



Development of Human Excretory System Module Based on Problem Based Learning to Improve Student Learning Outcomes in Class XI Science

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Abstract: This research aims to develop and test the feasibility and effectiveness of the module of human excretory system based on Problem Based Learning (PBL). The research method use is Research and Development (R&D) with the 4-D model, namely the defining stage, the design stage, the development stage, and the dissemination stage. Validation was conducted by module design experts with an average score of 93.32, material experts 92.32, learning experts 90.86, and one biology teacher of class XI 94.68, all categorized as "very feasible." The module appeal trial shows high results with assessment categories 85.01 - 100 (highly appealing), 70.01 - 85 (appealing), 50.01-70 (less appealing), and 01.00-50 (not appealing). The results of the individual trial were 3 students at 100 (highly appealing), a small group of 10 students at 82.14 (appealing), and a limited group of 20 students at 98.75 (highly appealing). The effectiveness of the module tested through student learning outcomes using independent *t* test. In the cognitive aspect, the average value of the experimental class reached 96.15 (very good) with *t* count 2.170 > *t* table 1.666 and supported by a significant value of 0.033 < 0.05. Affective aspects obtained a value of 94.30 (very good) with *t* count 2.296 > *t* table 1.666 supported by a significant value of 0.025 < 0.05, and psychomotor aspects reached 97.13 (very good) with *t* count 7.619 > *t* table 1.666 supported by a significant value of 0.000 < 0.05. The results of this study indicate that the developed module can be useful as an effective alternative learning media to improve students' learning outcomes.

Keywords: Development; module; problem-based learning; excretion; learning outcomes

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INTRODUCTION

Biology is one of the complex subjects, because students are required to study all living things on Earth. One of the materials taught in learning biology is the human excretory system. Human excretory system material is included in the material that is difficult to learn because it examines the internal organs of humans (Nuroifah & Bachri, 2015). Difficulties in the learning process that require students to memorize Latin in the introduction of organs involved in the human excretory process, difficult to distinguish the process of excretion in humans, and understanding of the excretory process in organs that are difficult to understand (Simorangkir & Napitupulu, 2020). So this material requires appropriate learning media to help students understand human excretory system material.

Good learning quality can be seen from student learning outcomes that meet predetermined standards, in terms of cognitive, affective and psychomotor aspects. (Yandi et al., 2023). However, the success of the learning process is influenced by various factors, such as the role of the teacher, learning methods, learning strategies,

teaching materials, and available facilities and infrastructure (Ramadhani et al., 2022). The low understanding of students' concepts in the learning process is influenced by students' learning styles, namely memorizing learning material without understanding it first so that later it will be easily forgotten, and also the teacher-centered learning process will create a passive learning atmosphere and students do not understand the material being taught (Dewi & Primayana, 2019).

A preliminary research conducted at SMA Negeri 2 Medan showed that 47.9% of students had difficulty in understanding the material of human excretory system. These difficulties include understanding the structure and function of human excretory organs in (35.2%), the process of excretion including urine, sweat, bilirubin, biliverdin, Co^2 and H_2O (water) in (50.7%), disorders and diseases related to human excretory organs in (36.6%), and health technology of human excretory system in (40.8%). Students find this material difficult to understand because it contains many scientific terms and requires considerable memorization. In addition, learning methods that still focus on textbooks without applying problem-based learning models are also an obstacle in improving student understanding (Abidah et al., 2022).

The difficulty in understanding complex excretory system material in accordance with the preliminary study that has been carried out is in line with previous research by Anggita et al. (2020) at SMA Teladan Medan showed similar results, where students had difficulty in understanding the human excretory system. This material is considered boring, difficult to memorize, and difficult to distinguish, especially related to Latin terms, excretion processes, and urine formation. The test results showed that 68.64% of students scored below the Minimum Completion Criteria (KKM) (<75) with an average score of 44.239. This shows that most students have difficulty in understanding the material of the human excretory system.

