



## Development of TPACK-Based Digital Economics Worksheets to Enhance Students' Critical Thinking Skills

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**Abstract:** This study aims to develop TPACK-based digital economics worksheets and to examine their validity, practicality, and effectiveness in enhancing students' critical thinking skills. The research employed a Research and Development (R&D) method using the ADDIE model, which consists of the analysis, design, development, implementation, and evaluation stages. The participants were tenth-grade students at SMK Negeri 1 Angkola Timur, North Sumatra. The research instruments included expert validation sheets, teacher and student response questionnaires, critical thinking skill tests, and learning achievement tests. Data were analyzed using descriptive quantitative and qualitative methods, normality testing, N-Gain analysis, and effectiveness testing. The findings revealed that the developed digital worksheets were highly valid based on evaluations by content, media, and instructional design experts. The practicality analysis indicated that the worksheets were highly practical, as reflected in positive responses from both teachers and students. Furthermore, the implementation of the TPACK-based digital worksheets was proven to be effective in improving students' critical thinking skills, as demonstrated by increased mean scores and moderate to high N-Gain values. Therefore, TPACK-based digital economics worksheets are suitable for use as innovative instructional materials in vocational high school economics learning.

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## Introduction

The development of 21st-century education emphasizes the importance of higher-order thinking skills as core learning outcomes, particularly critical thinking. Critical thinking is recognized as an essential competency that enables students to analyze information, evaluate arguments, and make reasoned decisions in complex situations (Facione, 2015; Ennis, 2011). In economics education, critical thinking is indispensable because students are required to understand abstract concepts, interpret economic data, and analyze real-world economic phenomena such as inflation, market dynamics, and economic policy.

In vocational education contexts, including SMK Negeri 1 Angkola Timur, economics learning plays a strategic role in preparing students not only for academic achievement but also for practical decision-making in their future careers. Preliminary observations conducted at SMK Negeri 1 Angkola Timur indicated that economics learning was still dominated by teacher-centered approaches, with limited use of digital learning materials. Classroom activities mainly focused on explaining concepts and completing textbook-based exercises, while opportunities for students to analyze economic cases, express opinions, or solve contextual problems were minimal. As a result, most students tended to be passive during



lessons and showed difficulties in responding to analytical and open-ended questions related to real economic phenomena.

In addition, discussions with economics teachers and a review of students' daily assessments revealed that students generally performed better on low-level cognitive tasks, such as remembering and understanding concepts, than on higher-order thinking tasks, including analysis and evaluation. Many students relied heavily on examples provided by the teacher and had limited confidence in developing independent reasoning. These conditions indicate that students' critical thinking skills were not yet optimally developed, making SMK Negeri 1 Angkola Timur a relevant and appropriate setting for implementing TPACK-based digital worksheets aimed at enhancing critical thinking skills.

However, several studies indicate that economics instruction at the secondary level is still dominated by teacher-centered approaches and conventional learning materials, which emphasize factual recall rather than analytical reasoning (Sugiyanto & Suryadi, 2020). Student worksheets (LKPD), which are intended to support active learning, are often designed as routine exercises with closed-ended questions, limiting students' opportunities to engage in critical thinking processes.

Empirical evidence suggests that such instructional practices contribute to low levels of student engagement and underdeveloped critical thinking skills (Trilling & Fadel, 2009). This condition is also reflected in vocational schools, where learning tends to prioritize completion of curriculum content over the development of cognitive skills required for problem-solving in real-world contexts. Consequently, there is a pressing need to redesign learning materials that actively foster critical thinking, particularly in economics learning.

The rapid advancement of digital technology offers significant potential to address these challenges. Digital learning materials enable the integration of multimedia elements, interactive tasks, and contextual problem scenarios that can support student-centered learning (Mayer, 2020). Digital student worksheets (LKPD Digital), when designed effectively, can transform learning activities into structured processes that guide students through analysis, evaluation, and reflection. However, the mere use of technology does not guarantee meaningful learning; technology must be pedagogically and conceptually integrated into the learning design.

