



5E learning cycle combined with mind mapping in the excretory system: effectiveness on curiosity

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ABSTRACT

Curiosity is one of the important characters developed in the 21st century. This study aimed to determine the effectiveness of the 5E (engage, explore, explain, elaborate, dan evaluate) learning cycle model combined with mind mapping on the curiosity of XI classes students in the excretion system material. This research was an experimental study with a non-equivalent pretest-posttest control group design. The study population included all students of XI science classes in Yogyakarta, Indonesia that amounted to 96 people. Samples were 32 for experimental as well as control group, with a total of 64 people. The instrument used was a non-test instrument in the form of a questionnaire consisting of 20 items. The validity of the instruments was good, and the reliability was very high, so the instruments were suitable to be used in data collection. Based on the results of data analysis using the Mann Whitney test, it was found that there were significant differences in the use of the 5E learning cycle model combined with effective mind mapping on student curiosity ($p: 0.007 < 0.05$). It is recommended for Biology teachers to use the 5E learning cycle model with mind mapping to improve student curiosity in excretory material.

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INTRODUCTION

Biology education is an effort to form individuals with character so that they are ready to face global challenges in the 21st century. According to The North Central Regional Educational Laboratory, students in the 21st century need to have inventive thinking that consists of curiosity (curiosity), creativity, and risk-taking (Burkhardt et al., 2003). Education is needed to create qualify characters. The characters suitable for the 21st century are increasingly complex, including attention, curiosity, courage, resilience, ethics, and leadership (Agboola & Tsai, 2012; Giacalone, 2015). Curiosity is considered essential to be developed in the 21st century because, through curiosity, there arises a drive within to obtain new information that is useful to overcome problems arise in the 21st century. Problems can present uncertainty in a person so that one's curiosity tends to arise to solve the problem. Curiosity is the basis of a desire within self to continue to find out to overcome the information gap between what is known and what someone wants to know (Harvey, Novicevic, & Breland, 2009; Narvaez & Lapsley, 2008).

Curiosity is an internal state that occurs if there is uncertainty in a person so that someone tends to explore to reduce or resolve uncertainty (Hsee & Ruan, 2016; Berlyne, 1978). In other words, exploration has a role in finding information or knowledge (Sele, 2019; Day, 1982). External stimuli can generate this attitude, including complexity, uncertainty, conflict, and novelty (Berlyne, 1954). To produce exploratory behavior, an appropriate level of stimulus is needed. Motivation in exploring will not arise, and if it is too high, will only produce anxiety (Ningsih, Rusdi, & Miarsyah, 2019; Borowske, 2005). Curiosity is part of a scientific attitude characterized by a desire to understand situations that cannot be explained (Hsee & Ruan, 2016; Lacap, 2015). Attitude lies as a foundation to bring up motivation in finding, knowing, and learning material (Ristanto, Zubaidah, Amin, & Rohman, 2018; Sari, 2016). Curiosity possessed by someone has the potential to improve learning (Pluck and Johnson, 2011). Intellectually curious students will show curiosity about learning so that academic achievement can ultimately increase (Vidler, 1980). Curiosity needs to be developed by teachers in schools, in subjects such as Biology, precisely the excretion system material.

Basic competence in the 2013 curriculum, particularly in the excretion system material, emphasizes students to analyze the relationship between the structure, processes, and impaired functions that may occur in excretory organs (Ristanto, Djamar, Heryanti, & Ichsan, 2020; Permendikbud, 2016). The material of excretory system that is real and the excretion process experienced by students in everyday life allows them to ask a variety of questions and develop their curiosity.