One solution that can be applied to overcome student learning difficulties is the development of teaching materials that are more interactive and contextual, such as modules based on Problem-Based Learning (PBL). Modules are teaching materials that are systematically organized and can be used independently by students (Sawitri, 2014). Problem-based learning-based modules are designed to improve critical thinking and problem solving skills by presenting contextual problems that are relevant to everyday life (Suharyat et al., 2022). According to Yackel (1993), Problem Based Learning is a learning model that involves students in solving problems through the stages of the scientific method. The use of modules based on PBL in learning biology has significant advantages, the main advantage is its ability to increase student involvement in the learning process. PBL encourages students to actively participate in problem solving, which not only improves their understanding of the material, but also helps them develop critical and analytical thinking skills (Setyowati et al., 2020). In the context of human excretory system material, the PBL model allows students to learn about biological concepts in a real way through the exploration of real problems that are often experienced by people around us such as kidney excretory organ disorders, namely kidney failure due to bad living habits.

Modules developed based on problem solving skills on excretory system material help students' learning process more deeply and train higher-order thinking skills. High-level thinking skills used to solve problems, one of which is critical thinking skills. In line with research by Christiyoda et al. (2016) showed that the use of Problem-based learning-based modules has advantages over conventional modules used in schools. This module integrates aspects of problem solving and critical thinking in each submaterial, indicator, student activity, and learning evaluation. Another study conducted by Widayati & Priantinah (2023) also showed that the use of interactive

learning media can help students understand the material better. The results showed that the application of PBL-based modules can improve students' understanding of complex concepts in biology subjects.

Based on this background, this study aims to develop a problem-based learning-based human excretory system module as a solution to improve students' understanding, improve students' problem-solving skills, and calculate the effectiveness of module feasibility to improve student learning outcomes in the cognitive, affective, and psychomotor domains. Thus, this research aims to develop and test the feasibility and effectiveness of the module of human excretory system based on Problem Based Learning (PBL).

METHOD

This research was conducted from October 2024 to February 2025 with module development at Medan State University and field trials at SMA Negeri 2 Medan. The research subjects included one person each for each module design expert validator, material expert, learning expert, and biology teacher. Module design expert validator by Mr. Dr. Ridwan Abdullah Sani, M.Si. physics lecturer at Universitas Negeri Medan, he is active in publishing learning books and is an expert in the field of learning module design. Module design expert validation consists of four aspects assessed, namely: (1) Module size, (2) Module cover design which consists of several components, namely: cover layout, cover typography, and cover illustration. (3) Module content design which consists of several components, namely: layout, typography, and content illustrations. (4) Module language.

The material expert validator by Mr. Hendro Pranoto, S.Pd., M.Si. is a lecturer in human anatomy and physiology at Universitas Negeri Medan. Material expert validation consists of three aspects assessed, namely: (1) The feasibility of module material content, which consists of several indicators, namely: concept suitability, concept depth, and material accuracy. (2) Feasibility of module presentation, which consists of several indicators, namely: presentation techniques, clarity of sentences, language, and completeness of presentation. (3) Product assessment, which consists of product attractiveness.

The learning expert validator by Mr. Dr. Hasruddin, M.Pd. is an expert lecturer in the field of learning at Universitas Negeri Medan. learning expert validation consists of two aspects assessed, namely: (1) Feasibility of module content, which consists of several indicators including: concept suitability, concept depth, and material accuracy. (2) Feasibility of presentation, which consists of several indicators including: presentation techniques (problem based learning syntax), sentence clarity, language, and presentation completeness. The biology teacher response was conducted by Mrs. Isnaini Fadilah Sari, S.Pd. who is a biology teacher of class XI science at SMA Negeri 2 Medan. The biology teacher's response consists of four aspects assessed, namely: (1) Module appearance, (2) Feasibility of material presentation, (3) Problem based learning component, (4) Language.