The integration of technology into learning design has been extensively discussed through the Technological Pedagogical Content Knowledge (TPACK) framework, which emphasizes the intersection of technological knowledge, pedagogical knowledge, and content knowledge (Mishra & Koehler, 2006). Research on TPACK indicates that effective learning occurs when digital tools are used not as add-ons but as integral components that support pedagogical strategies and content understanding (Koehler et al., 2013).

Several studies have explored the development of digital learning materials, such as e-modules and digital worksheets, and reported positive impacts on student engagement and learning outcomes. Research by Hidayat et al. (2021) and Sari & Putra (2022) shows that digital worksheets facilitate active learning and increase student motivation by providing interactive and contextual learning experiences. In economics and social science education, digital learning materials have been found to help students connect theoretical concepts with real-life economic issues (Widodo & Kartikasari, 2020).

From a cognitive perspective, critical thinking development has been widely studied in educational research. Facione (2015) conceptualizes critical thinking as a set of core cognitive skills, including interpretation, analysis, evaluation, inference, and explanation. Similarly, Ennis (2011) emphasizes that critical thinking requires intentional instructional



design and cannot be developed through passive learning activities. Empirical studies confirm that learning materials designed with problem-based and inquiry-based approaches significantly improve students' critical thinking skills (Hmelo-Silver, 2004; Abrami et al., 2015).

Despite these findings, existing studies reveal several limitations. First, many studies on digital learning material development prioritize learning outcomes and motivation rather than explicitly targeting critical thinking as the primary learning objective (Rahmawati et al., 2021). Second, research on TPACK-based learning often focuses on teachers' competencies or instructional media design, with limited attention to student-centered learning tools such as LKPD (Chai et al., 2019). Third, studies on LKPD development are predominantly conducted in science and mathematics subjects, leaving economics education, particularly in vocational schools, relatively underexplored (Prasetyo & Nugroho, 2020).

Theoretically, constructivist learning theory provides a strong foundation for the development of critical thinking-oriented learning materials. Constructivism posits that learners actively construct knowledge through interaction with learning environments and meaningful tasks (Piaget, 1970; Vygotsky, 1978). Digital LKPD aligned with constructivist principles can support critical thinking by engaging students in problem identification, data analysis, and reflective reasoning. When integrated with the TPACK framework, constructivist-oriented digital LKPD can create a coherent learning design that effectively supports critical thinking development. The state of the art analysis indicates that while digital learning materials, TPACK, and critical thinking have been widely studied, their integration into a single instructional product—specifically a digital LKPD for economics learning in vocational schools—remains limited. Existing research tends to address these components separately, resulting in fragmented instructional innovations.

Based on the state of the art, the scientific novelty of this study lies in the systematic integration of the TPACK framework into the development of a digital LKPD for economics learning that explicitly targets students' critical thinking skills. Unlike previous studies that focus on digital media or TPACK-based instruction independently, this study embeds critical thinking indicators—analysis, evaluation, inference, and reflection—into each LKPD activity. Furthermore, this study contextualizes the development and implementation of the TPACK-based digital LKPD within vocational education at SMK Negeri 1 Angkola Timur. This contextual focus represents a novel contribution, as research on digital LKPD in economics learning at vocational schools is still scarce. The digital LKPD developed in this study is designed not merely as an electronic worksheet but as a structured learning tool that guides students through higher-order thinking processes supported by digital technology.

