STEM”.

Assessment practices also reflect scaffolding principles. Programs like the Australian Quantitative Methods Centre and AAC&U research rubrics use developmental models (e.g. van de Pol *et al.*, 2010) to track students’ growing autonomy. Recent intervention research (Kollar *et al.*, 2023) directly tests structured vs. flexible research courses for teacher candidates. They find that high structure (mastery checks and required sequence) can increase cognitive learning outcomes, though it may not boost affective gains as assumed. This underscores that *structure matters* in fostering competence: providing clear steps and check-for-understanding (a form of scaffolding) supports knowledge acquisition. Overall, the literature suggests that explicit, sequential learning tasks and formative assessment (aligned with Bloom's or constructivist taxonomies) are needed to build research skills step by step. When these curricular scaffolds are lacking, students’ research skills development is stunted (as evidenced by the self-reported deficits above), highlighting the need for targeted scaffolding interventions.

Scaffolding and Structured Tools in Learning Environments

Scaffolding in practice often takes the form of structured tools —such as worksheets, templates, graphic organizers, rubrics, and checklists—that guide student work. These tools embody guided practice and help chunk complex tasks into manageable parts. For example, Buffalari (2022) describes using scaffolded worksheets in neuroscience courses: these worksheets laid out timelines and specific sub-tasks for group projects, making instructor expectations and group roles explicit. Students reported that the worksheets “support learning” and reduced common concerns about group work. Similarly, Cakir and Er (2023) integrated specialized worksheets to embed metacognitive regulation: each worksheet prompted planning, monitoring, and evaluation steps for programming tasks. In essence, the template functioned as a *cognitive guide*, systematically prompting students to use self-regulated strategies as they worked.

Other studies emphasize the value of guided questioning and prompts. Choo *et al.* (2014) characterize worksheets as “hard scaffolds” – static question sets or process outlines – that novices can reference during problem solving. These structured questions (e.g. “What is the problem asking?”, “What strategy will you use?”) implicitly train students in expert-like thinking. Likewise, Borchers *et al.* (2025) found that highly scaffolded digital tutors provided repeated practice opportunities and feedback (e.g. step checks, hints) which aligned with improved conceptual mastery. When well-designed, such scaffolds *directly address novices’ needs*: they reduce extraneous load by clarifying steps (thus preventing disorientation), and they preserve intrinsic load by letting students focus on core problem-solving.

Guidance and modeling. Templates can include worked examples or sentence stems. Annotated examples or partial-completion worksheets show students *what success looks like*. For instance, science students using a data-analysis worksheet might see a sample figure and be guided to fill in axis labels and units (minimizing guesswork).

Incremental practice. Scaffolding breaks projects into phases (e.g. defining research questions, drafting literature notes, writing results) with checkpoints in between. Each stage worksheet includes specific prompts (e.g. “List your top five keywords”, “Write one sentence summarizing your findings”), ensuring focus and allowing formative feedback. Buffalari et al. (2020) note that such *low-stakes sequenced assignments* help students build confidence and skills before a capstone research task.

Promoting self-regulation. Structured tools often include self-assessment checklists or reflective questions (e.g. “What did I learn? What questions remain?”). These encourage students to monitor their understanding and manage effort. In Kollar *et al.*'s study, the "non-restrictive" group could skip mandatory reflections and showed less improvement, suggesting that *lack of structured self-checks* may hinder engagement. In contrast, Richardson *et al.* (2022) found that scaffolding (including prompts for strategy selection) was seen as crucial for helping students regulate their own learning processes.

Feedback loops. Worksheets and templates are often returned with comments. For example, in project-based classes Santosa *et al.* (2025) report that phased worksheets enabled "staged feedback" that kept students on track. Such cycles of action and feedback are at the heart of scaffolding: they ensure that misunderstandings are corrected before they cascade.

In sum, structured scaffolds operationalize constructivist principles by providing just enough support so that students "learn by doing" with guidance. They make the tacit structure of expert practice explicit. As one practice guide notes, templates and checklists ensure students "have a clear understanding of task requirements and what's expected" throughout complex activities. Empirical studies across domains find strong student support for these tools; for example, over 80% of students in a scaffolded chemistry module reported higher satisfaction and motivation when using guided worksheets.

