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Development of a Jigsaw Oriented Student Worksheet for Teaching the Human Excretory System

Hana Priskila Samolo, Universitas Pendidikan Ganesha, Indonesia
I Wayan Sukra Warpala, Universitas Pendidikan Ganesha, Indonesia
Desak Made Citrawathi, Universitas Pendidikan Ganesha, Indonesia

Author Corresponding: *hana.priskila@undiksha.ac.id*

Abstract

The human excretory system is one of the biology topics that requires students to understand complex concepts and relationships among organs. However, existing student worksheets mainly provide learning summaries and individual exercises, with limited opportunities for collaborative learning. This study aimed to develop a Jigsaw-oriented Student Worksheet for teaching the human excretory system to Grade XI senior high school students. The study employed a Research and Development (R&D) design using the ADDIE model, which was limited to the Analysis, Design, and Development phases. Data were collected through expert validation questionnaires completed by subject matter experts and instructional media experts. The data were analyzed using descriptive quantitative and qualitative methods. The developed worksheet integrates the complete syntax of the Jigsaw cooperative learning model, including home-group formation, expert-group discussion, peer teaching, collaborative discussion, reflection, and evaluation. The validation results showed that the worksheet obtained a validity score of 85.76% from the subject matter experts and 87.00% from the instructional media experts, indicating that the product was very valid and suitable for use in biology learning after minor revisions. The developed worksheet provides a structured learning resource that supports collaborative learning and student-centered instruction. Future studies are recommended to evaluate the practicality and effectiveness of the worksheet in improving students' learning outcomes and scientific literacy.

ADDIE model; Biology education; Human excretory system; Jigsaw cooperative learning; Student worksheet

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1. Introduction

Biology is an important subject because it helps students understand living organisms and natural phenomena. Besides learning biological concepts, students are also expected to develop scientific literacy, critical thinking, and problem-solving skills. In recent years, biology education has increasingly emphasized active learning because it encourages students to participate in the learning process, construct their own understanding, and improve learning outcomes. A recent systematic review also reported that active learning approaches consistently improve students' conceptual understanding, classroom engagement, and academic achievement in biology education (Alabi et al, 2026). Despite these expectations, biology learning in many schools still focuses on delivering information rather than helping students actively construct knowledge. As a result, students often memorize concepts without fully understanding their relationships or applying them to real-life situations (McDaniel et al., 2022)

This problem also affects students' scientific literacy, which includes the ability to explain scientific phenomena, evaluate scientific evidence, and make decisions based on scientific knowledge. According to the PISA 2022 results, Indonesian students obtained an average science score of 383, which is still below the OECD average of 485. This result indicates that improving students' scientific literacy remains an important challenge in biology education.

One biology topic that students often find difficult is the human excretory system. This topic requires students to understand the structure and function of several organs, including the kidneys, liver, lungs, and skin, as well as the relationships among these organs in maintaining homeostasis. In addition, many physiological processes, such as filtration, reabsorption, urine formation, and sweat production, cannot be directly observed. Therefore, students frequently experience misconceptions and have difficulty understanding the topic when learning mainly depends on teacher explanations. To overcome these problems, biology teachers need not only appropriate learning models but also effective teaching materials. One important teaching material is the student worksheet. A well-designed worksheet guides students through observation, discussion, problem solving, data analysis, and reflection instead of simply providing exercises. Recent review studies also indicate that interactive worksheets can improve students' scientific literacy, critical thinking, and learning engagement when they are integrated with active learning strategies (Suwarno, 2020).

A preliminary observation conducted during the teaching practicum at SMA Negeri 1 Singaraja showed that biology teachers had implemented several active learning models, such as Problem-Based Learning (PBL), Project-Based Learning (PjBL), and Inquiry Learning. However, the Jigsaw cooperative learning model had not been applied to the human excretory system. Classroom observations also revealed that students' participation during discussions was still low. Only six out of 36 students (16.67%) actively participated by asking questions, expressing opinions, or responding to discussions, while most students remained passive. Interviews with the biology teacher further showed that no worksheet had been specifically designed to support the Jigsaw learning process. The existing worksheets mainly contained summaries and individual exercises, providing limited opportunities for collaborative discussion and knowledge sharing.