## **Research Method**

This study employed a research and development (R&D) method aimed at producing a valid, practical, and effective TPACK-based digital student worksheet (LKPD Digital) to enhance students' critical thinking skills in economics learning. The research was conducted at SMK Negeri 1 Angkola Timur during the second semester of the academic year. The methodological procedures were designed to ensure rigor, transparency, and replicability. The research design adopted the ADDIE development model, consisting of five systematic stages: Analyze, Design, Develop, Implement, and Evaluate (Branch, 2009; Molenda, 2015). The ADDIE model was selected because it provides a structured yet flexible framework for developing digital learning materials and allows continuous evaluation at each stage. At the Analyze stage, a comprehensive needs analysis was conducted to identify learning problems



in economics instruction, students' learning characteristics, curriculum demands, and the limitations of existing learning materials. Data were obtained through classroom observations, semi-structured interviews with economics teachers, and document analysis of syllabi and lesson plans. The Design stage involved formulating learning objectives aligned with curriculum standards and critical thinking indicators. The structure of the digital LKPD was designed to include learning orientation, problem presentation, guided inquiry activities, reflection tasks, and evaluation components. At this stage, the integration of Technological, Pedagogical, and Content Knowledge (TPACK) was explicitly planned to ensure coherence between digital tools, instructional strategies, and economics content. During the Develop stage, the digital LKPD prototype was produced using digital authoring tools that support interactivity and multimedia integration. The prototype underwent expert validation by material experts, media experts, and instructional design experts. Validation focused on content accuracy, pedagogical appropriateness, technological functionality, language clarity, and visual design. Revisions were conducted based on experts' feedback to improve product quality. The Implement stage involved applying the validated digital LKPD in actual classroom learning. Students used the LKPD during economics lessons, while the teacher facilitated learning activities in accordance with the designed instructional flow. Classroom observations were conducted to document student engagement and learning processes. The Evaluate stage aimed to assess the practicality and effectiveness of the digital LKPD. Practicality was measured through teacher and student response questionnaires, while effectiveness was evaluated by comparing students' critical thinking skills before and after the implementation of the LKPD.

The research was conducted at SMK Negeri 1 Angkola Timur, a public vocational high school. The research activities were carried out over a period of approximately three months, encompassing the stages of needs analysis, product development, validation, implementation, and evaluation. The population of this study consisted of all students enrolled in the economics subject at SMK Negeri 1 Angkola Timur. The sample was selected using purposive sampling, based on class availability, curriculum alignment, and students' learning characteristics. The product trial was conducted in two stages: a small-group trial involving 10 students ( $n = 10$ ) to evaluate initial practicality and readability, followed by a field trial involving one class of 32 students ( $n = 32$ ) during the implementation stage to examine practicality and effectiveness of the digital LKPD. In addition to student participants, expert validators were involved, including one economics education expert, one instructional design expert, and one educational technology or media expert. Economics teachers at SMK Negeri 1 Angkola Timur also participated as practitioners in evaluating the practicality of the digital LKPD.

Multiple data collection techniques were employed to ensure data completeness and triangulation. These techniques included observation, interviews, questionnaires, tests, and documentation. Observation was conducted during the analysis and implementation stages to identify learning conditions and student engagement. Interviews with economics teachers were conducted to explore learning challenges and expectations for digital learning materials. Questionnaires were used to collect data on the feasibility and practicality of the digital LKPD from experts, teachers, and students. Tests were administered in the form of pre-tests and post-tests to measure students' critical thinking skills. Documentation techniques were used to collect supporting data such as lesson plans, student work, and learning records.

Research instruments were developed based on theoretical frameworks and research objectives. The critical thinking skills test was constructed using indicators adapted from



recognized critical thinking models, including analysis, interpretation, evaluation, inference, and explanation. The test items were designed to reflect economics learning contexts and real-world economic problems. Validation instruments for the digital LKPD included assessment aspects related to content accuracy, pedagogical suitability, TPACK integration, language use, and visual design. Teacher and student response questionnaires were developed to measure practicality, focusing on ease of use, clarity of instructions, and perceived usefulness. All instruments were reviewed and refined to ensure clarity, relevance, and alignment with research objectives.

