

Development of Student Worksheets Based on Thinking Empowerment by Questioning for Grade XI Cell Biology

Pengembangan LKPD (Lembar Kerja Peserta Didik) Berbasis Model Pembelajaran TEQ (*Thinking Empowerment by Questioning*) pada Materi Sel Kelas XI

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Abstract	Article Information									
<p>This study aimed to develop a Student Worksheet (LKPD) based on the Thinking Empowerment by Questioning (TEQ) learning model on the cell biology topic for grade XI of SMA 2 Sinjai, and to determine its validity, practicality, and effectiveness. The method used was Research and Development (R&D) with the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). The subjects were 30 grade XI students of SMA 2 Sinjai. Data were collected through expert validation sheets, response questionnaires, and learning achievement tests. The results showed that: (1) the LKPD was highly valid with an average score of 3.77; (2) highly practical based on student responses (average 3.32) and teacher responses (average 3.80); and (3) it resulted in 90% class-wide mastery (27 of 30 students achieved the minimum mastery criterion). Therefore, this LKPD is suitable for use in Biology learning as an alternative interactive teaching material.</p>	<p>Keywords: ADDIE; Student Worksheets; TEQ (Thinking Empowerment by Questioning)</p>	<p>Kata kunci: ADDIE; LKPD; TEQ (Thinking Empowerment by Questioning)</p>								
<p><i>Penelitian ini bertujuan mengembangkan LKPD berbasis model pembelajaran Thinking Empowerment by Questioning (TEQ) pada materi sel kelas XI SMA 2 Sinjai, serta mengetahui tingkat kevalidan, kepraktisan, dan keefektifannya. Metode yang digunakan adalah penelitian dan pengembangan (Research and Development) dengan model ADDIE (Analysis, Design, Development, Implementation, Evaluation). Subjek penelitian terdiri atas 30 peserta didik kelas XI SMA 2 Sinjai. Data dikumpulkan melalui lembar validasi ahli, angket respons, dan tes hasil belajar. Hasil penelitian menunjukkan bahwa: (1) LKPD sangat valid dengan rata-rata nilai 3,77; (2) sangat praktis berdasarkan respons peserta didik (rata-rata 3,32) dan guru (rata-rata 3,80); serta (3) menghasilkan ketuntasan belajar klasikal sebesar 90% (27 dari 30 peserta didik mencapai kriteria ketuntasan minimal), sehingga LKPD ini layak digunakan dalam pembelajaran Biologi sebagai bahan ajar alternatif yang interaktif.</i></p>	<p>History</p> <table><tr><td>Manuscript received</td><td>: 09/07/2026</td></tr><tr><td>Revised</td><td>: 21/07/2026</td></tr><tr><td>Accepted</td><td>: 12/10/2026</td></tr><tr><td>Published</td><td>: 31/10/2026</td></tr></table>	Manuscript received	: 09/07/2026	Revised	: 21/07/2026	Accepted	: 12/10/2026	Published	: 31/10/2026	
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A. INTRODUCTION

Biology instruction under the Merdeka Curriculum is implemented by giving teachers the freedom to adapt teaching methods to students' needs, abilities, and interests so that learning is flexible and enjoyable (Kemendikbudristek, 2022). To support this ecosystem, Student Worksheets (LKPD) have been developed as an essential tool to facilitate teaching and learning

activities, thereby fostering effective interaction between students and educators (Muslimah, 2020). As instructional materials, LKPDs serve as concrete facilitators that summarize content to help teachers conduct structured learning in the classroom (Manurung et al., 2023). The use of appropriate media and instructional materials has been proven to make it easier for teachers to teach and help students understand the material, thereby making learning more effective and efficient (Utami & Bintaro, 2024).

Based on observations and initial interviews with biology teachers at SMA 2 Sinjai, 11th-grade biology instruction still faces low active student engagement; students tend to be passive, spend more time listening to the teacher's explanations, and are less active in discussions or asking questions. This situation is exacerbated by the use of worksheets that remain very basic, with unengaging questions and minimal activities that encourage students to think actively. Consequently, instruction lacks variety and fails to motivate students to explore the complex and abstract nature of cell-related material.