However, the quantity of student questions on the excretion system material is still low (Djamar, et al., 2018; Ristanto, et al., 2020). The quantity of oral questions by students is only around 23% (Samosir, Hasruddin, & Dongoran, 2019). These results are in line with the results of an observation in SMAN 1 Pundong, Indonesia. Students' curiosity on the material in the excretion system at school is still low. Based on the results of observation conducted with class XI teachers at SMAN 1 Pundong in the 2018/2019 school year, it is known that students' curiosity in the material of the excretion system is still low. Students rarely asked about the material studied, mainly because they were not enthusiastic about observing the teacher's material. Many students do not express their opinions related to the material. The lack of students' curiosity can be caused by apperception at the beginning of learning that is less attractive, so many students are passive during learning (Trilipi, Subali, Anwar, & Santoso, 2019; Ningsih, et al., 2019). Lack of development of scientific attitudes, including the attitude of curiosity can be caused by the use of presentation methods widely used by teachers (Leasa, Sanabuky, Batlolona, & Enriquez, 2019; Ristanto et al., 2018). Students present the results of the material summary, which only comes from textbooks and does not add material from other sources (Melani, Harlita, & Sugiharto, 2012). Other causes are due to teachers who tend to use

the lecture method and teachers who lack question and answer so that student activity is reduced (Djamahar, et al., 2018; Kristiana, 2016). In overcoming the lack of curiosity, the teacher needs to use a learning model that presents problems in daily life experienced by students and not just problems in the textbook as a stimulus so that the question and answer interaction between students and teachers will have an impact on increasing curiosity.

The 5E learning cycle model, combined with mind mapping, is a breakthrough to overcome these problems. This model is an innovative combination of 5E learning cycle models and mind mapping techniques. At present, there is still no research related to 5E with mind mapping of curiosity. However, based on existing theories, the 5E learning cycle model and mind mapping techniques have the potential to increase curiosity. The 5E learning cycle model is a learning model that uses a constructivist (Cahyarini, Rahayu, & Yahmin, 2016; Bybee, 2014).

5E learning model has five stages, including engage, explore, explain, elaborate, and evaluate (Tuna & Kacar, 2013; Balci, Cakiroglu & Tekkaya, 2006). The first stage, engage, has aimed to attract the attention and interest of students towards learning. At this stage, students are focused on the problem or situation following the learning objectives to be achieved (Bybee, 2014). The teacher's task at this stage is to assess the initial knowledge of students and help them to engage in new concepts to be learned by giving questions or problems so that students' curiosity about learning can emerge (Cahyarini, et al., 2016). In the second stage of exploration, students are allowed to investigate phenomena previously proposed at the engage stage (Goldston, Day, Sundberg, & Dantzler, 2010; Kaynar, Tekkaya, & Çakiroğlu, 2009). This stage facilitates students to carry out activities in order to develop skills and generate new ideas. In the third stage, namely explanation, students are allowed to explain their findings, explain the understanding of concepts that they have through presentations, while the teacher guides, clarify explanations, and deepens student understanding (Bybee, 2015; Goldston, et al., 2010). In the fourth stage, elaboration, students develop skills, expand their understanding of new situations or problems. In the final stage, evaluate, the teacher and students evaluate the learning activities that have been carried out and assess the achievements achieved during learning (Bybee, 2015; Kaynar et al., 2009; Bybee, 2010; Bybee, 2014; Balci, et al., 2006). The evaluation syntax sequence ranks last, but the evaluation stage's position is to see the whole stage starting from engaging, exploring, explaining, and elaborating. The stages in the 5E learning cycle model can be visualized through Figure 1.