Cooperative learning has been widely recognized as an effective approach for promoting active participation and conceptual understanding. Among various cooperative learning models, Jigsaw encourages every student to become responsible for learning one part of the material before teaching it to other group members (Puger, 2023). This learning process promotes individual responsibility, collaboration, communication, and positive interdependence (Baken et al., 2022). A recent systematic review and meta-analysis reported that the Jigsaw method generally improves students' academic achievement and has the potential to enhance motivation and social interaction, although its effects vary across educational contexts (Cochon Drouet et al., 2023). A recent systematic review and meta-analysis reported that the Jigsaw method generally improves students' academic achievement and may also enhance motivation and social interaction, although its effects vary across educational settings (Cochon Drouet et al., 2023). Similarly, a meta-analysis synthesizing 91 effect sizes from 53 studies showed that collaborative group work significantly improved students' academic performance in biology classrooms (Driessen et al., 2024).

Several previous studies have developed biology worksheets using Problem-Based Learning, inquiry learning, or scientific literacy approaches. Other studies have investigated the effectiveness of the Jigsaw model in improving students' learning outcomes. However, most of these studies focused either on applying Jigsaw during classroom instruction or on developing worksheets without fully integrating the complete Jigsaw learning process into the worksheet design. As a result, existing worksheets do not systematically guide students through expert-group discussion, peer teaching, collaborative learning, and reflection, which are the main characteristics of the Jigsaw model. Therefore, this study aims to develop a Jigsaw-oriented Student Worksheet for the human excretory

system. The worksheet integrates all stages of the Jigsaw learning model into structured learning activities, including expert-group discussion, home-group discussion, presentation, reflection, and evaluation. It is expected that the developed worksheet can increase students' participation, improve conceptual understanding, and support the development of scientific literacy in biology learning.

2. Method

This study employed a Research and Development (R&D) design using the ADDIE instructional design model, which consists of five phases: Analysis, Design, Development, Implementation, and Evaluation (Branch, 2009). The ADDIE model was selected because it provides a systematic and iterative framework for developing and evaluating instructional materials. Each phase allows for continuous revision to ensure that the developed product meets learners' needs and instructional objectives. In this study, a Jigsaw-oriented Student Worksheet for the human excretory system was developed following the ADDIE framework. However, considering the scope of the study, the development process was limited to the first three phases: Analysis, Design, and Development. Therefore, the Implementation and Evaluation phases were beyond the scope of this study.

During the Analysis phase, a needs analysis was conducted to identify classroom problems, students' learning needs, and the characteristics of the existing teaching materials. Curriculum analysis was also carried out to identify the learning outcomes and learning objectives for the human excretory system in Grade XI Biology based on the Kurikulum Merdeka. In addition, students' characteristics, learning materials, and existing worksheets were analyzed through classroom observations, interviews with the biology teacher, and document analysis. The findings from this phase served as the basis for developing the worksheet. The Design phase focused on planning the structure and content of the worksheet. The worksheet was designed following the principle of constructive alignment, ensuring consistency among learning outcomes, learning objectives, learning activities, assessment, and the syntax of the Jigsaw cooperative learning model. The learning content, illustrations, and learning activities were then organized into an initial worksheet prototype. During the Development phase, the initial prototype was transformed into a complete Jigsaw-oriented Student Worksheet. The prototype was evaluated through expert validation involving subject matter experts and instructional media experts. The validators assessed the worksheet in terms of content, presentation, language, and visual design. Their feedback was used to revise the product. The validation and revision process was conducted iteratively until the worksheet met the established validity criteria and was considered suitable for use.