Cell-related material has characteristics that demand appropriate instructional materials. The subject matter is microscopic and cannot be observed directly; it also involves numerous scientific terms and the interrelated structures and functions of organelles. Students are required to connect concepts at the submicroscopic, cellular, and organismal levels to achieve a coherent conceptual understanding; thus, specifically designed learning strategies are necessary (Verhoeff et al., 2008). Therefore, cell-related material requires student worksheets that not only present information but also guide students in gradually building connections between concepts through questions and activities. These characteristics are the primary reason for the need for worksheets specifically designed for cell-related material.

In light of these issues, numerous studies have examined the development of worksheets based on learning models (Abdullah et al., 2025). Rahman (2020) developed worksheets based on contextual learning to improve student learning outcomes. Hariyati et al. (2025) developed problem-based learning worksheets to improve students' critical thinking skills, while Sugiarti & Munfaridah (2024) developed discovery learning-based worksheets to train students' critical thinking skills. In addition, the development of worksheets based on "*Pemberdayaan Berpikir Melalui Pertanyaan*" (PBMP)—which is the Indonesian equivalent of "Thinking Empowerment by Questioning" (TEQ)—has also been conducted by Astuti (2024). However, these studies have limitations. First, these studies focus more on learning outcomes or critical thinking skills than on conceptual understanding. Second, these studies did not specifically develop worksheets for 11th-grade cell material; for example, Hariyati et al. (2025) developed them for the topic of the properties of light in elementary school. Third, the PBMP-based worksheets by Astuti (2024) are oriented toward fostering higher-order thinking skills (HOTS) in 10th-grade students, whereas Nur et al. (2023) investigated the effect of applying the TEQ model in biology instruction on conceptual knowledge and critical thinking, rather than developing worksheets. Thus, TEQ-based worksheets specifically designed to facilitate conceptual understanding of 11th-grade cell-related material within the context of the Merdeka Curriculum have not yet been extensively studied and represent a relevant research need.

To address this issue, the solution integrated into the development of this instructional material is the application of the Thinking Empowerment by Questioning (TEQ) learning model. The TEQ model seeks to systematically and sequentially empower students' thinking abilities through a series of guiding questions using the "provide," "do," "think," and "evaluate and direct" syntax (Nur et al., 2023). Through the integration of the TEQ model into worksheets, students are encouraged to actively engage in organizing and discovering relationships between concepts independently, rather than merely passively receiving knowledge (Khasanah & Astuti, 2018). Compared to other models, TEQ was chosen because it is considered the most suitable for the characteristics of cell-related material. Problem-based learning, discovery learning, and inquiry-based learning models tend to require students to solve problems or discover concepts with a high degree of independence; for microscopic,

terminology-heavy material such as cells, this type of minimally guided learning risks making it difficult for students to construct concepts (Kirschner et al., 2006). In contrast, TEQ provides step-by-step guidance through a sequence of guiding questions—ranging from the provision of initial information, activities, and reasoning to evaluation and feedback—ensuring that students' thought processes are guided and can be directly documented in the worksheet format. The impact of this model on conceptual knowledge and critical thinking in biology education has also been studied (Nur et al., 2023), making it relevant to the need for conceptual understanding of cell-related material. Given this urgency, this study aims to develop a TEQ-based worksheet for 11th-grade cell-related material at SMA 2 Sinjai and to determine its validity, practicality, and effectiveness.

B. METHOD

This study is a research and development (R&D) project aimed at developing student worksheets based on the TEQ learning model for cell-related material and testing the feasibility of the product in terms of validity, practicality, and effectiveness. The development model used is the ADDIE model, which consists of five stages: analysis, design, development, implementation, and evaluation (Branch, 2009).