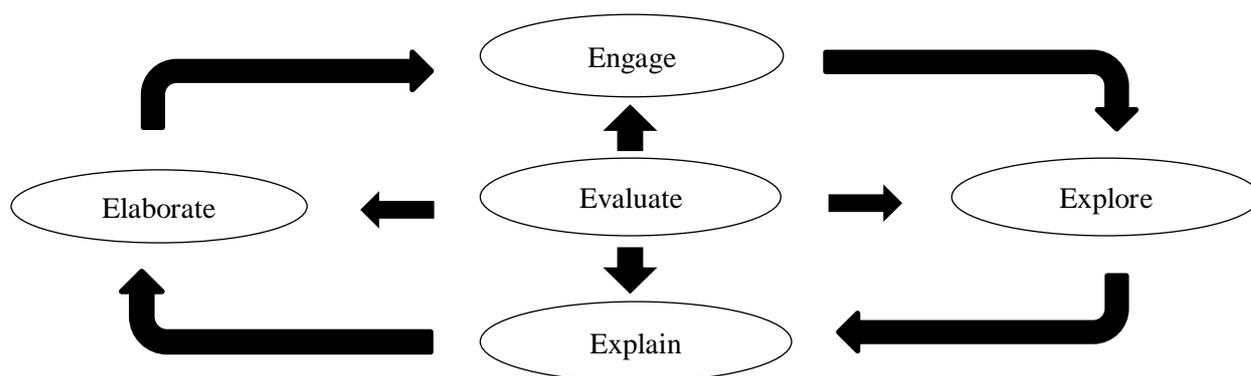


Figure 1. Syntax of 5E Learning Cycle (Source: Bybee, 2015)

In solving problems at the elaborate stage, students need much information that is useful in producing solutions to problems. The elaborate stages will be combined with mind mapping techniques. Mind mapping is a recording technique that was first created by Tony Buzan and is used to structure and organize thoughts (Buzan and Buzan, 1990). The purpose of mind mapping is to find relationships between ideas so that, in principle, mind mapping is an

association map (Buzan, 1974). The form of unstructured mind maps can facilitate a person in solving problems (Royal, 2010). Mind map elements include colors, symbols, images, branches (Buzan & Buzan, 2000; Rustler, 2012). Mind mapping can help students assimilate new information, remember information, and develop their conceptual schemes so that students are motivated and significantly improve student learning outcomes (Indriani & Mercuriani, 2019; Tee et al., 2014). The benefits of mind maps are easy to learn and apply, represent hierarchical relationships, and can develop creativity and self-expression (Buzan, 1995; Buzan, 1974). Based on the explanation above, this study was conducted to determine the effectiveness of the learning cycle model combined with mind mapping of student curiosity.

METHODS

Research Design

This type of research is a quasi-experimental study using a non-equivalent pretest-posttest control group design. This study used two groups. The experimental group was given the treatment model of the 5E learning cycle combined with mind mapping, while the control group was given the 5E learning cycle. The description of the research design is shown in Table 1.

Table 1

Design of Nonequivalent (Pretest-Posttest) Control Group

Group	Pretest	Independent Variable	Posttest
Experiment	O ₁	X _E	O ₂
Control	O ₃	X _K	O ₄

Note:

O₁: Pretest of experiment group (5E learning cycle combined with *mind mapping*).

O₂: Posttest of experiment group (5E learning cycle combined with *mind mapping*).

O₃: Pretest of control group (5E learning cycle).

O₄: Posttest of control group (5E learning cycle).

X_E: 5E learning cycle combined with *mind mapping*.

X_K: 5E learning cycle.

Population dan Samples

This research was conducted at SMAN 1 Pundong, Bantul, Yogyakarta, Indonesia. The study population was all students of XI IPA at SMAN 1 Pundong in 2018/2019, amounting to 96 students. The sample used as an experimental group and a control group has 32 students each. So the total sample used was 64. Determination of group sampling used as an experimental group and control group were done using cluster random sampling techniques. Cluster random sampling technique is a sampling technique in groups/groups that already exist (Leavy, 2017).

Instrument

The curiosity instrument used was a questionnaire that used the Likert scale. The Likert scale used was composed of 4 categories: always, rarely, and never. The preparation of items on the questionnaire was designed based on indicators of curiosity (Harlen, 1996), namely (1) enthusiastic in seeking answers, (2) focus on the observed objects, (3) enthusiastic in the science process, (4) asking each step of the activity. The number of statement items compiled was 20 items.

Before being used, the instrument was tested for validity and reliability. Validity limited to the judgment of expert judgment. The instrument was not empirically tested for validity because the number of samples used in this study amounted to 64 people. The number was

relatively small, while the requirement for an empirical test for non-test instruments is to use a sample of 100 people for 1 indicator. In this study, 4 indicators were used so that as many as 400 respondents were needed. Non-test instruments use a scale with a value of 1-5. The validity test results in the form of quantitative data were converted into qualitative data adopting criteria from Sukardjo (2009), presented in Table 2.