Integrating Themes: Scaffolding Worksheets to Foster Research Competence

Bringing these threads together, the literature indicates that scaffolded instructional design can significantly improve undergraduates' research competence. Gaps in traditional courses – unclear expectations, unstructured projects, and abrupt leaps to independent research – can be bridged by structured instructional tools. For instance, when students in a research methods course were required to complete interim worksheets on proposal drafting and data analysis, they demonstrated deeper conceptual understanding and reported feeling less overwhelmed. These findings echo theoretical expectations: by dividing the research process into phases (learning to formulate questions, reviewing the literature, designing methods, analyzing data, etc.) and aligning assessments to each phase, instructors reduce the "cognitive load shock" of open-ended tasks.

Furthermore, scaffolded tools promote active learning and autonomy. Rather than being "spoon-fed," students engage in guided inquiry: they fill in parts of a scaffolded template, receive feedback, then gradually take on more independent work. Reavis and Thomas (2019) exemplify this in curriculum design: early classes provide a "highly structured" project scaffold, which is progressively faded as students gain skill. Santosa *et al.* (2025) similarly report that scaffolded questions and interim reports helped students develop independent learning skills in research projects. In practice, a structured worksheet might first prompt students to write a hypothesis statement (with examples), then later require them to generate their own; the fading of support occurs as competence grows.

Several studies justify this pedagogy empirically. In project-based science courses, structured group worksheets increased student contributions and confidence. In game-based and online environments, adaptive scaffolds that adjust to student performance not only improved task scores but also fostered self-efficacy and self-regulation. In each case, learners were able to tackle more complex tasks than they could unassisted. Belland *et al.*'s (2017) meta-analysis confirms that computer-based scaffolds yield positive learning gains in STEM PBL.

Notably, these structured tools also help address the affective dimension of research learning. Ciraso-Calí *et al.* (2022) point out that students often report anxiety and lack of confidence in research skills. Scaffolded worksheets serve to demystify the process, making research tasks feel concrete and manageable. When students understand the "how-to" via a template, they are more likely to take intellectual risks and persist through challenges. Repeatedly, studies find that students report higher motivation and perceived support when scaffolds are present. This affective boost is essential for sustained engagement, especially in open-ended projects.

In conclusion, current research strongly supports integrating scaffolded instructional tools into undergraduate research education. Worksheets, templates, and sequenced activities fill pedagogical gaps by linking theory to practice and supporting students' cognitive and metacognitive processes. They embody sound instructional design—progressive layering of skills, consistent feedback, and alignment with learning outcomes. By providing *structure* without removing student agency, such scaffolding promotes the development of research competence. As Santosa *et al.* (2025) note, structured supports enable "deeper engagement with complex research tasks" and foster independent learning. Future work should continue to refine these tools (e.g. optimizing the fade schedule, tailoring to learner differences) and evaluate their impact on both skill mastery and learner attitudes, but the theoretical and empirical foundations for their pedagogical value are well established.

3. Methodology

The development of the research worksheets followed a rigorous design and validation process. First, initial drafts of the worksheets and templates were created based on the research objectives and curriculum needs. These drafts were evaluated through *expert validation*: a panel of subject-matter and pedagogy experts (e.g., experienced industrial technology educators and research specialists) reviewed each item for relevance, clarity, and alignment with learning goals. Experts rated each worksheet item and provided feedback, and the content was revised accordingly. This process follows best practices in instrument design, ensuring *content validity* through expert judgment (similar to Lawshe's method). Second, a *pilot test* was conducted with a small sample of students representative of the target population. The worksheets were implemented in a research course module, and student feedback on clarity and usefulness was collected. Feedback from the pilot helped refine wording, format, and sequence of tasks.