The students involved were divided into two stages, namely the development stage with individual trials (3 students of class XI-Orbit), small group trials (10 students of class XI-Pluto), and limited group trials (20 students of class XI-Comet). The aspects assessed by students to see the response are the appearance of the module, and the presentation of the module. The purpose of this trial is to see the response of students' appeal to the module that has been developed and get suggestions from students, which in turn will be used to improve the module before the dissemination stage. At the dissemination stage, the module was tested on classes XI-Ativa and XI-Sativa.

The method used is Research and Development (Sugiyono, 2013). this method must go through several stages, namely: potential and problems, data collection, product design, design validation, design revision, product testing, product revision, usage testing, product revision, mass production. So that this framework of steps is carried out, and in detail using the stages of the model used. The development mode used is 4D by Thiagarajan (1974) with four stages namely; defining, designing, developing, and disseminating as presented in Table 1.

Table 1. Development stages using 4D

Development Stage	Activity
Define	<p>The initial stage is carried out with the aim of establishing and defining learning requirements. In establishing and defining learning requirements, it begins with analyzing the objectives of the material restrictions of the learning materials developed in the form of modules.</p> <ol style="list-style-type: none"> Front-end analysis Initial observations by conducting interviews directly with biology teachers at SMA Negeri 2 Medan to find out the basic problems in developing learning media. So that at this stage the researcher will find the fact that in learning students still have difficulty in understanding the material of the human excretory system and determine alternative solutions. Learner analysis Conduct an analysis by considering the characteristics, abilities, and experiences of students, both as groups and individuals. By knowing the characteristics of students directly, it will be able to understand the learning media needed by students according to their academic abilities. Task analysis The task analysis stage of the researcher analyzes the main tasks that must be mastered by students in order to achieve minimum competencies. Concept analysis The concept analysis stage aims to determine the content of the teaching media material developed. Researchers identified the human excretory system material that needs to be taught. Specifying instructional objectives The learning objectives analysis stage is carried out to determine learning achievement indicators based on material analysis and curriculum analysis. Based on the results of the curriculum analysis conducted, it shows that the material of the human excretory system is indeed a biology learning material that is carried out in the even semester of class XI.
Design	<p>The second stage formed a module with human excretory system material. The steps for preparing the module in this study followed the module development guidelines by Purwanto et al. (2007), starting from the planning stage, namely the preparation of the module content outline (GBIM), the preparation of the module design (outline), starting writing, review and revision stages, finalization and printing. And the module writing guidelines in this study follow the format according to the Directorate of Educational Innovation and Development (DIPP) Universitas Airlangga (2023). The module to be developed consists of one learning activity with the topic of human excretory system material.</p>
Development	<p>This stage produces the developed module and assesses the feasibility of the module according to experts. The feasibility test was carried out by experts, namely the feasibility test of the module according to module design experts, material experts, and learning experts and also by biology teachers. The feasibility of the module is also seen from the response of the module's attractiveness seen from the students' responses.</p>
Disseminate	<p>Disseminating the human excretory system module that has been designed, the dissemination of this module is carried out in class XI Aktiva SMA Negeri 2 Medan in the 2024/2025 academic year.</p>

The research instrument used was a validation questionnaire to module design experts consisting of 36 questions, material experts consisting of 26 questions, learning experts consisting of 27 questions, teacher response questionnaires consisting of 17 questions and student interest response questionnaires to the module consisting of 9 questions. Module validation by validators and biology teacher response using a Likert scale with 4 assessment scores as in table 2. And the student attractiveness response questionnaire to the module uses a guttman scale as in table 3.

The test of student learning outcomes in the cognitive domain consists of 20 multiple choice questions containing human excretory system material. The affective domain consists of 10 indicator items that contain 4 aspects of affective assessment, namely: Accepting (A1), Responding (A2), Appreciating (A3), and Organizing (A4). The psychomotor domain consists of 9 indicator items containing 5 aspects of psychomotor assessment, namely: Imitation (P1), Manipulation (P2), Precision (P3), Articulation (P4), and Naturalization (P5).