Table 2

Conversion category validity of quantitative data into qualitative data.

Range	Category
$X > 4.2$	Very good
$3.4 < X \leq 4.2$	Good
$2.6 < X \leq 3.4$	Quite good
$1.8 < X \leq 2.6$	Less good
$X \leq 1.8$	Not good

Reliability was calculated using the Spearman-Brown split-half test through SPSS software. The reliability coefficient category refers to the reliability coefficient category (Guildford, 1956), shown in Table 3.

Table 3

Category of non test instruments reliability.

Range	Category
$X > 0,80$	Very high
$0,60 < X \leq 0,80$	High
$0,40 < X \leq 0,60$	Medium
$0,20 < X \leq 0,40$	Low

Validation was carried out by two validators (expert judgment). Non-test instruments are validated from the aspects of material, construction, and language. Based on the results of validation, it was known that non-test items were feasible to be used with an average value of all aspects of 4.08, which was included in both categories. From the material aspects, we could say that all items have a value of 4.13 in the top category. In terms of the construction aspect, a score of 3.83 was in good category and viewed from the Language aspect; a score of 4.20 was in proper category. Based on the results of the reliability Spearman-Brown test, it was known that the coefficient reliability was 0.876. The results of non-test instrument validation can be seen in the following Table 4.

Table 4

Validation results from expert judgment

Aspect	Criteria	Validator		Average criterion	Average aspect	Category
		1	2			
Material	1. Item fit to indicator.	3	4	3.5	4.13	Good
	2. The statement is formulated correctly.	4	5	4.5		
	3. Substance fit to purpose.	4	5	4.5		
	4. Substance fit to the school level, type of school and grade level.	4	4	4		
Construction	1. Formulation of sentences in the form of statements.	3	4	3.5	3.83	Good
	2. There are clear instructions on how to fill out the questionnaire.	3	4	3.5		

	3. The list of statements reflects the indicators.	4	5	4.5		
	1. The sentence formulation must be communicative.	4	3	3.5		
	2. Sentences use excellent and correct language.	4	3	3.5		
	3. The formulation of the sentence does not lead to a double interpretation.	5	4	4.5		
Language					4.20	Good
	4. Using a common language (not a local language that is not known throughout the test).	5	4	4.5		
	5. Does not contain words that offend testicles.	5	5	5		
	Average		4.08			Good

Procedure

The research began with population determination and research samples. The next stage was the development of a non-curiosity test instrument that refers to the curiosity indicator. After the instrument has finished, an analysis of the instrument's validity and reliability was carried out. Instruments that fulfill validity and reliability will be used in research in the experimental and control groups. Non-curiosity test instruments were used twice before, namely by giving a pretest and after learning by giving a post-test. The pretest and post-test data will then be analyzed. The control group used the 5E learning cycle model, while the experimental group used the 5E learning cycle model with mind mapping. The implementation of the 5E learning cycle model with mind mapping in the experimental class is presented in the following [Figure 2](#).

Data Analysis

The pretest and post-test curiosity data were analyzed descriptively to see the students' curiosity descriptions in each group. Besides, the percentage of curiosity tends to be analyzed then the percentage value obtained will then be converted into a category value. The categories of attitude tendency are distinguished to be very high with a value of ≥ 80.94 , a high category with a range of values of $80.94-69.75$, a low category with a range of values of $69.75-58.56$, and very low with a value of $<58, 56$ (Purwanto, 1994). Pretest and post-test data were analyzed using the Mann-Whitney test with the SPSS 17.0 program. The Mann-Whitney test is a non-parametric statistical test used on data using ordinal or ranking scales (Field, 2009). The non-parametric test is a statistical analysis that assumes that the data distribution does not follow a specific distribution, so the statistical test used is a non-parametric statistical test. In this study, no normality test and homogeneity test were conducted. The pretest and post-test data were analyzed using the N-Gain test to find out how effective the use of learning models was. The N-gain score was then categorized as follows: high category if $g \geq 0.7$, medium category if $0.3 \leq g < 0.7$, and low category if $g < 0.3$ (Hake, 1999).