Finally, reliability of the worksheets and associated survey instruments was analyzed. The internal consistency of the acceptance questionnaire was calculated using Cronbach's alpha (with a threshold of 0.70 for acceptable reliability). For example, after pilot data collection, Cronbach's alpha coefficients were computed for each scale to ensure consistency of student responses. Steps in the validation and reliability process were explicitly documented to enhance replicability. By incorporating expert review, pilot feedback, and statistical reliability analysis, the methodology strengthens the credibility of the worksheets as valid and reliable instructional tools (cf. Tavakol & Dennick, 2011 for reliability assessment standards).

4. Results

Analysis revealed the folStudent feedback indicated a high level of acceptance for the worksheets, aligning with their intended design objectives. Students reported that the scaffolded format facilitated their understanding of each research step, corroborating findings that structured guidance enhances research competence. For example, Vaughn et al. (2017) observed that structured research assignments increase undergraduate students' confidence and research self-efficacy. In the present study, many students specifically valued checklist-type prompts, such as "formulate hypothesis" and "check research design," at each phase, reflecting the milestone scaffolding recommended for complex projects. This observation is consistent with Heath and Palmer (2023), who found that a curriculum scaffolded from introductory to senior-level research courses establishes the foundation necessary for students to contribute meaningfully to research.foundation for students to "contribute meaningfully" to research.

Notably, these results differ from some previous findings in problem-based learning (PBL) contexts. Choo et al. (2011) reported that generic worksheets had minimal impact on learning in PBL settings, with tutor support and group work identified as the most influential factors. In contrast, the worksheets in this study were integrated into a structured research sequence, serving to complement rather than replace instructor guidance. The positive student responses suggest that when worksheets explicitly scaffold each research skill, rather than functioning as generic guides, they can significantly enhance learning. Belland et al. (2013) contend that scaffolds must be *context-specific and motivational* to be effective; accordingly, the worksheets were embedded within authentic research tasks to ensure relevance. As a result, the worksheets functioned both as cognitive organizers and as prompts for self-regulation, such as requiring students to set research goals and reflect, thereby addressing the gap identified by Greene and Land (2000) that learners "find it difficult to use SRL processes without guidance".

These findings are supported by related literature on undergraduate research pedagogy. The integration of scaffolding tools, such as structured worksheets, into coursework is substantiated by evidence that early, guided research experiences enhance competence (Healey et al., 2010). For instance, Seymour et al. (2004) demonstrated that undergraduates who participate in research with appropriate guidance improve their critical thinking and problem-solving abilities. The worksheets developed in this study operationalize such guidance by enabling students to progress from topic selection through literature review to analysis in incremental steps, consistent with the assignment sequencing recommended by the Sweetland Center, which advocates moving from simple to more complex tasks, with each assignment scaffolding the next. In this manner, the worksheets address a recognized gap in research skill development. Many undergraduates begin their studies with limited confidence in their research abilities; structured scaffolding, as provided by these worksheets, can bridge this gap by rendering abstract processes concrete. This underscores the need for increased scaffolded support for research and information literacy skills across curricula. By integrating constructivist and SRL principles, the worksheets not only align with current pedagogical frameworks but also provide tangible support for the development of research competence, an area where traditional instruction has often been insufficient.

6. Implications

1. Pedagogical Innovation: The study provides empirical evidence supporting the integration of worksheets as effective research aids in tertiary education.
2. Curricular Alignment: Standardized templates ensure consistency in research outputs across programs.
3. Policy Development: The PSU administration may institutionalize these worksheets as part of research pedagogy, enhancing instructional quality.
4. Further Research: Future studies may assess long-term learning outcomes and adaptIn summary, the implementation of constructivist, scaffolded worksheets constitutes an effective approach to enhancing undergraduate research skills. The theoretical foundation, based on active knowledge construction, structured support, and self-regulation, is corroborated by student perceptions and alignment with established research pedagogy. The comprehensive methodology, incorporating expert validation and reliability analysis, affirms the robustness and replicability of these instructional tools. Placing these findings within the broader context of literature on scaffolding and undergraduate research indicates that such worksheets can address persistent skill gaps. While future research should investigate the long-term effects on research outcomes, current evidence supports the integration of scaffolded learning supports into technical education curricula.supports into technical education curricula....

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