Table 2. Likert scale type score guideline criteria

Category	Score
Very Feasible	4
Feasible	3
Less Feasible	2
Not Feasible	1

(Sumber: Sugiyono, 2016)

Table 3. Guttman scale type score guideline criteria

Answer	Score
Yes	1
No	0

The interval data is then analyzed with the following formula.

$$V = \frac{Tse}{Tsh} \times 100$$

Description:

V = Validity

Tse = Total empirical score (validation result)

Tsh = Total maximum score

The percentages generated at the validation stage are then interpreted as presented in Table 4 and Table 5.

Table 4. Module feasibility criteria

Presentation Interval	Criteria	Qualification
85,01-100	Very Feasible	The module can be used in the field and there are no revisions
70,01-85,00	Feasible	The module can be used in the field for learning activities but needs to be slightly revised

Presentation Interval	Criteria	Qualification
50,01-70,00	Less Feasible	The module is recommended not to be used because it needs to be revised and find the weaknesses of the product to be perfected
01,00-50,00	Not Feasible	Product failure, revise the whole module from basic to product content

Table 5. Criteria for module attractiveness according to student response

Presentation Interval	Criteria
85,01-100	Highly Appealing
70,01-85,00	Appealing
50,01-70,00	Less Appealing
01,00-50,00	Not Appealing

(Sumber: Akbar, 2013)

Data analysis in this research is qualitative and quantitative analysis. Descriptive qualitative analysis is used to see suggestions from validators at the module development stage, these suggestions will be used to make revisions to the module. For suggestions and improvements made from validators can be seen in Table 13. Quantitative analysis is used to measure the effectiveness of the module to improve student learning outcomes.

Cognitive learning outcomes were measured through pretests and posttests conducted in experimental classes (using modules) and control classes (using textbooks). The data were analyzed by calculating the increase in scores using the Independent t-test with a significant criterion of $p < 0.05$, by first conducting a normality test (Shapiro-Wilk) and homogeneity test (Levene Test) to ensure the data met statistical assumptions using SPSS software. The module is said to be effective if the experimental class posttest score is higher than the control class and meets the minimum completeness criteria (≥ 75).

Affective learning outcomes are evaluated through a questionnaire conducted by the teacher. The assessment of student attitudes measured contains criteria, namely: whether students show attention to the problems given by the teacher in learning the human excretory system, actively ask questions and give responses during the learning process, actively participate in group discussions to solve the problems given, respect the opinions of friends during discussions, be responsible, and be able to make decisions with the group about solutions related to the problems given. Data were processed using a Likert scale and categorized into very high, high, medium, low, and very low levels.

Psychomotor learning outcomes were analyzed through observations of student activity during learning, especially in solving problems given in the module. Observations were made based on an assessment rubric with categories of very good, good, sufficient, less, and very less. This data provides an overview of students' skills in critical thinking and problem solving in the context of problem-based learning.

RESULTS AND DISCUSSION

The developed human excretory system module consists of a table of contents, a list of images, instructions for using the module for teachers and for students, a concept map, and four learning activities that each focus on human excretory organs, namely: kidney, liver, skin, and lung. Each learning activity in the module contains the syntax of the PBL learning model, namely there are problems related to excretory organ diseases that generally often occur in the surrounding environment, discussion questions that will be carried out with group members, columns of investigation results and observations of the problem, directions for presenting the results and ideas of each group, multiple choice evaluation questions, and self-assessment. In the learning process in the classroom, each set of activities must be carried out in accordance with the learning sequence in the module in accordance with the PBL syntax. Learning with this learning model encourages students to be more active in expressing ideas obtained from the results of problem analysis, connecting theory with real-world applications, and improving understanding of biological concepts more easily.