RESULTS AND DISCUSSION

A complete description of the pretest and posttest data in the two groups is presented in [Table 5](#) and [6](#).

Table 5

Description of curiosity in experiment group and control group.

Data	5E Learning Cycle with Mind Mapping		5E Learning Cycle	
	Pretest	Posttest	Pretest	Posttest
Mean	60.27	78.63	58.98	71.36
Minimum	45.00	62.50	47.50	53.75
Maximum	73.75	97.50	67.50	88.75
SD	7.53	10.07	5.19	8.44

Table 6

Description of curiosity in experiment and control group.

No	Indicators	Average value	
		Pretest	Posttest
1.	Enthusiastic in seeking answers	73.40	98.00
2.	Focus on the observed objects	73.80	92.00
3.	Enthusiastic in the science process	81.80	89.00
4.	Asking each step of the activity	73.00	86.00

Based on Figure 2 (a), (b), students' curiosity tendencies are very high, high, low, and very low. Before learning, students' curiosity in both the experimental and the control class tended to be low. In contrast, after learning, there is an increase in curiosity in the experimental and control groups. The experimental group improved better than the control group. Complete results regarding the percentage description of curiosity categorization are listed in Figure 2 (a) and (b).

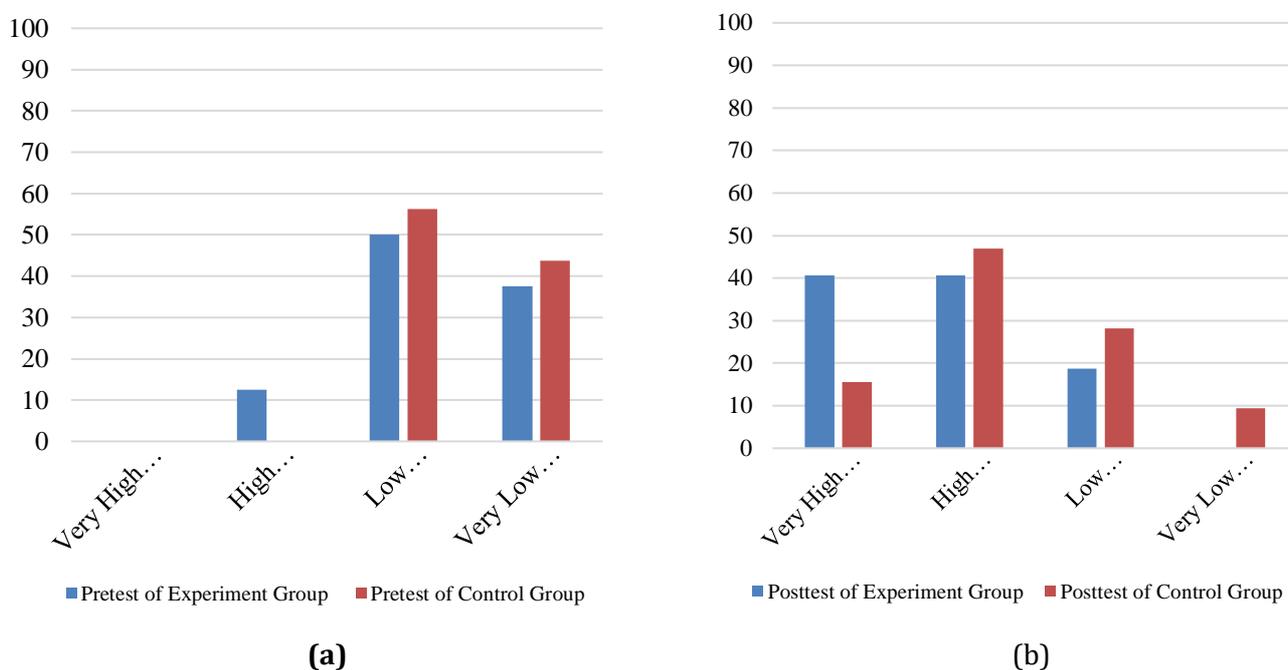


Figure 2. (a) Description of percentage of curiosity categorization in pretest, (b) Description of percentage of curiosity categorization in posttest.