Data were collected using expert validation questionnaires to evaluate the quality of the developed Jigsaw-oriented Student Worksheet. The questionnaires were administered to subject matter experts and instructional media experts. All items were rated using a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The subject matter expert questionnaire consisted of 16 items covering seven aspects: content suitability, material quality, presentation, language, visual design, implementation of the Jigsaw model, and assessment. These aspects were developed based on the criteria for instructional material evaluation and the principles of cooperative learning proposed by Slavin (2015). The instructional media expert questionnaire consisted of 10 items evaluating three aspects: product usability, layout and visual appearance, and media effectiveness. The instrument was designed to assess whether the worksheet was visually appropriate, easy to use, and capable of supporting biology learning through the Jigsaw cooperative learning model.

The data obtained from the expert validation questionnaires were analyzed using descriptive quantitative and descriptive qualitative methods. Quantitative analysis was conducted to determine the validity level of the developed Jigsaw-oriented Student Worksheet based on the scores provided by the subject matter experts and instructional media experts. Each questionnaire item was rated using a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The validity level of the

developed worksheet was interpreted based on the criteria proposed by Akbar (2013), as presented in Table 1

Table 1. Validity Score

Percentage (%)	Validity Level
85.01–100.00	Very Valid
70.01–85.00	Valid
50.01–70.00	Less Valid
0.00–50.00	Invalid

In addition to the quantitative analysis, qualitative data in the form of comments and suggestions from the validators were analyzed descriptively and used as the basis for revising and improving the worksheet.

3. Findings

3.1 Needs Analysis

A needs analysis was conducted through interviews with the Grade XI biology teacher at SMA Negeri 1 Singaraja. The analysis focused on the curriculum, students' characteristics, existing teaching materials, teaching methods, and instructional models used in biology learning. The main findings are summarized in Table 2.

Table 2. Needs Analysis Results

Aspect	Key Findings
Curriculum	The school implements the Kurikulum Merdeka.
Students	Students need more active and collaborative learning activities.
Existing worksheet	Existing worksheets focus on summaries and individual exercises.
Teaching practice	Teachers mainly use Discovery Learning, PBL, and PjBL.
Research need	No Jigsaw-oriented worksheet has been developed for the human excretory system.
Aspect	Key Findings

As shown in Table 1, the school has implemented the Kurikulum Merdeka, which emphasizes competency-based and student-centered learning. Although teachers had applied several instructional models, such as Discovery Learning, Problem-Based Learning (PBL), and Project-Based Learning (PjBL), the Jigsaw cooperative learning model had not yet been implemented for teaching the human excretory system. In addition, the existing worksheets mainly contained learning summaries and individual exercises, providing limited opportunities for collaborative learning. These findings indicate the need for a Jigsaw-oriented Student Worksheet that supports active participation, peer interaction, and collaborative knowledge construction.

3.2 Design Phase

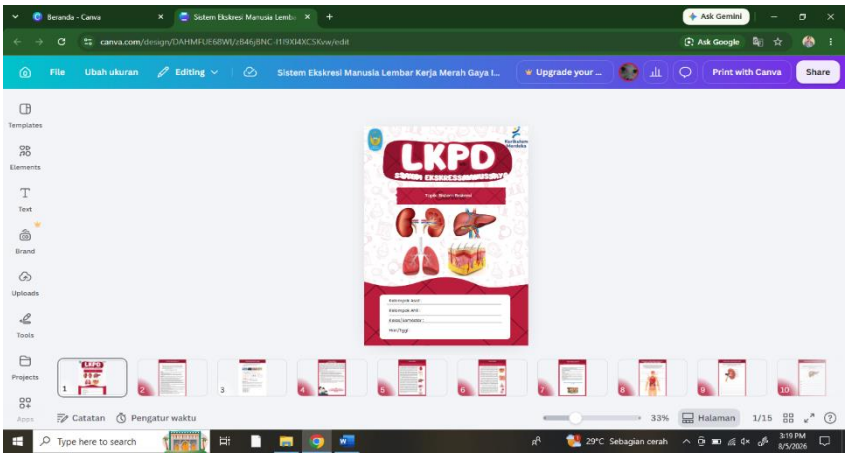
Based on the results of the needs analysis, the design phase focused on developing the initial prototype of the Jigsaw-oriented Student Worksheet. The worksheet was designed following the principle of constructive alignment, ensuring consistency among the learning outcomes, learning objectives, learning materials, learning activities, assessment, and the syntax of the Jigsaw cooperative learning model. During this phase, the expert validation questionnaires for the subject matter experts and instructional media experts were also developed. Unlike conventional worksheets that mainly provide learning summaries and individual exercises, the developed worksheet was designed to integrate every stage of the Jigsaw cooperative learning model into the learning activities. The

worksheet guides students through home-group formation, expert-group discussion, peer teaching, collaborative discussion, reflection, and evaluation. This design encourages students to actively participate in collaborative learning while developing their conceptual understanding and communication skills.

