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To cite this article: Wildan Navisa Barra *et al* 2019 *J. Phys.: Conf. Ser.* **1233** 012046

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The Effect of Inductive Learning Model Assisted Mindmap Mindjet Mindmanager towards Critical Thinking Skills of Students

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Abstract: Physics learning should be oriented towards students, whereas physics learning oriented towards teachers make students as passive object thus they train less critical thinking skills in process of forming and concept analysis of physics. This study aims to know the effect of inductive learning model assisted mindmap MindJet MindManager towards critical thinking skills of students in learning physics on topic optical eye. This study is a quasi experimental with one group pretest – posttest design. This study was carried out in senior high school state 6 Yogyakarta. 33 students of second grade of mathematics and science major first class are chosen as our subject research based on the recommendation of a teacher that students in that class have sufficient academic potential with consideration if students with good academic potential are given good learning, they are expected will also get good result. We used essay questions as test and instrument in gathering technique. Thus, we analyzed the data using pair sample t test. The result of data analysis shows Sig. (2-tailed) 0.032 on pair sample t test. There is a difference in critical thinking skills of students between before and after experiment of physics learning with inductive learning model assisted mindmap MindJet MindManager. We conclude that mindmap inductive learning model assisted MindJet MindManager influences critical thinking skills of students.

Keywords: Inductive model; Critical thinking skillss; Mindmap; MindJet MindManager.

1. Introduction

The 21st century brings new challenge to education world in all fields, including physics education [1]. Physics teachers are demanded to use student center learning model and information technology as study media of physics, thus physics learning can be meaningful. Nevertheless, in the last three decades, the fact in field is not as expected. Physics learning in schools is still teacher center making students as passive object only listen their teachers' explanation and physics learning becomes not maximal [2,3]. Teacher center learning activity hinders students to exchange their minds with their friends and teachers thus it affects critical thinking of students, in which it does not train their critical thinking [4]. A student who think critically in learning sees and analyzes a problem through physics phenomena with different point of view by seeing the strength and weakness of the problem [5]. Students are demanded to be able to understand, analyze and evaluate the concept, and synthesize information from various sources, and present a result or theory using critical thinking [6].

Physics subject can be understood easily if students have basic thinking skills [7] and goof critical thinking skills [8]. Critical thinking is someone's skills to think logically and reflective in making decision based on his/her beliefs. Moreover, critical thinking involves someone's ability to reflect, produce, and evaluate evidences [9]. Aspects of critical thinking skills such as: 1) giving simple explanation; 2) building basic skills; 3) giving further explanation; and 4) arranging strategy and tactic

[10]. It also can be said that critical thinking is using common sense skills reflecting something by involving evaluated evidences in making decision. Critical thinking skills is needed by students in learning physics.

Critical thinking can be trained by implementing innovative learning. Inductive learning model pioneered by Joyce, *et al.* is one of the alternatives. Inductive learning model is a learning model based on information process thus students are demanded to gather and filter the information to build ideas and test them carefully and in the end they can formulate and test the assumptions based on what they learned [11]. Inductive learning model is learning activity demanded the students to observe, measure, gather the data and test the assumptions to obtain the conclusion [12]. Therefore, it can be said that inductive learning model is learning model constructing the concepts by gathering information, building ideas or opinions until formulating and testing the assumptions.

The advantages of inductive learning are as follows: 1) guide the students to study independently [13] and based on point of view of constructivism learning theory, teaching is an activity allowing students to construct their own knowledge [14]; 2) create student center learning [15]; and 3) improve critical thinking skills [16]. According to Joyce, *et al.* four main steps in inductive learning are presented in Table 1 [11].

Table 1. Syntax of inductive learning

Number	Step	Description
1	Data Gathering and Presentation	Gather and create a set of data or information related to the topic learned.
2	Data test and computation	Identify, label, calculate, and test the truth of data.
3	Classification	Classify and compare the data that have been analyzed into certain categories based on its characteristics.
4	Build and test assumptions	Build assumptions based on categories that had been arranged in “classification” step and test those using available theories or proper principles and investigate the reasons behind assumptions built. Therefore, make conclusion.