Data analysis involved both qualitative and quantitative approaches. Qualitative data obtained from observations, interviews, and open-ended questionnaire responses were analyzed descriptively to identify patterns and inform product revisions. Quantitative data from validation questionnaires were analyzed using descriptive statistics to determine the feasibility level of the digital LKPD. Scores were converted into feasibility categories based on predetermined criteria. To evaluate the effectiveness of the digital LKPD, students' pre-test and post-test scores were analyzed. The improvement in critical thinking skills was measured using normalized gain (N-gain) analysis to determine the level of learning improvement after using the LKPD.

The study employed a Likert scale-based validation and evaluation approach, supported by expert judgment and user responses. Product validity was measured using an expert validation instrument with a 4-point Likert scale (1 = not valid, 2 = less valid, 3 = valid, 4 = very valid) to avoid neutral responses and ensure clearer expert agreement. Validation involved multiple experts who assessed the content, pedagogical, and technological aspects of the digital LKPD. The validity level was determined by calculating the mean score of expert ratings and interpreting it according to predefined validity criteria. Practicality was assessed using questionnaire responses from teachers and students after the implementation phase, also based on a Likert scale, to capture perceptions of ease of use, clarity, attractiveness, and usefulness of the digital LKPD in real classroom settings. Effectiveness was evaluated by analyzing improvements in students' critical thinking skills through pre-test and post-test results. The gain in scores was used to determine the extent to which the digital LKPD contributed to students' cognitive development, rather than relying solely on subjective perceptions.

## **Results and Discussion**

### **Validity of the TPACK-Based Digital Economics LKPD**

The developed digital LKPD was validated by three experts consisting of an economics education expert, an instructional design expert, and a learning media expert. The validation aimed to ensure conceptual accuracy, pedagogical appropriateness, and technological feasibility in accordance with the TPACK framework.

**Table 1. Expert Validation Results of the Digital LKPD**

<b>Aspect</b>	<b>Indicator</b>	<b>Score (%)</b>	<b>Category</b>
<b>Content Accuracy</b>	Accuracy of economic concepts	93	Very Valid
	Relevance to curriculum (SMK)	95	Very Valid
	Contextual relevance	92	Very Valid
<b>Pedagogical Aspect</b>	Learning objective clarity	94	Very Valid
	Integration of critical thinking	91	Very Valid
	Learning activity structure	93	Very Valid
<b>Technological Aspect</b>	Digital interactivity	90	Very Valid



	Accessibility and navigation	92	Very Valid
<b>Language &amp; Design</b>	Instruction clarity	94	Very Valid
	Visual layout	91	Very Valid
	Average Score	<b>92.5</b>	<b>Very Valid</b>

Table 1 indicates that the LKPD achieved an average validity score of 92.5%, categorized as *very valid*. This shows that the developed LKPD meets academic standards and is suitable for use in vocational economics learning.

## 2. Practicality of the Digital LKPD

Practicality was assessed through teacher and student questionnaires after classroom implementation.

**Table 2. Teacher Practicality Responses**

Indicator	Score (%)	Category
Ease of implementation	94	Very Practical
Instruction clarity	96	Very Practical
Learning time efficiency	92	Very Practical
Student engagement support	93	Very Practical
Average	<b>93.8</b>	<b>Very Practical</b>

**Table 3. Student Practicality Responses**

Indicator	Score (%)	Category
Ease of access	92	Very Practical
Task clarity	91	Very Practical
Visual attractiveness	95	Very Practical
Material understanding	90	Very Practical
Average	<b>92.0</b>	<b>Very Practical</b>

The data show that both teachers and students considered the LKPD easy to use and supportive of learning activities.

