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Developing Learning Design Employing PBL with Mind Mapping to Train Critical and Creative Thinking Ability for Junior High School Students

Eva Lia Yulianti¹✉, Siti Alimah¹

¹Biology Department, FMIPA, Universitas Negeri Semarang, Indonesia

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Abstract

This present study aimed at producing a feasible learning design employing problem-based learning with mind mapping model to develop the ability of critical and creative thinking for Junior high school students in the excretory system material. This research belongs to Research and Development following ADDIE research model without including the implementation stage. The stages which were adopted in this research stopped on the development stage. The products of the developed learning design are lesson plan, learning module, student worksheet, and test instrument. The data collection technique of this research was validation by seven validators involving expert lecturers and science teachers to examine the validity and quality of the learning design. The validation analysis result showed that the learning design is categorized into "very valid" criteria in each scoring aspect. Based on that analysis, the learning design is valid and is able to be tested in the learning activity. However, the validators gave comment and suggestion which were used to improve the products. The test instrument was tested for students and its result was analyzed to figure out the validity, reliability, level of difficulty, and discriminating power of the test items. Based on the item's analysis, six question items are classified as valid, reliable, having a moderate level of difficulty, and having a good discriminating power. The results of this study are in the form of a PBL model with mind mapping learning design products that can be used to train students' critical and creative thinking skills and as an alternative to learning design innovations in the excretion system material.

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✉ Address Correspondence:

D6 Building 1st Floor, Jl. Raya Sekaran, Gunungpati, Semarang
E-mail: evaliyulianti@gmail.com

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INTRODUCTION

Education becomes a crucial aspect as the provision to face the demands of the current development in this 21st century. In this 21st century, students are required to master higher thinking ability which is essential to win the global challenges. The 21st century skills involve the skills of critical thinking and problem solving; communication; creativity and innovation; and collaboration. In connection to that, science learning could potentially train the 21st century skills since in science learning, critical and creative thinking are highly demanded in solving a given problem. One of the science learning materials is excretory system which covers many concept relations pertaining to structure and function, and varied work mechanisms with abnormalities or disorders that might happen. From those parts, students are expected to analyze the relations by employing their critical and creative thinking ability.

Indonesian students thinking ability is still in the low level, which can be seen through Trends International Mathematics and Science Study (TIMSS) survey 2011 which revealed that Junior High school students on grade VIII only reached average correct answer of 17% on reasoning ability (Mullis et al., 2011). This score was way lower than the international score which was 30%. This result is not way different with the result of TIMSS 2015 which released that Elementary school students in the grade IV showed their reasoning ability in the score 20%. This score was definitely lower than the international result which scored 44% (Mullis et al., 2015). According to PISA 2018, Indonesian students reading proficiency got score 371, mathematics 379, and science 396. Each field of the tests scored lower than the international OECD average score which was 487-489. The results of PISA and TIMSS showed that low ability of reasoning indicates the low ability of critical and creative thinking. The ability of critical and creative thinking is part of reasoning ability. Referring to Absoring & Sugiman (2018) reasoning ability is reflected on the ability of logical thinking, critical thinking, creative thinking, systematic thinking, and being objective, honest and discipline in solving problem. Therefore, the results of TIMSS and PISA could be the reference showing that students' critical and creative thinking ability needs special attention.

In addition to the previously mentioned data, based on the observation and interview with a teacher of Junior high school 13 Semarang, it can be concluded that critical and creative thinking have not been optimally developed. From the learning result, 50% of the students have not met the passing grade ($KKM \geq 72$). Students were less confident and tend to be silent in the process of discussing a problem solving. The used student worksheet has not yet facilitated critical and creative thinking ability in solving problem. Moreover, it was made from student textbook containing summary of the materials, student activities, and exercises. The question items in the exercises only accommodated C1-C3 cognitive level. According to Ristiani and Sunarti (2018) C1-C3 level belongs to lower thinking category. On the other hand, higher thinking category covers analysis aspect of C4-C6. Indications of the weak critical and creative thinking skills of Indonesian students in the international arena and when learning in class are written down because the learning process is not accustomed to practicing analytical thinking skills. Lack of facilities to develop students' critical and creative thinking skills is one of the factors not accustomed to practicing these skills in the classroom. Learning in the classroom should involve students actively and facilitate critical and creative thinking.