Teachers not only must be able to choose precise learning media but also precise learning mode because media help teachers to achieve learning objectives. Learning media can stimulate students' minds and interests into study process [17]. Learning medium that is compatible with inductive learning model is mindmap. By using mindmap will support learning process becoming more creative and create more critical study pattern. Mindmap is able to map students' minds by connecting information and concepts into branches shape [18]. This mindmap is accordance with a step in inductive learning process, in which classification step demanding students to be able to categorize data or information based on certain characteristics.

Students having good mindmap, will not find difficulty in analyze a problem, this they can find solutions or determine accurate action [19]. This is in accordance with critical thinking skills indicator in arranging strategy and tactic. Therefore, the usage of mindmap in syntax or inductive learning model step contributes towards improving critical thinking skills of students.

Empowering information and communication technology is one of efforts to improve education quality, for example by using media based on Information and Communication Technology (ICT). Utilizing ICT in creating mindmap, for example is by using MindJet MindManager program. MindManager is software made by Mike and Bettina Jetter in 1998, using basic principle of mind mapping method in order to ease learning process for students [20]. The advantages of using MindJet MindManager are 1) when making mind mapping if there is an error occurred in creating steps, it will be easy to be corrected or edited because it uses computer and 2) it has many features. The newest MindJet MindManager software, easily downloaded and free is MindJet MindManager. The aim of this study is to know the effect of inductive learning model assisted mindmap MindJet MindManager critical thinking skills of students

There are several prior studies investigating the benefit of inductive learning and the usage of mindmap as solution to develop thinking skills of students. Birnbaum, *et al.* have studied how role of insertion page of numerous categories of data can improve inductive learning in biology subject. Practical implication of this study is through inductive learning students are encouraged to be able to differentiate problem categories from numerous available cases [21]. Students recognizing well problem categories from the cases can give solution by implementing exact procedures. In this study, inductive learning is implemented in physics subject to develop deeply critical thinking skills of students.

Mondal's study (2013) is explained that inductive learning model helps in strengthening cognitive structure in thinking guiding the students to develop thinking skills [22]. This writing gives information that inductive learning model facilitate students in their thinking activity. Prince and Felder's study (2006) informs that inductive learning model improve students' ability in learning more deeply thus it helps students to learn on how thinking critically and studying independently [13]. This result also gives information that inductive learning model disagrees if learning depends on memorizing method. Hayati (2005) conducted a study towards class action by implementing inductive learning model to improve critical thinking of students in physics subject of work and energy. The result of Hayati's study shows improvement in critical thinking of students based on comparison of questionnaire result among cycle 1 questionnaire, cycle 2 questionnaire and cycle 3 questionnaire that is 61%, 70% and 73% respectively [23]. Our study has similarity with that Hayati's as using inductive learning model to improve critical thinking. Nevertheless, in our study the inductive learning model is helped by mind mapping to ease mapping of students' minds in critical thinking. Moreover, our study uses quasi experimental design to know if there is effect of inductive learning model towards critical thinking.

Santiago in [24] developed critical thinking of students through visualization using mindmap. Mindmap concept trains students to think systematically and structurally. Mind mapping allows students to arrange premis, pros and cons in each arguments and convert them this student are encouraged to associate relationship among knowledge concepts. Mindmap is an effective medium for students to develop critical thinking skills [24]. In our study, mindmap used to develop critical thinking skills is electronic mindmap because it is more practical with MinJet MindManager program. Moreover, nowadays, teachers also are demanded to utilize information technology.

In our study, inductive learning model is combined with mindmap medium MindJet MindManager program and investigated its effect on critical thinking skills of students in physics subject. Mindmap is used in classification step in inductive learning model thus it helps students in forming relationship among concepts and organizing data in mindmap form then students are trained to think critically and become active in learning process.

The rest of this paper is organized as follow: Section 2 describes the proposed research method. Section 3 presents the obtained results and following by discussion. Finally Section 4 concludes this work.