The developed module has been validated by module design experts, material experts, and learning experts to assess the feasibility of problem-based learning-based excretory system modules. The average value of the validation results by module design experts was 93.32 with the category "Very Feasible", the results of validation by material experts were 92.32 with the category "Very Feasible", and the results of validation by learning experts were 90.86 with the category "Very Feasible". Can be seen in Table 6, Table 7, and Table 8. Based on this assessment, it can be said that the module can be used as a learning media on the material of the human excretory system, and also have to make improvements if there are revisions and suggestions from experts on the module.

Table 6. Module feasibility data according to module design experts

Aspects	Average Assessment	
	Value	Criteria
Module size	100	Very Feasible
Cover design	100	Very Feasible
Module design	90	Very Feasible
Module language	83,3	Feasible
Average	93,32	Very Feasible

Table 7. Module feasibility data according to material experts

Aspects	Average Assessment	
	Value	Criteria
Module material content	92,85	Very Feasible
Module presentation	90,38	Very Feasible
Product assessment	93,75	Very Feasible
Average	92,32	Very Feasible

Table 8. Module feasibility data according to learning experts

Aspects	Average Assessment	
	Value	Criteria
Module content	87,5	Very feasible
Presentation	94,23	Very feasible
Average	90,86	Very feasible

The results of the biology teacher's response to the module resulted in an average assessment score of 94.68 with the criteria "Very Feasible" can be seen in Table 9. The biology teacher's response is needed to see the results of the module assessment of the assessment aspects that have been made, because the teacher is one of the important aspects in the learning process and who will guide students in the learning process in the classroom.

Table 9. Module feasibility data according to biology teacher response

Aspect	Average Assessment	
	Value	Criteria
Module display	100	Very Feasible
material presentation	95	Very Feasible
Problem-based learning component	90	Very Feasible
Language	93,75	Very Feasible
Average	94,68	Very Feasible

The assessment of students' interest in the module includes individual trials, small group trials, and limited group trials. The average results of students' attractiveness assessment of the module in the individual test were 100 with the criteria "Highly Appealing", in the small group test were 82.14 with the criteria "Appealing", in the limited group test were 98.75 with the criteria "Highly Appealing". Can be seen in Table 10, Table 11, and Table 12. Based on the results of this student attractiveness assessment response to the module, it can be said that the module is very attractive to students. This student attractiveness response is very necessary because students who will later use this module in the learning process of the human excretory system, thus students will be interested in reading and completing all learning activities in the module.

Table 10. Results of student attractiveness responses on individual trials

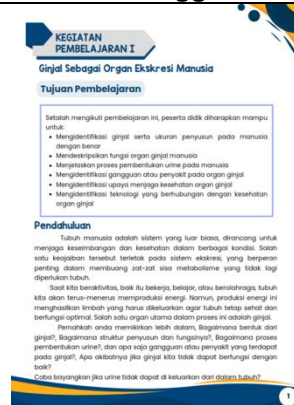
Aspect	Average Assessment	
	Value	Criteria
Module display	100	Highly Appealing
Module presentation	100	Highly Appealing
Average	100	Highly Appealing

Table 11. Results of student attractiveness responses on small group trials

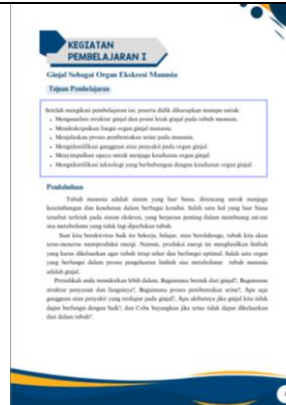
Aspect	Average Assessment	
	Value	Criteria
Module display	80	Appealing
Module presentation	84,28	Appealing
Average	82,14	Appealing

Table 12. Results of student attractiveness responses on the limited group trial

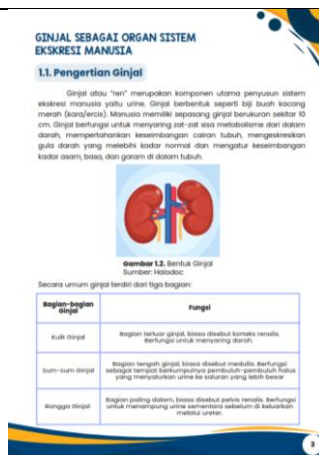
Aspect	Average Assessment	
	Value	Criteria
Module display	97,5	Highly Appealing
Module presentation	100	Highly Appealing
Average	98,75	Highly Appealing