The worksheet consists of four main sections: introduction, learning activities, reflection and assessment, and references. The introduction includes the worksheet identity, learning outcomes, learning objectives, instructions for use, and procedures for organizing home groups and expert groups. The learning activities include learning materials, expert-group tasks, collaborative discussions, illustrations, and guided questions designed according to the Jigsaw learning syntax. The final section contains reflection activities, evaluation questions, and references.

The initial prototype was designed using Canva, followed by the refinement of the worksheet layout, illustrations, typography, and visual elements to improve readability and attractiveness before the expert validation stage. The design process of the developed worksheet is presented in Figure 1.

Figure 1. Design process of the Jigsaw-oriented Student Worksheet.



3.3 Subject Matter Expert Validation

The developed Jigsaw-oriented Student Worksheet was evaluated by two subject matter experts to assess its content validity. The evaluation covered six aspects: content suitability, material quality, presentation, language, visual design, and the implementation of the Jigsaw cooperative learning model. The results are presented in Table 3.

Table 3. Results of Subject Matter Expert Validation

Validation Aspect	Percentage (%)	Category
Content suitability	86.0	Very Valid
Material quality	87.5	Very Valid
Presentation	85.0	Valid*
Language	83.3	Valid
Visual design	88.0	Very Valid
Jigsaw characteristics	86.0	Very Valid
Overall validity	85.76	Very Valid

As presented in Table 3, the developed worksheet achieved an overall validity score of 85.76%, indicating that it was very valid. The highest score was obtained for the visual design aspect (88.0%), suggesting that the worksheet was visually attractive and well organized. Meanwhile, the language

aspect received the lowest score (83.3%), indicating that several revisions were needed to improve clarity and readability. Overall, the subject matter experts agreed that the worksheet met the required content standards and could be used after minor revisions. The experts also provided several recommendations to improve the worksheet, including revising the worksheet title, improving the user instructions and page layout, adding visual elements to support group organization and theoretical explanations, replacing several illustrations with more appropriate images, and correcting biological illustrations. These suggestions were incorporated into the revised version of the worksheet before the final product was produced.

3.4 Media Expert Validation

The developed worksheet was evaluated by two instructional media experts to assess its usability, text quality, image quality, completeness, and visual design. The validation results are presented in Table 4.

Table 4. Results of Instructional Media Expert Validation

Validation Aspect	Percentage (%)	Category
Product usability	86.0	Very Valid
Text quality	87.5	Very Valid
Image quality	85.0	Valid
Worksheet completeness	83.3	Valid
Visual design	88.0	Very Valid
Overall validity	87.0	Very Valid
Product usability	86.0	Very Valid

As shown in Table 4, the developed worksheet achieved an overall validity score of approximately 85.96%, indicating that it was very valid. The highest score was obtained for the visual design aspect (88.0%), reflecting the attractiveness and readability of the worksheet. The lowest score was obtained for worksheet completeness (83.3%), indicating that several components required minor improvements. Overall, the media experts agreed that the worksheet was suitable for classroom use after minor revisions. Based on the experts' feedback, several improvements were made to the worksheet, including revising the cover design, improving the page layout and margins, enhancing the organization of collaborative activities, adding supporting illustrations, replacing several images with more appropriate visuals, and correcting biological illustrations.

3.5 Product Overall Validity

To determine the overall validity of the developed Jigsaw-oriented Student Worksheet, the validity scores obtained from the subject matter experts and instructional media experts were averaged.