2. Research Method

This study used one group pretest – posttest design as experimental approach that aiming to compare condition of a group between before and after given treatment. This study only used one class as subject research due to school's policy. Research design is presented in Figure 1. Before given inductive learning model assisted mindmap MindJet MindManager treatment, students were given pretest aiming to know preliminary students' ability. Thereafter, students were given treatment and after treatment finished they were tested again (posttest).

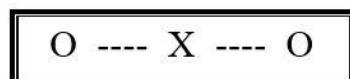


Figure 1. One group pretest-posttest research design

Description:

O test conducted to students.

X treatment given as inductive learning model assisted mindmap MindJet MindManager.

Data gathering technique used in this study was pretest and posttest questions in essay form regarding optic eye topic an amount of four items for measure critical thinking skills in following aspects 1) giving simple explanation; 2) concluding; 3) arranging strategy and tactic. All pretest and posttest essay questions had been reviewed by two lecturers of graduate program of Yogyakarta State University and those questions to measure critical thinking skills of students on optics topic had been stated having good validity. Paired sample t test was used as analysis technique assuming the data are normally distributed. The result of paired sample t test could prove whether treatment given could provide significance influence towards critical thinking skills of students.

2.1. Respondents

This study was carried out in senior high school state 6 Yogyakarta. A group of 33 students in second grade of mathematic and science major first class are chosen as subject research based on the recommendation of a teacher that students in the class have sufficient academic potential. In assumption when students with good academic potential are given good learning, they are expected will also get good result.

2.2. Materials

Materials used in physics subject are 1) animation videos of optics (vision) and lenses of glasses; 2) MindJet MindManager computer program to map eye vision cases and its solution by using glasses for patients in mindmap form made by students; and 3) student worksheets and handouts are given to students so they can understand briefly about optic eye and eye defects. Student worksheets provide numerous cases of eye defects to encourage students to identify the cases. After they identify, students are instructed to implement exact solution by using the suitable lenses of glasses for each case and calculate power of the lenses. After answering student worksheets, they are instructed to create mindmap using MindJet MindManager software. Students' mindmaps are presented in front of each discussion group.

2.3. Teaching

Inductive learning model assisted mindmap MindJet MindManager were conducted as follows:

1. Preliminary activity

- a. Teacher gives brief motivation in order to emerge students' interest and attention in studying.
- b. Disclose preliminary concept of students related to topic to be teach in class.
- c. State learning objectives

2. Learning activity with inductive learning model assisted mindmap Mindjet MindManager

Step I: Data gathering and presentation

- a. As instructed by teacher, students form discussion group.
- b. Teacher explains physics subject (optic eye) then each group is instructed to analyze eye vision cases presented in student worksheets and gather the data, either data in form of information or quantitative obtained from handouts and student worksheets given by teacher.

Step II: Data Test and Calculation

Through group discussion, students label, count and test the truth of the data. This activity is intended to train students' carefulness.

Step III: Classification

Through teacher's guidance in this step, students classify their data test result based on certain characteristics into mindmap using Mindjet MindManager 2017 software. This activity aims to train students' creativity in producing ideas through branching concept in creating mindmap to improve thinking process.

Step IV: Assumption formulation and test

a. Students are demanded to formulate and test assumption based on cases given in student worksheets, thus students know what to do to obtain something.

b. Teacher appoints some groups to present their discussion result and mindmap.

3. Last Activity (Closing)

Consolidate the knowledge recently obtained by students with prior knowledge. This activity aims to strengthen students' new knowledge.

3. Results and Discussion

Learning activity of physics subject used inductive model with mindmap and MindJet MindManager software is shown from Figure 2 to Figure 6. Figure 2 shows that students gathered data (information) through observing animation video and several sources such as handouts and text book to solve the problem in eye vision cases inside student worksheets. Figure 3 presents students when doing data test to identify type of eye vision defects and value power of lenses of glasses. Figure 4 shows that students while formulating assumptions and investigating reasons motivating the assumptions formed. Figure 6 presents presentation activity of each discussion group's mindmap as well as confirmation activity of each group's result. Evaluation result of critical thinking skills of pretest posttest is shown in Figure 7 below. Figure 7 pictures that there is difference in average value between before and after given treatment of inductive learning model assisted mindmap MindJet MindManager.