Tabel 13. Product revision results**Feedback/Suggestions**

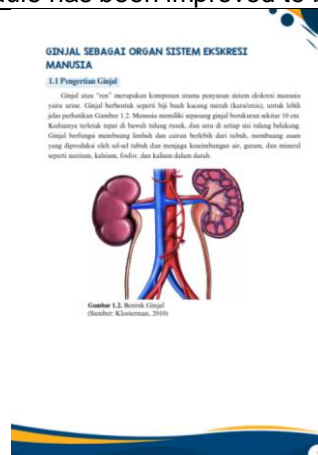
Before the revision, the margins on the module were still small, and the consistency of the text neatness on the module was still not good

Revision Results

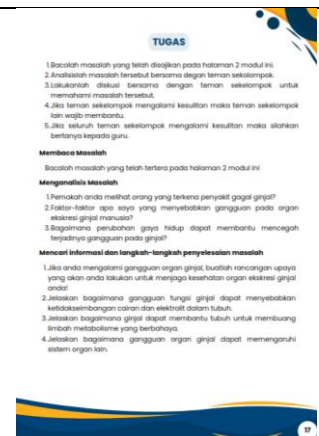
After revision, the margins have been set according to the module format standards and the left side has been added to 4 throughout the module content. And the consistency of neatness in the module has been improved to be neater.



Before the revision, the material explanation on the module was still too detailed, and exceeded the learning objectives on page 3 in the module.



After revision, the learning material in the module focuses more on the learning objectives only and the explanation of the material is easier to understand on page 3 in the module.



Before the revision, the information seeking questions still did not fulfill the case study questions for problem solving on page 17 in the module.



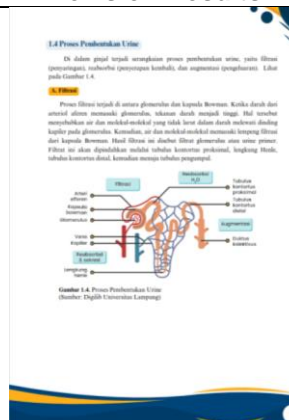
After revision, the questions to find information are already in the form of case studies and will then be assigned to students for problem-solving discussions on page 17 of the module.

Feedback/Suggestions



Before the revision, there was no introductory sentence referring to the images contained in the whole module content, here is one of them on page 7 of the module.

Revision Results



After revision, the introductory sentence referring to the picture has been made in the explanation text throughout the module content, here is one of them on page 7 of the module there is already an introductory sentence referring to figure 1.4 in the module.

The effectiveness of the module of human excretory system based on problem-based learning is indicated by the difference in the average post-test scores in the experimental class (class that uses the module) with the control class (class that uses the textbook). The average value of the experimental class is 92.31 while the average value of the control class is 89.49. The difference in learning outcomes in the experimental and control classes was due to the learning process in the experimental class using a problem-based learning module while the control class used a textbook and a conventional learning model. Modules based on problem solving skills train higher-order thinking skills through exploring problems that occur around so that better conceptual understanding is obtained (Trevathan & Myers, 2013).