## 3. Effectiveness on Students' Critical Thinking Skills

**Table 4. Pre-Test and Post-Test Scores**

Test	Mean	Min	Max
Pre-test	55.6	38	70
Post-test	82.1	72	96

**Table 5. N-Gain Analysis**

Pre-Test	Post-Test	N-Gain	Category
55.6	82.1	0.60	Moderate

## 4. Improvement by Critical Thinking Indicators

**Table 6. Indicator-Based Improvement**

Indicator	Pre (%)	Post (%)	N-Gain	Category
Problem identification	56	84	0.64	Moderate
Analysis	54	88	0.74	High
Evaluation	55	83	0.63	Moderate
Inference	56	79	0.52	Moderate
Explanation	57	76	0.44	Moderate

## Discussion

The findings indicate that the developed digital LKPD achieved a valid to moderately high category across content, pedagogical, and technological aspects. Although this result demonstrates that the LKPD has integrated the three core components of the TPACK framework—content knowledge, pedagogical knowledge, and technological knowledge—the



level of validity has not yet reached the highest category. This suggests that the integration, while effective, may not have been fully optimal in all aspects.

One possible factor influencing these moderate results is the limited duration of the intervention. As discussed in the metacognition section, students were exposed to the digital LKPD within a relatively short instructional period, which may not have been sufficient for them to fully adapt to inquiry-based and technology-mediated learning processes. Consequently, some pedagogical and cognitive features of the LKPD may not have been maximally perceived or utilized by students.

In addition, technical constraints within the vocational school environment, such as inconsistent internet access and limited availability of digital devices, may have affected the implementation quality of the LKPD. According to Mishra and Koehler (2006), the effectiveness of digital learning materials depends not only on design quality but also on contextual conditions that support technology integration. Suboptimal infrastructure may have reduced the practical effectiveness of the technological components, thereby influencing validation outcomes. Furthermore, the inherent complexity of economics content, particularly when contextualized to vocational settings, may also have contributed to the moderate results. Transforming abstract economic concepts into pedagogically meaningful and cognitively accessible representations requires sustained instructional scaffolding, as emphasized in Shulman's PCK theory (1987). In this study, while content accuracy and relevance were achieved, the depth of conceptual engagement may have been constrained by time and learner readiness.

Previous studies support the importance of these factors. While Wulandari et al. (2019) and Sutrisno and Wibowo (2021) reported high validity in TPACK-based instructional materials, their studies were conducted under conditions with longer implementation periods and more stable technological support. Therefore, the moderate results in this study should be interpreted as a reflection of contextual and implementation limitations rather than a weakness of the LKPD design itself.

The novelty of this study lies in applying the TPACK framework specifically to digital LKPD for vocational economics education, a context that has received limited attention in earlier research. Most previous studies focused on general secondary education, whereas vocational students require contextual and practice-oriented learning materials. The very high practicality scores from both teachers and students indicate that the digital LKPD is feasible and efficient for classroom implementation. This can be explained through Cognitive Load Theory which states that instructional materials should minimize extraneous cognitive load to allow learners to focus on essential cognitive processes.

The structured layout, clear instructions, and intuitive navigation of the LKPD reduced unnecessary mental effort, enabling students to engage more deeply with learning tasks. Teachers' positive responses also suggest that the LKPD aligns well with instructional time constraints and classroom management needs, which are critical factors in vocational education. These findings are consistent with Hidayat et al. (2020), who reported that digital worksheets improve learning efficiency when designed with usability principles in mind. In addition, Putra and Sari (2022) emphasized that practicality is a crucial determinant of successful implementation of digital learning materials, especially in vocational schools where students often have diverse academic backgrounds.

From a pedagogical perspective, the practicality of the LKPD supports student-centered learning theory, which emphasizes learner autonomy and active engagement. The LKPD allowed students to explore economic problems independently while still receiving



structured guidance, fostering a balance between autonomy and scaffolding. The moderate N-gain value obtained in this study indicates that the digital LKPD effectively enhanced students' critical thinking skills. This finding aligns with Bloom's revised taxonomy (Anderson & Krathwohl, 2001), which categorizes critical thinking as higher-order cognitive processes such as analysis, evaluation, and creation.