Furthermore, after treatment was given, the two groups were analyzed again using the Mann Whitney test. The analysis was performed using post-test data. Based on the results in Table 7, it appears that the significant value was smaller than the value of α (0.05). From there, we can conclude that hypothesis null rejected or there are significant differences in the average

value of the experimental group and the control group after being given treatment. In other words, the usage of the 5E learning cycle model combined with useful mind mapping increase students' curiosity.

Table 7

Results of mann whitney test.

	Sig (2 tailed)	Decision	Information
Pretest	0.400	Ho accepted	There is no significant difference
Posttest	0.007	Ho rejected	There is a significant difference.

In order to elaborate on the effectiveness of the model, the N Gain test was performed. Based on the results in [Table 8](#), it is known that the experimental group has a higher N-Gain value than the control group.

Table 8

Results of n-gain analysis.

Group	N-Gain Results	Category
Experiment	0.49	Medium
Control	0.28	Low

The characteristics of the material on excretion system is real and the learning of this material could come from problems in daily life. These problems are very compatible with the characteristics of the 5E learning cycle model with mind mapping using constructivist paradigms that students are actively involved in building their knowledge based on their experiences (Cahyarini, et al., 2016). Increased student curiosity in the experimental class and the control class because both classes use the 5E learning cycle model. The stages in the 5E learning cycle model support an increase in curiosity in all indicators, namely enthusiastic searching for answers, focus on the observed objects, enthusiastic about the science process, asking every step of the activity on the material (Goldston, et al., 2010; Kaynar et al., 2009). However, the highest increase in the value of curiosity is found in the indicator enthusiastic search for answers. This relates to the syntaxes of the 5E learning cycle model with mind mapping that focuses on extracting concepts from the phenomena or problems.

In the engage phase of the 5E learning cycle model, students are given a stimulus about a phenomenon experienced by students in everyday life. It stimulates students to ask questions or explore answers to the problems raised (Cahyarini, et al., 2016). In the material excretion system, students are given a phenomenon about ants that surround the urine (Ristante, et al., 2020). Students will ask about the urine content so that the ants are interested in swarming it. Students will be enthusiastic about finding answers to questions that arise at the engaging stage due to the limitations of the initial knowledge students have. The information gap between what students know so far, and the teacher's stimulus will increase students' curiosity. The result is by the opinion of Harvey et al. (2009) that curiosity is the basis of a desire to continue to find out which aims to overcome the information gap between what is known and what someone wants to know.

Then in the next stage, that is exploring students conducting urine test experiments. The stages of exploration in the 5E learning cycle model are considered necessary because they have the potential to increase student curiosity. Laboratory practice done by students can train them to focus on the observed object, be enthusiastic about the scientific process, and ask every step of the activity during the activity. Students are asked to explain the results of the experiments that have been conducted in the explained stage. If the results of experiments conducted by students are not following the theory, then questions arise that can foster student

curiosity because they will be enthusiastic about finding answers. The findings of this study in line with the [results](#) of research conducted by (Ditriguna, Sujana, & Suniasih, 2013) that the 5E learning cycle model significantly influences students' scientific attitudes, including curiosity and in line with the opinion (Suyanto, 2011) that the 5E learning model can enhance various characters, including curiosity.