Tabel 14. t- Test results on students' cognitive learning outcomes

Independent Samples Test										
Levene's Test for Equality of Variances				T-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Nilai	Equal variances assumed	,052	,821	2,170	70	,033	2,806	1,293	,227	5,384
	Equal variances not assumed			2,170	69,640	,033	2,806	1,293	,226	5,385

Based on Table 14, the results of data analysis of students' cognitive learning outcomes through the Independent t-test using SPSS. The calculated T value is 2.170 while the T table is 1.666, so it can be concluded that T count > T table. And also obtained a significant value (2-tailed) which is 0.033 < 0.05. So it can be concluded that the problem-based learning-based human excretory system module is effective in improving students' cognitive learning outcomes compared to using textbooks. Rombe et al. (2021) explained that learning with the PBL model increases students' active participation in group discussions during the learning process, and trains students to think critically, creatively, and actively in problem solving. The problem-solving ability-

based module product has advantages over the package book provided by the school because each material description, student activity and evaluation question is integrated into the problem-solving ability and critical thinking aspects. Thus, the student learning process that requires all students to play an active role in each series of stages of learning activities.

In line with research conducted by Fatimah & Haikal (2023) stated that the application of conventional learning methods is not effective in honing students' thinking skills, lack of understanding of the material taught, and obtaining low learning outcomes. So that in this study developed a problem-based learning module to encourage students to be more responsible for their learning independently with problem assignments that must be resolved. So that this problem-based learning process is more effective in inviting students to be more active and helping students to understand the material more easily from the problem solving process.

Tabel 15. t- Test results on students' affective learning outcomes

Independent Samples Test									
Levene's Test for Equality of Variances		T-test for Equality of Means							
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference
									Lower Upper
Nilai	Equal variances assumed	,556	,458	2,295	70	,025	3,583	1,561	,469 6,697
	Equal variances not assumed			2,295	67,828	,025	3,583	1,561	,468 6,699

Based on the table above, the analysis results show that students in the experimental class have higher affective learning outcomes compared to students in the control class. The T-test result (T count = 2.295 > T table = 1.666) and significance value (<0.05) confirmed that the problem-based learning module significantly improved students' affective ability compared to the textbook.

Tabel 16. t- Test results on students' psychomotor learning outcomes

Independent Samples Test									
Levene's Test for Equality of Variances		T-test for Equality of Means							
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference
									Lower Upper
Nilai	Equal variances assumed	2,025	,159	7,619	70	,000	12,222	1,604	9,023 15,422
	Equal variances not assumed			7,619	64,945	,000	12,222	1,604	9,018 15,426

Based on the table above, the analysis results show that students in the experimental class have higher psychomotor learning outcomes compared to students in the control class. The t-test result (T count = 7.619 > T table = 1.666) and significance value (<0.05) confirmed that the problem-based learning module significantly improved students' psychomotor ability compared to the textbook.

Module of human excretory system based on problem-based learning is effective to improve cognitive, affective, and psychomotor learning outcomes of 11th grade students at SMA Negeri 2 Medan. Based on the T-test results obtained, it was found

that the developed module was significant in improving students' learning outcomes compared to the learning process that only used textbooks. In the learning process in the classroom is also very different, all students in the experimental class are active in the process of solving and analyzing the problems of each learning activity in the module, and students also discuss with each other with group members.

CONCLUSION

Module on human excretory system based on problem-based learning developed based on PBL learning model syntax is effective in improving cognitive, affective, and psychomotor learning outcomes of XI grade students at SMA Negeri 2 Medan. The learning outcomes obtained from the experimental and control classes through tests and affective and psychomotor assessments by teachers showed differences in scores in these two classes. The average learning outcomes in the experimental class were higher than the control class.

Module based on problem solving helps students to understand the material of the human excretory system more easily through the process of solving problems given in each learning activity, and also problem analysis activities in groups lead students to take responsibility so that all students become more active in the learning process of the excretory system.

Thus it can be concluded that the module of the human excretory system based on problem-based learning developed can be a solution to students' difficulties in understanding the material of the human excretory system, and low student learning outcomes. So that with this module it is produced that students more easily understand the material of the human excretory system more easily through problem-based learning and obtained average learning outcomes that have met the criteria for achieving learning objectives.

RECOMMENDATIONS

This module of the human excretory system based on problem-based learning can be used by students in learning independently with the teacher as a facilitator in the learning process, so further research that can be done is to develop modules with various other biological materials that can be used as learning resources.

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