The analysis phase was conducted through observations and initial interviews with 11th-grade biology teachers at SMA 2 Sinjai, a needs assessment survey of 11th-grade students, and an analysis of cell-related material based on Learning Outcomes (CP) and Learning Objectives (TP). The analysis results indicated low levels of active student engagement, the use of worksheets that were still too simple, and cell-related material that was difficult for students to understand—particularly membrane transport (71.9%), cell organelles and their functions (62.5%), and cell structure and function (56.3%). During the design phase, the worksheets were created using the Canva app in A4 size with a sequential structure following the TEQ syntax: “Provide” (presenting stimulus images accompanied by an initial question), “Do” (group discussion to fill in tables, connect diagrams, or match concepts—for example, the analogy of a cell as a small factory), “Think” (guiding questions to analyze group work and write conclusions), and “Evaluate and Direct” (three to four evaluation questions and follow-up tasks, such as creating a concept map or studying material for the next session). At this stage, validation instruments, response questionnaires, and learning achievement test items were also developed. During the development stage, the design was transformed into a preliminary product that was validated by two expert validators, then revised based on the validators' suggestions (cover, images and background colors, syntax explanations, placement of learning outcomes, and answer columns) until it was ready for implementation. During the implementation phase, the worksheets were used with 30 eleventh-grade students at SMA 2 Sinjai over five sessions (2 lesson periods each), beginning on November 11, 2025. The procedure included presenting learning objectives and conducting an apperception; dividing students into six small groups to work on the worksheets following the TEQ syntax—that is, answering the initial question after viewing the provided image stimulus, discussing to complete the activity (do), presenting the results of the discussion and writing conclusions (think), as well as answering evaluation questions and receiving follow-up assignments (evaluate and direct); and a joint conclusion at the end of the lesson, followed by the completion of questionnaires by the teacher and students and the administration of a learning achievement test. During the evaluation phase, formative evaluation was conducted throughout the development process through feedback and suggestions from validators to refine the product, while summative evaluation was conducted at the end of the lesson via a learning achievement test consisting of 25 multiple-choice questions, and the results were used to assess the effectiveness of the worksheet (Gaspersz et al., 2023).

This study was conducted at SMA 2 Sinjai. The study population consisted of all 11th-grade students across five classes, with a sample of 30 students from Class XI-4 selected using convenience sampling. Data collection methods included observation, interviews, questionnaires, and achievement tests. Observations and interviews were conducted during the preliminary stage to assess the actual classroom conditions. Questionnaires were used to obtain data on validity and practicality, while tests were used to measure the effectiveness of the worksheets. The research instruments included an expert validation sheet, teacher and student response questionnaires, and learning achievement test items. The expert validation sheet contained 16 statements across five aspects: appearance, content/material, technical quality, language, and ease of use. The student response questionnaire contained 21 statements across five aspects: benefits, appropriateness of language, appearance, content, and usability; while the teacher response questionnaire contained 20 statements across four aspects: appearance, appropriateness of language, appropriateness of content, and usability. All non-test instruments used a four-point Likert scale with scores ranging from 1 to 4 (validation sheet: 1 = not relevant to 4 = very relevant; response questionnaire: 1 = strongly disagree to 4 = strongly agree). The learning achievement test consisted of 25 multiple-choice questions. Data were analyzed qualitatively to process the validators' suggestions and quantitatively to calculate the levels of validity, practicality, and effectiveness of the product. The validity criteria are presented in Table 1.

Table 1. Validity Level Criteria

Validity Categories	Criteria
3,26 – 4,00	Highly Valid
2,51 – 3,25	Valid
1,76 – 2,50	Fairly Valid
1,00 – 1,75	Invalid

Source: (Ulfah et al., 2022)

The LKPD is deemed suitable for use if the final average score falls into the “valid” or “highly valid” category. If it does not yet meet the standards, revisions are made according to the validator's recommendations until it meets the criteria. Next, the level of practicality is classified based on the teacher and student response questionnaires according to the categories in Table 2.

Table 2. Practicality Level Criteria

Practically Categories	Criteria
3,26 – 4,00	Highly Practical
2,51 – 3,25	Practical
1,76 – 2,50	Fairly Practical
1,00 – 1,75	Not Practical

Source: (Ulfah et al., 2022)

Effectiveness is evaluated using learning outcome mastery criteria. Students are deemed to have achieved individual mastery if they meet the applicable Learning Objective Achievement Criteria (KKTP) (BSKAP, 2024), specifically a score range of 70–100. Class-wide mastery is achieved when at least 80% of students meet the individual mastery criteria (Widoyoko, 2014). The effectiveness criteria are presented in Table 3.

Table 3. Effectiveness Level Criteria

Mastery Percentage (P)	Criteria
$P > 80$	Highly Effective
$60 < P \leq 80$	Effective
$40 < P \leq 60$	Fairly Effective
$20 < P \leq 40$	Less Effective
$P \leq 20$	Ineffective

Note: P = percentage of students who completed the course.