The alternative that could be chosen to develop the ability of critical and creative thinking is by innovating problem-based learning using mind map learning model. Problem-based learning is one of learning models that could improve students' critical and creative thinking. Referring to the research result by Ramadhani et al (2014), there was a distinction on the reasoning ability between students who were taught using problem-based learning and not. Tosun & Taskeseligil (2010) showed that problem-based learning positively contribute to critical thinking ability. Problem-based learning will be more optimal if it is modified with the the addition of variation on the learning stages to offer more alternative solutions, which in this case, is by using mind map. Khoiriyah et al (2015) explained that mind map is a technique that eases students gaining knowledge, skill, and critical thinking pattern to picturesque the thought or idea that the students deliver. Darusman (2014) stated that students who use mind mapping learning model achieve better in mathematic creative thinkking ability in comparison to those who use conventional learning model.

Therefore, in accordance to the explained background, it needs developing learning design employing

problem based-learning with mind mapping model to develop critical and creative thinking ability of junior high school students, and to create a product which is feasible and can be tested in the learning process.

RESEARCH METHOD

In developing the product, this present research used ADDIE model (analysis, design, development, implementation, and evaluation). The stages that were adopted in this research stopped on the third stage which is development. Implementation stage of the learning design could not be conducted due to the corona virus pandemic which has caused the school activities to be closed for uncertain time. The material of excretory system as the material content used in this research was given in the even semester which started on March 16, 2020. However, on March 13, 2020, the government announced that all learning activities at school were closed, and at that time, the school, which was the participant of this research, was not ready to conduct online learning optimally. Hence, the excretory system material was missed and the research could not be conducted.

This present study only conducted feasibility test by experts to analyze the validity of the learning design which includes lesson plan, learning module, student worksheet, and test instrument. The data were collected through questionnaire validation, which was in the form of a written question list to be chosen based on the provided choices by the validators. The data of the validation result by the seven validators was in the form of score validating the lesson plan, learning module, student worksheet, and test instrument which then were analyzed using descriptive percentage. The scores were categorized based on the validity criteria as displayed in Table 1.

Table 1 Validity scoring criteria of the learning design

Percentage	Criteria
82% - 100%	Very valid
63% - 81%	Valid
44% - 62%	Sufficiently valid
25% - 43%	Less valid
24% - 0%	Not valid

Source: Adapted from Riduwan (2013)

Having been validated by the experts, the test instrument was tested on students who had learned the excretory system. The data of the testing result was a test score which was used to analyze the test items using the formula of validity, reliability, discriminating power, and level of difficulty test.

RESULTS AND DISCUSSION

Results

This present research is aimed at exploring the feasibility of the learning design which used problem-based with mind mapping learning model to develop critical and creative thinking ability of junior high school students. This development research was conducted via online by validating the learning design which covers lesson plan, learning module, student worksheet, and test instrument which is in the form of essay test. In addition, the test was tested via online on students grade IX who had learnt the material of excretory system.

The information on the validity of the learning design was gained from the expert validation using questionnaire which comprised several lesson plan scoring aspects. The learning design is said valid according to Riduwan (2013) if the percentage of the validity result for each aspect reaches the score $\geq 61\%$ which ranges from valid to very valid criteria. The score of validation result recap was calculated and can be seen in Table 2.

Table 2 Data of The Percentages on The Lesson Plan Validation Results

No	Lesson Plan Scoring Aspect	Validator's Score (%)						Average (%)
		1	2	3	4	5	6	
1.	The compatibility of mind mapping as a problem solving	75	100	100	100	100	100	96
2.	The lesson plan reflects the integration model of problem based learning with mind mapping	75	75	100	100	100	100	92
3.	The completeness of lesson plan components	100	100	100	100	100	100	100
4.	The compatibility with 2013 curriculum	75	100	100	100	100	75	92
5.	The clarity of the material	50	100	100	100	100	100	92
6.	The apperception or preliminary activity	75	75	75	100	100	75	83
7.	The learning objectives comprise ABCD components	75	75	100	100	100	100	92
8.	The learning scenario is sequential and clear	75	100	100	100	100	75	92
9.	The assessment compatibility using essay test	75	100	100	100	100	100	96

Table 2 displays the percentages of lesson plan validation result by experts which shows that the each of all scoring aspects is categorized into very valid criteria. However, the experts commented and suggested to revise some aspects of the product. The next validation analysis is on the learning module. To know the validity of the learning module, it is validated by the experts using questionnaire comprising several learning module scoring aspects. The analysis of the validation result score is visualized in Table 3.