Table 5. Overall Product Validity

Expert	Validity (%)	Category
Subject matter experts	85.76	Very Valid
Instructional media experts	87.00	Very Valid
Overall validity	86.38	Very Valid

As presented in Table 5, the worksheet achieved an overall validity score of 86.38%, which falls into the very valid category. These findings indicate that the developed worksheet meets the

required standards for content, instructional design, language, and visual presentation, and is therefore suitable for use as a learning resource for teaching the human excretory system.

3.5 Final Product

After incorporating the experts' suggestions, the final product was successfully developed. The main differences between the initial prototype and the final product included improvements in the worksheet title, cover design, page layout, user instructions, illustrations, visual elements, and the accuracy of the biological content. These revisions enhanced the clarity, readability, visual appeal, and overall quality of the worksheet, making it suitable for use as a learning resource in biology instruction. The sample of the final product can be seen in Figure 2.

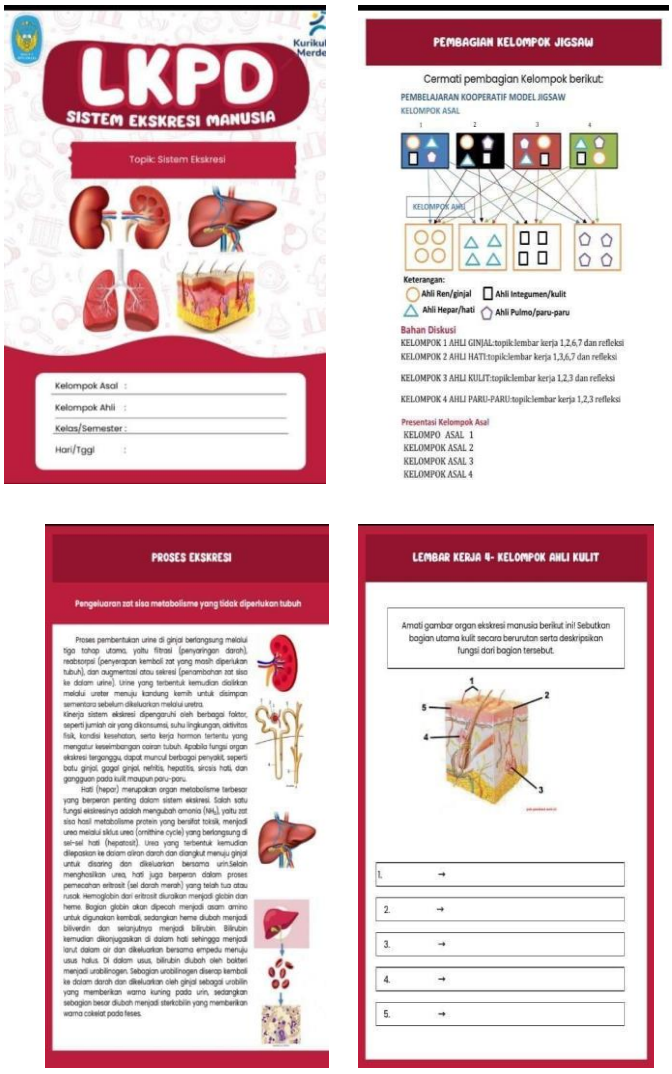


Figure 2. Sample of Final Product

4. Discussions

The present study developed a Jigsaw-oriented Student Worksheet for teaching the human excretory system using the ADDIE model. The development process was limited to the Analysis, Design, and Development phases and resulted in a worksheet that integrates the complete syntax of the Jigsaw cooperative learning model into structured learning activities. Unlike conventional worksheets that mainly provide learning materials and exercises, the developed worksheet guides students through

home-group formation, expert-group discussion, peer teaching, reflection, and evaluation, thereby supporting collaborative learning and active knowledge construction.

The design of the worksheet was based on the results of the needs analysis, curriculum analysis, and students' characteristics. The analysis revealed that although teachers had implemented several student-centered learning models, such as Discovery Learning, Problem-Based Learning, and Project-Based Learning, no worksheet had been specifically developed to support the implementation of the Jigsaw model. Therefore, the developed worksheet fills this gap by providing structured learning activities that align with the learning outcomes of the Kurikulum Merdeka while integrating every stage of the Jigsaw learning process. These findings support previous studies reporting that Jigsaw promotes students' participation, responsibility, and collaborative learning (Dhani, et al., 2023;Mumtamza & Selaras, 2023).