The LKPD was intentionally designed to include contextual economic problems, guiding questions, and reflective tasks that require students to analyze data, evaluate alternatives, and justify decisions. These instructional features directly support the development of critical thinking as defined by Facione (2015), who describes critical thinking as a purposeful, self-regulatory process involving analysis, evaluation, inference, and explanation. Empirical evidence from previous studies supports this result. Rahmawati et al. (2021) found that digital learning materials significantly improve students' higher-order thinking skills when learning activities emphasize problem-solving and reasoning. More recently, Susanti and Nugroho (2023) demonstrated that digital worksheets embedded with critical thinking tasks lead to measurable improvements in students' analytical abilities. Compared to these studies, the present research contributes additional insight by demonstrating that critical thinking skills can be enhanced through TPACK-based digital LKPD in a vocational economics context, which often prioritizes practical skills over cognitive reasoning.

The results revealed varying levels of improvement across critical thinking indicators, with analysis skills showing the highest gains and explanation skills showing relatively lower gains. This pattern can be explained through Metacognitive Theory (Flavell, 1979), which posits that reflective and explanatory reasoning develops gradually and requires sustained practice. Analytical skills tend to improve more rapidly because students are frequently exposed to tasks involving comparison, classification, and interpretation of information. In contrast, explanation and inference require students to articulate reasoning processes and justify conclusions, which demand higher levels of metacognitive awareness.

Similar trends were observed by Sari et al. (2020), who reported that students' analytical abilities improved faster than their reflective reasoning skills in economics learning. Anwar and Pratama (2022) also noted that explanation and justification skills often require longer intervention periods to show significant improvement. These findings suggest that while the digital LKPD effectively supports critical thinking development, longer-term implementation and repeated exposure may further enhance reflective components of critical thinking.

Vocational education emphasizes practical competencies and real-world applications. The effectiveness of the digital LKPD in this study can be attributed to its contextual design, which connects economic concepts to vocational scenarios familiar to students. According to Constructivist Learning Theory (Vygotsky, 1978), learning occurs most effectively when students actively construct knowledge through meaningful experiences. The LKPD provided such experiences by presenting economic problems relevant to students' vocational fields, thereby enhancing engagement and comprehension. Previous studies by Arifin et al. (2019) and Kurniawan et al. (2021) emphasized that contextual learning materials are particularly effective in vocational settings. This study reinforces those findings while extending them through the integration of digital technology and the TPACK framework.



## Conclusion

This study concludes that the development of a TPACK-based digital Economics LKPD is an effective instructional innovation in vocational education, particularly in enhancing students' critical thinking skills. The integration of technology, pedagogy, and content knowledge enables the LKPD to function not merely as a digital worksheet, but as a structured learning environment that promotes active learning, contextual understanding, and higher-order cognitive processes such as analysis, evaluation, and decision-making. The findings indicate that vocational students are capable of developing critical thinking skills when learning materials are intentionally designed with clear cognitive objectives and supported by appropriate technological features. This challenges the assumption that vocational education should prioritize practical skills alone and highlights the importance of cognitive development alongside vocational competence. From a scientific perspective, the study contributes empirical evidence to the literature on TPACK-based learning by demonstrating the feasibility and effectiveness of digital LKPDs in vocational economics education, thereby providing a foundation for future research on technology-integrated instructional materials aimed at fostering higher-order thinking skills.

## Recommendation

For teachers, it is recommended to implement TPACK-based digital LKPDs over a longer instructional period to allow students to gradually develop higher-order thinking skills, particularly inference and explanation. Teachers are also encouraged to provide initial guidance or training related to digital literacy to ensure that all students can effectively engage with digital learning materials. In addition, flexible time management and adequate technological support should be considered so that learning activities can run optimally and provide sufficient opportunities for reflection and discussion.

For future researchers, it is suggested to conduct studies with larger and more diverse samples across different vocational schools and study programs to improve the generalizability of findings. Future research may also integrate additional variables such as learning motivation, metacognitive awareness, digital literacy, and problem-solving skills to obtain a more comprehensive understanding of the effectiveness of TPACK-based digital LKPDs. Moreover, exploring the use of more advanced technological features and longer-term implementation is recommended to examine the sustained impact on students' critical thinking skills.

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