Table 3 Data of Percentages on The Learning Module Validation Results

No	Assessment Aspects	Validator's Score (%)						Average (%)
		1	2	3	4	5	6	
1.	The completeness of the learning module structure	100	100	100	100	100	100	100
2.	The completeness of material coverage	75	75	100	100	100	100	92
3.	The material's accuracy	75	100	100	75	75	100	88
4.	The tables and pictures are given number, named, and sources	100	100	100	75	75	75	88
5.	The accuracy of scientific or foreign names writing	75	100	100	100	100	100	96
6.	The learning module reflects problem based learning with mind mapping	50	75	100	100	100	100	88

Table 3 displays the percentages of learning module validation result with the criteria of very valid for each of all aspects. Nevertheless, the validators gave comment and suggestion with a little revision on some aspects of the product. The next is analyzing the validity of student worksheet which aims at finding out the validity of the worksheet as part of the learning design. This was conducted by validating the worksheet by experts using questionnaire comprising several worksheet scoring aspects. The analysis on the worksheet validation result score is visualized on Table 4.

Table 4 Data of Percentages on The Worksheet Validation Result

No	Scoring aspect	Validator's Score (%)						Average (%)
		1	2	3	4	5	6	
1.	The completeness of the worksheer structure	100	100	100	100	100	100	100
2.	The completeness of the provided materials	75	100	100	100	100	75	92

3.	The compatibility between the activities and the learning objectives	75	100	75	100	100	100	92
4.	The chosen problems correlates the fact	75	75	100	75	75	100	83
5.	The compatibility of the worksheets with the PBL- mind mapping theory	50	75	100	100	75	100	83

Table 4 displays the percentages of student worksheet validation result by experts with the very valid criteria for each of all aspects. However, the expert commented and suggested to give a little revision on some parts of the product.

Table 5 Data of Percentage on The Test Instrument Validation Results

Validator	I(%)
Instrument validation percentage	90,2%

Table 5 shows the data analysis of the test instrument validation result by the expert lecturers which are categorized into very valid for each of all the aspects. However, the expert commented and suggested to give a little revision on some parts of the product.

After the instrument was revised based on the validators' feedback, the test was tested on students to know whether or not the instrument was valid and qualified to be used to assess student critical thinking ability. The testing result was then analyzed using instrument analysis method adopting the formula of validity, reliability, level of difficulty, and discriminating power test. The result of the test instrument analysis is displayed on table 6 to 9

Table 6 Item Validity Analysis Results

Criteria	Item Number	Total
Valid	1,2,3,4,5,6,7,8,9,10,11,12,13,14	14
Not valid	-	0

Table 7 Item Reliability Analysis Result

Variation	Result
Reliability test	0,93
Total item	14
Total subjects	30
Reliability criteria	Very high

Table 8 Item Difficulty Level Analysis Result

Criteria	Item Number	Total
Difficult	6	1
Moderate	1,3,4,5,7,8,9,10,11,12,13,14	12
Easy	2	1

Table 9 Item Discriminating Power Analysis Result

Criteria	Item Number	Total
Good	1,2,5,8,11,12,13	7
Sufficient	3,4,7,9,10	5
Bad	6,11	2

The next is deciding the quality of the essay test as an instrument to assess critical thinking ability with the total 6 questions which are said as valid, reliable, having good discriminating power, and having moderate difficulty level. The questions that are eligible for assessment instrument are shown in the Table 10.

Table 10 Total of Qualified Items

Information	Number of Testing Item	Number of Tested Item	Total
Used	1,5,8,11,12,13	1,2,3,4,5,6	6
Not Used	2,3,4,6,7,9,10,14	-	7

In conclusion, based on the validation result and the testing of the test instrument, there are test instrument which are qualified from 15 items which can be seen on Table 10.