Curiosity is an important character possessed by students because great curiosity can affect the improvement of learning outcomes (Agboola & Tsai, 2012; Giacalone, 2015). Curiosity is an aspect of motivation within oneself, which is very potential in improving learning (Agboola & Tsai, 2012; Pluck & Johnson, 2011). The experimental group that used the 5E learning cycle model combined with mind mapping was more effective in enhancing curiosity because mind mapping can provoke students' curiosity in finding information relevant to the problem. Problems can trigger students' enthusiasm in finding answers (Nabilah, Anwar, & Riyanto, 2019; Astuti, Nurhayati, Ristanto, & Rusdi, 2019). The problems that students must solve on the excretory system material, namely regarding disorders of the excretion system. In the elaborate stage, in the experimental group, all students created mind maps individually, while in the control group, students only worked on problems in groups like discussions in general. The low curiosity of students in the control group could be caused by the method of working on the problems to solve problems at the elaborate stage is done in groups. A large number of members in a group makes only some students active and enthusiastic about solving problems while some group members tend to be passive. The number of students in the control group, who were passive, showed that students' curiosity about the problem was still low. This result was inversely proportional to the experimental group that used mind mapping. Mind mapping makes all students actively involved and enthusiastic about solving problems (Indriani & Mercuriani, 2019; Tee et al., 2014). Mind mapping is a proper technique for improving students' ability to solve problems and to gather information (Indriani & Mercuriani, 2019; Tee et al., 2014; Jibrin, Abdullahi, Zayum, & Abdullahi, 2012). Each student is required to solve problems independently. Problems solved through mind mapping can stimulate student curiosity. This is because to create a student mind map requires much information that is used to solve problems. The more information obtained by students, the more ideas/solutions can appear. The more ideas, the more branches students will make on the mind map. For example, in the example, students make a mind map that connects problems with their causes (See [Figure 3](#)). These results are consistent with the opinion (Sasongko, 2017) that mind mapping can encourage students' curiosity about learning.

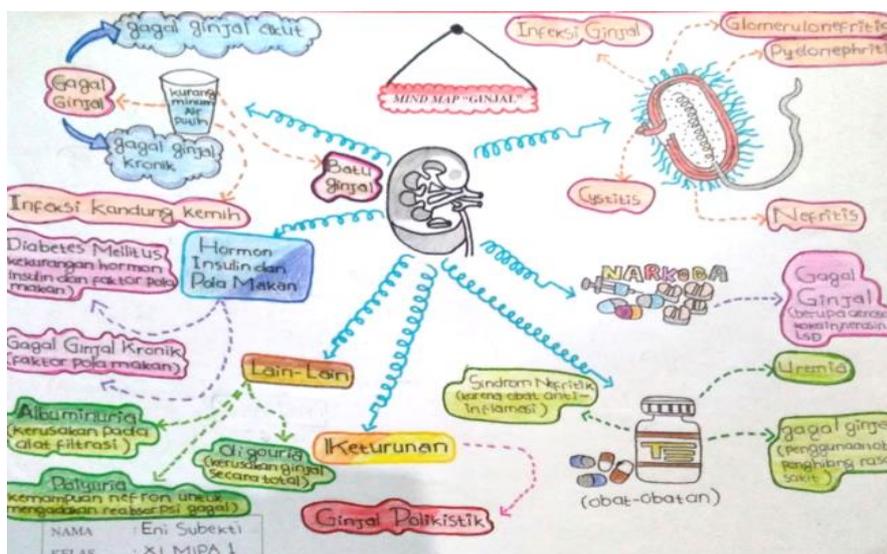


Figure 3. Examples of Mind Map made by a student.

This research is inseparable from the advantages and disadvantages. The advantage of this research is that it can be applied to all schools because it does not cost much. The syntax of 5E learning model, which is not many, makes it easy for teachers to implement it in school. The weakness of this study is that the sample used is reasonably small to validate non-curiosity test instruments that are only limited to validation by expert judgment. Therefore, further research is recommended to use more samples, so that non-test instruments meet face validity and meet empirical validity.

CONCLUSION

Based on the results of the study, it can be concluded that the 5E learning cycle model combined with useful mind mapping could increase student curiosity, which is shown from the results of the Mann Whitney test, that the sig value was smaller than the alpha value ($0.007 < 0.05$). The higher the student's curiosity, the more information obtained, and the more branches are created on the mind map. So, based on these results, teachers are recommended to use the 5E learning cycle model with mind mapping to increase student curiosity.

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