Source: (Widoyoko, 2014)

C. RESULTS AND DISCUSSION

The results of this study cover three main aspects: the validity, practicality, and effectiveness of the TEQ-model-based worksheets on cell material developed using the ADDIE model. The product was designed using the Canva application on A4 paper and then validated by two expert validators. Based on the validators' suggestions, the product was revised by improving the cover (adding an image of a cell organelle and using the university logo), replacing images with more relevant ones accompanied by their sources, changing the background color to white, removing the syntax explanation, combining the learning outcomes with the usage instructions, and adding an answer column to each activity. The assessment results from both validators are presented in Table 4.

Table 4. Validator Assessment Results

Evaluation Aspects	Validator I	Validator II	Total	Category
LKPD Presentation	4,00	3,75	3,87	Highly Valid
LKPD Content/Materials	4,00	3,60	3,80	Highly Valid
Technical Quality	3,60	4,00	3,80	Highly Valid
Language	3,60	4,00	3,80	Highly Valid
Ease of Use	3,60	3,60	3,60	Highly Valid
Average	3,76	3,79	3,77	Highly Valid

Source: Primary data from the study

The validation results show that the TEQ-model-based worksheets received an average total score of 3.77, which falls into the "highly valid" category. This indicates that the worksheets have met the feasibility criteria in terms of appearance, content, technical quality, language, and ease of use. The presentation aspect received the highest score (3.87), indicating that the visual design of the LKPD was deemed to meet the criteria for acceptable learning media. The content and language aspects each received a score of 3.80 because the material aligns with the Learning Outcomes (CP) and Learning Objectives (TP) and is presented in communicative language in accordance with PUEBI (General guidelines for Indonesian Spelling) (Muzaki et al., 2019). This high level of validity is consistent with the results of the development of other 11th-grade Biology worksheets, which were also deemed valid by expert validators. For example, a critical-thinking-based worksheet on the human musculoskeletal system received an 84% validation rate from subject matter experts and a 98% validation rate from media experts (Hanifah et al., 2024), as well as guided inquiry-based worksheets that received high ratings from language, media, and content validators (Adelia et al., 2026). The consistency of these findings indicates that worksheets developed systematically using the ADDIE model and validated by experts tend to meet the criteria for suitability.

The practicality of the worksheets was assessed through student and teacher response questionnaires. The results of the analysis in Table 5 and Table 6 show that the worksheets fall into the “highly practical” category.

Table 5. Results of Student Questionnaire Responses

Assessment Aspect	Score	Category
Benefit	3,30	Highly Practical
Language Suitability	3,33	Highly Practical
Appearance	3,38	Highly Practical
Content	3,30	Highly Practical
Usage	3,32	Highly Practical
Average	3,32	Highly Practical

Source: Primary data from the study

Table 6. Results of the Teacher Questionnaire

Assessment	Score	Category
Appearance	4,00	Highly Practical
Language Suitability	3,60	Highly Practical
Relevance of Content	3,40	Highly Practical
Usability	4,00	Highly Practical
Average	3,80	Highly Practical

Source: Primary data from the study

Based on Table 5 and Table 6, the worksheets received an average score of 3.32 from students and 3.80 from teachers; both scores fall into the “highly practical” category. This high level of practicality is supported by clear instructions, structured steps, and an attractive visual design, which make it easier for students to engage in learning activities—both independently and in groups. From the teachers’ perspective, the worksheets are practical because they can be used directly in the classroom without requiring complex adaptations and are easy to carry (Batubara & Batubara, 2020). This finding aligns with Nieveen (1999) who states that a product is considered practical if users find it engaging and usable in real-world learning contexts. Similar results were also reported for other 11th-grade Biology worksheets, which were deemed highly practical, with a response rate of 90% among educators and 87.24% among students (Hanifah et al., 2024) as well as an average practicality score of 90.31% (Adelia et al., 2026).

The effectiveness of the worksheets was measured through a 25-item multiple-choice learning achievement test administered to 30 students. The percentage of learning mastery is presented in Table 7.