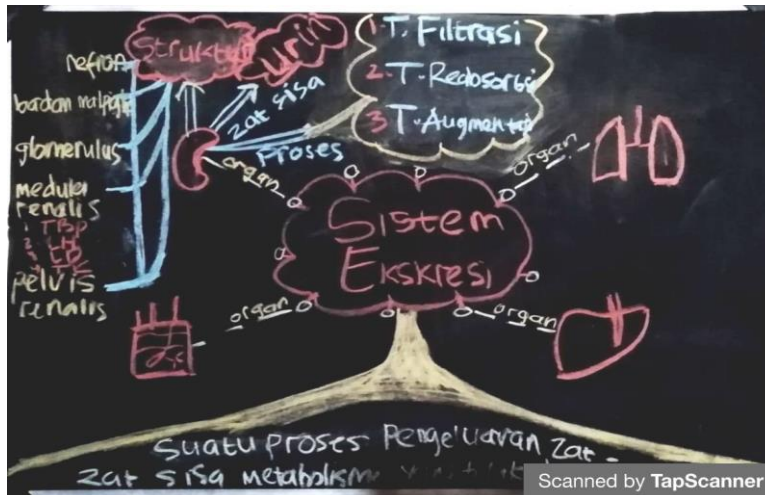
Discussion

The product of the learning design is lesson plan which is completed with learning module, student worksheet, and test instrument. The learning design can be claimed feasible and can be tested if the expert validator confirmed that all of the learning components are categorized into very valid criteria. Based on the experts' validation shown in Table 1.1, it is obtained that the lesson plan is categorized into very valid criteria. This is because the developed lesson plan fulfills the principles of lesson plan making format stated in the attachment of Permendikbud number 22 year 2016. In line with Aruan and Lubis (2016), the correct lesson plan making follows the principles of lesson plan curriculum making stated on Permendikbud number 22 year 2016. In addition, the learning design which is created on the lesson plan has been adjusted following the current curriculum referring to the core competence and basic competence. Problem-based learning has been in line with the learning model suggested by the 2013 curriculum. Hence, in practice, the problem-based learning could be applied for 2013 curriculum well. This supports a research by Sofyan and Komariah (2016) which concluded that problem-based learning is highly potential in 2013 curriculum.

Problem based learning with mind mapping learning design could develop critical and creative thinking ability. Through this model, those skills are trained. This learning design could regulate students' cognitive ability through learning activities or learning stages when solving problem using mind map. This learning strategy could stimulate regulation for students in the form of revealing and monitoring their own mind, feeling, and behavior to achieve the goal. The goal could be in the form of academic achievement which belongs to cognitive ability. According to Traini and Swanson (2005) cognitive aspect involves every mental behavior pertaining to understanding, considering, information processing, problem solving, on purpose, and belief. In this learning design, the stage that regulates students' cognitive aspect is the learning syntax started from the second phase.

The implementation of that stage can be found in lesson plan, for instance, in the first meeting discussing the topic of "the introduction of excretory system and kidney" to achieve 3.10.1 indicator which is to explain the function of excretory system and 3.10.2 indicator which is to relate the structure and function of kidney with the disorders or diseases on that organ. The second phase of the lesson plan is orientating students on problem, which is assisted with student worksheet and material summary as the learning module. In the first phase of the student worksheet, students are given a problem that is an article of kidney stones disorder. In the second phase, students identify the problem through questions, like 1) based on the article, is kidney stone disease related to the excretory system? Explain the function of that excretory system; 2) what organ is damaged as the result of the disease mentioned in the article? 3) what residue is removed? 4) explain the structure in that organ and explain the function! 5) how is the mechanism of blood filtering and urine formation in that organ? After students understand and decide the solution of the given problem, in the third phase, students formulate solutions using mind map. The answer prediction of student's problem

solving can be seen in the Picture 1.



Picture 1 student mind mapping answer prediction on the excretory system material

In the problem solving process using mind map, students practiced and developed their critical and creative thinking ability. This is coherent to Dewi and Riandi (2016) stating that problem-based learning employing mind mapping could improve complex thinking ability covering the ability of problem solving, decision making, and critical thinking. According to Darusman (2014) student achievement on mathematic creative thinking who used mind mapping is better than those who use conventional learning model. Those two findings support the notion that problem-based learning using mind mapping learning design could train the ability of critical and creative thinking. In the process of solving problem, students could use the learning module that is provided in the learning design page 7-15 which comprises the introduction of excretory system and kidney organ.

Besides, students could also use other literature reviews, observation, and interview to experts. To examine the development of students' critical thinking ability, test by using instrument could be given for students; for instance, question number 4 with C4 cognitive category which is "Excretion is excessing waste in a form of urine through blood filtering process, so what organ is involved in that process? Explain the structure and functions that involved in it!" In that question, students could analyze the structure and function of kidney with the critical thinking indicator of argument analysis.

Student creativity can be seen through the mind map those students created. The more branches of idea that students made, the more creative the students are. Darusman (2014) mentioned that mind mapping demands students to produce ideas related to the concept of excretory system materials, give students' freedom to express their ideas regarding the concept in a creative way, develop elaborative ability to create something from every mentioned idea. Therefore, mind mapping can be the benchmarks to navigate the development of student creative thinking ability.