The expert validation results indicate that the developed worksheet has a high level of validity. The subject matter experts rated the worksheet 85.76%, while the instructional media experts rated it 87.00%, indicating that the worksheet is suitable for use after minor revisions. The positive evaluation suggests that the worksheet has met the required standards in terms of content, presentation, language, and visual design. The revisions suggested by the experts mainly focused on improving the worksheet title, layout, user instructions, illustrations, and visual presentation, thereby enhancing the overall quality of the product.

The high validity of the developed worksheet can be explained from both theoretical and instructional perspectives. From the perspective of social constructivism, learning becomes more meaningful when students actively construct knowledge through interaction with their peers. Vygotsky emphasized that learning occurs within the Zone of Proximal Development (ZPD), where students receive temporary support (*scaffolding*) from teachers or more capable peers. In the developed worksheet, scaffolding is facilitated through expert-group discussions and peer teaching activities, enabling students to collaboratively build their understanding of the human excretory system.

The findings are also consistent with Slavin's (2015) cooperative learning theory, which emphasizes positive interdependence, individual accountability, face-to-face interaction, interpersonal skills, and group processing as essential components of effective cooperative learning. These elements were explicitly integrated into the worksheet through group formation, collaborative discussions, peer teaching, reflection, and evaluation activities. Consequently, the worksheet functions not only as a learning resource but also as a guide for implementing the Jigsaw cooperative learning model in biology classrooms. Similar findings have been reported by Cochon Drouet et al. (2023), whose systematic review and meta-analysis showed that the Jigsaw method generally improves students' academic achievement and collaborative learning outcomes. In addition, a recent meta-analysis demonstrated that collaborative group work significantly enhances students' academic performance in biology education (Driessen et al., 2024)

The developed worksheet also supports the implementation of student-centered learning, which is one of the key principles of the Kurikulum Merdeka. The learning activities encourage students to actively discuss, explain concepts, exchange ideas, and reflect on their learning experiences, while teachers act as facilitators throughout the learning process. Such activities provide opportunities for students to develop communication, collaboration, critical thinking, and responsibility, which are considered essential competencies for twenty-first-century learning. These findings are consistent with previous studies reporting that systematically designed worksheets improve students' engagement and learning experiences (Soedimardjono & Pratiwi, 2021)

Overall, this study contributes to biology education by developing a validated Jigsaw-oriented Student Worksheet that integrates every stage of the Jigsaw cooperative learning model into a single instructional material. Unlike previous studies that mainly examined the effectiveness of the Jigsaw model during classroom instruction, this study focuses on developing a worksheet that operationalizes

the complete Jigsaw learning process. Therefore, the developed worksheet not only provides learning content but also serves as a practical guide for implementing collaborative learning in accordance with the principles of the Kurikulum Merdeka

5. Conclusion and Suggestion

This study successfully developed a Jigsaw-oriented Student Worksheet for teaching the human excretory system to Grade XI senior high school students using the ADDIE development model, which was limited to the Analysis, Design, and Development phases. The developed worksheet integrates the complete syntax of the Jigsaw cooperative learning model into structured learning activities, providing students with opportunities to learn collaboratively through expert-group discussions, peer teaching, reflection, and evaluation.

The expert validation results indicate that the developed worksheet is suitable for use in biology learning. The worksheet obtained a validity score of 85.76% from the subject matter experts and 87.00% from the instructional media experts, indicating that it meets the required standards in terms of content, instructional design, language, and visual presentation. Therefore, the developed worksheet can serve as an alternative instructional material to support the implementation of cooperative learning and student-centered learning in teaching the human excretory system. Future studies are recommended to continue the Implementation and Evaluation phases of the ADDIE model to examine the practicality and effectiveness of the worksheet in improving students' learning outcomes, collaboration skills, and scientific literacy.

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