Table 7. Percentage of Student Learning Mastery

No	Student Score	Frequency	Percentage
1	70 - 100 (Pass)	27	90%
2	0 - 69 (Not Passed)	3	10%
Total		30	100%

Source: Primary data from the study

Table 7 shows that 27 students scored in the 70–100 range with a class-wide mastery rate of 90%, while 3 students did not meet the standard (scores of 64, 64, and 68, or 2–6 points below the minimum passing score of 70; since item-level scores were not analyzed, the specific

causes of non-achievement cannot yet be determined and need to be investigated through item analysis in future research), with an overall average learning achievement score of 80. Because the achievement rate exceeded 80% ($P > 80$), the TEQ-model-based biology worksheets fall into the “highly effective” category. However, since this study used only a posttest without a pretest and did not calculate N-Gain, it cannot be fully confirmed that this achievement in mastery is solely due to the use of the worksheets; improvements in learning outcomes need to be confirmed in future research through a pretest-posttest design and N-Gain analysis. This high percentage of mastery indicates that the application of the TEQ model in the worksheets has the potential to help students understand cell-related material in a more focused manner through learning centered on thinking activities and the use of questioning (Kariman et al., 2019).

The high quality of the worksheets in terms of validity, practicality, and effectiveness is supported by a systematic development process oriented toward students’ needs. The structure of the worksheets is arranged sequentially following the TEQ model’s syntax: provide, do, think, evaluate, and direct. Mechanistically, each stage of the TEQ syntax plays a role in shaping conceptual understanding. In the “provide” stage, students receive initial information or stimuli regarding cell material as the foundation of knowledge to be processed. In the “do” stage, students engage in activities that transform abstract concepts into more concrete experiences. In the “think” stage, guiding questions encourage students to analyze and connect concepts so that their knowledge is organized systematically. In the “evaluate and direct” stage, students reflect on their answers and receive guidance to correct any misunderstandings. This sequence of stages is believed to contribute to a 90% mastery rate because students receive step-by-step guidance from initial information through to the consolidation of concepts (Nur et al., 2023; Khasanah & Astuti, 2018). Each stage includes activities and open-ended questions that encourage students to observe, analyze, reflect, and draw conclusions, so that students do not merely receive the material but construct their understanding independently. These step-by-step question-answering activities make cell material—which was previously considered abstract—easier to understand (Nur et al., 2023). The systematic use of the ADDIE model also ensures that the resulting product aligns with learning needs and can be used effectively in the classroom.

Previous research has also reported that the development of systematically and interactively designed worksheets can increase students’ motivation to learn (Setianingrum et al., 2022). Compared to previous studies—namely, context-based worksheets (Rahman, 2020), problem-based learning (Hariyati et al., 2025), discovery learning (Sugiarti & Munfaridah, 2024), as well as worksheets based on fostering higher-order thinking skills (HOTS) through questions for 10th-grade students (Astuti, 2024), the novelty of this study lies in the development of worksheets based on TEQ specifically tailored to 11th-grade cell biology material, designed to facilitate conceptual understanding, and structured in alignment with the Learning Outcomes (CP) and Learning Objectives (TP) of the Merdeka Curriculum, thereby providing a more meaningful learning experience through independent concept formation. The pilot study involved only one of five 11th-grade classes and was selected through convenience sampling; therefore, the results of this study cannot yet be generalized. Another limitation lies in the limited variety of activities, which still focused primarily on question-and-answer patterns and discussions; thus, it is recommended that future researchers incorporate more visual elements and diverse activity formats to further optimize student engagement (Wang, 2025).

D. CONCLUSION

Based on the research results and discussion, three conclusions can be drawn in line with the research objectives. First, the TEQ-based worksheets on cell material for 11th-grade students at SMA 2 Sinjai fall into the “highly valid” category, with an average score of 3.77

based on evaluations by subject matter and media experts. Second, these worksheets are highly practical, with an average student response questionnaire score of 3.32 and a teacher response questionnaire score of 3.80. Third, the worksheets are highly effective based on the criteria for class-wide mastery, with a class-wide learning mastery rate of 90% and an average learning achievement score of 80. Thus, the TEQ-model-based biology worksheets are suitable for use as an alternative interactive teaching material for the cell unit in high school, based on the results regarding validity, practicality, and student learning mastery.

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