The expert validation of the learning materials aimed at knowing its validity. The validation is conducted to avoid misunderstanding or misconception on the materials. Sawitri *et al* (2015) explained that a module and learning sources are valid if it fulfills validity standards that has been assessed by experts. Based on the expert validation, this learning material is categorized into very valid criteria which is shown in Table 4. This is so since the material has been adjusted following the current curriculum. The learning module has been designed compatible with the students' needs and the materials for grade VII. The learning sources have been modified to improve learning quality in developing student critical and creative thinking. And also, the learning method has been made compatible with the problem-based learning with mind mapping learning design. In addition, evaluation is also given in the end of every material. This supports Lestari (2013) who stated that learning module contains learning materials, methods, scope, and the evaluation instruction that are interestingly and systematically designed to achieve the learning objectives. In a broad sense, the learning module in the learning design is compatible with the structure and function of learning module completeness according to BSNP (2014) covering content feasibility, linguistic feasibility,

presentation feasibility, and graphic feasibility.

Based on the validation result analysis on Table 6, the developed worksheet is categorized into very valid which means it can be tested in the learning design. This is so since the worksheet follow the format of worksheet making according to Depdiknas (2008). The worksheet components cover title, learning instruction, competence and learning objective, supporting information, and task and the work step. Shobirin *et al* (2013) stated that the worksheet that fulfills the worksheet making components set by Depdiknas is adjusted to the problem-based learning with mind mapping learning design referring to the core and basic competence and aligning to the used learning module and test instrument. This is in line with Sidah *et al* (2014) stated that the result of validity test is achieved if the materials of the learning module are coherent to the competence standard/core competence and basic competence, and also the learning module is compatible with the basic competence aimed to achieve. The provided activity and task in the worksheet have been made compatible with the envisioned indicators and learning objectives. According to Prastowo (2014) materials and tasks in the worksheet should be congruent with the learning objectives.

The developed test instrument on the problem-based with mind mapping learning design is in the form of essay test. The developed test comprises 14 test items and indicators coming from five aspects of critical thinking ability. The developed test instrument contains 8 indicators representing 5 aspects of critical thinking in which one indicator comprising several test items. Based on the test instrument validation, the experts categorized the test as very valid which is shown in Table 8. This means that the validators confirmed that the critical thinking test instrument is valid to be brought into testing. This because the test instrument has been made compatible with the focused problems that are provided in the worksheet in order to be harmonious with the materials that the student learn.

Having been validated, the testing of test instrument was given for students who have learnt the excretory system material. The goal of the testing is to measure and gain the validity, reliability, level of difficulty, and discriminating power of the test items. Based on the analysis, all the 14 test items are valid and represented 5 aspects of critical thinking ability. The validity of the test item shows that the test items support the test validity since the items have a higher calculated r - value than the r - table value. Therefore, the instrument of critical thinking assessment is confirmed valid and can be used to measure student critical thinking. Having found that the 14 test items are valid, so the test items' reliability is investigated. Based on the calculation, r_{11} is higher than r table which means that the test items are reliable. The Alpha Cronbach r_{11} reliability coefficient scored 0.93 with very high category and r table scored 0.36. This result released that the validity and the reliability of the test instrument gained a good result that can be used to measure student critical thinking. This because the developed test instrument is compatible with the critical thinking indicators used in this learning design. Besides, the test instrument has been previously validated by the material expert. In congruent with Istiyono *et al.* (2014), that there are four factors that make a good validity and reliability, namely a) the test items are developed following the development procedure; b) the test items are developed from the right reference; c) the test items pass content validity stage; d) the test items are empirically tested on the respondents who work earnestly.

The analysis result of the difficulty level test showed that there are 12 items are moderate, one item is difficult, and one item is easy. The items of the test instrument are good if the items have a difficulty level on the interval 0.31-0.70 that is categorized into moderate according to Arikunto (2013). He mentioned that a good item is a moderate item having difficulty index between 0.30-0.70. Test instrument can be employed to measure critical thinking if the test has a good discriminating power. Referring to Arikunto (2013) good items are the items with 0.4-0.7 discriminating index. The developed test instrument has a good discriminating power to distinguish between the students with higher thinking ability and the students with lower thinking ability.

Based on that explanation, the developed test instrument in the problem-based learning with mind mapping learning design fulfills a qualified test criteria to measure critical thinking ability since the learning design has been confirmed valid by the expert validators and by the testing which showed that the test items are categorized as valid, reliable, having a moderate difficulty level, and having a good discriminating power.

CONCLUSION

Based on this present development research, it can be summarized that problem-based learning with mind mapping learning design to develop critical and creative thinking ability of junior high school students in the excretory system materials is feasible to be tested into learning activity with very valid criteria from the expert validators. The results of this study are in the form of a PBL model with mind mapping learning design products that can be used to train students' critical and creative thinking skills and as an alternative to learning design innovations in the excretion system material.

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