Figure 2. Phase 1: Data gathering and presentation step



Figure 3. Phase 2: Data test and calculation step



Figure 4. Phase 3: Data classification step in mindmap form

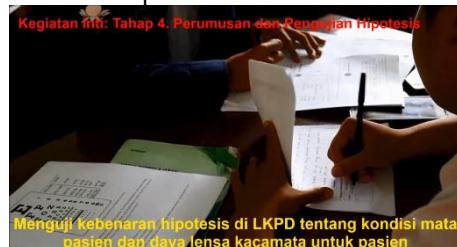
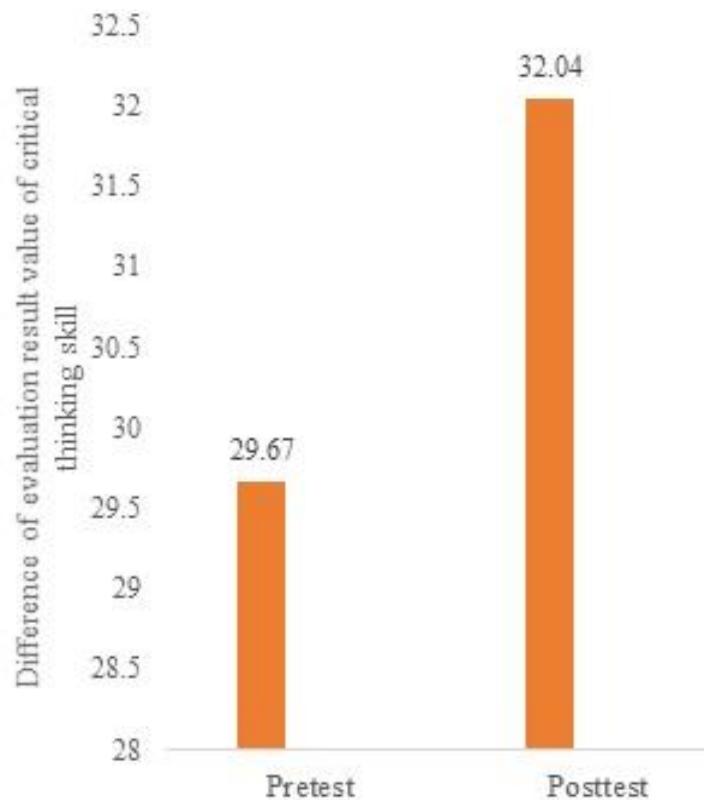


Figure 5. Phase 4: Assumption formulation and test step



Figure 6. Mindmap presentation of students

**Figure 7.** Difference of evaluation result value of critical thinking skills**Table 2.** Analysis result of test of data normality of instrument critical thinking skills

Kolmogorov-Smirnov ^a			Shapiro-Wilk			
Statistic	df	Sig.	Statistic	df	Sig.	
Diff	0.114	33	0.200*	0.974	33	0.603

Table 3. Analysis result of paired sample t test

Paired Differences in Paired Samples Test								
	95% Confidence Interval of the Difference						Sig. (2-tailed)	
	Mean	Std. Dev	Std. Error Mean	Lower	Upper	t		
Pair1 - SMEAN (PRETEST) - SMEAN(POS TTEST)	-2.373	6.097	1.061	-4.535	-0.211	-2.236	32	0.032

Result of normality test of critical thinking skills is shown in Table 2. Shapiro Wilk normality test shows significant value 0.603 (see Table 2). Table 2 shows value (Sig.) (0.603) > 0.05, in which it shows that the data is normally distributed and can be tested by using paired sample t test.

We can see if there is a difference between before and after given inductive learning model assisted mindmap MindJet MindManager from Sig. value (2-tailed) in paired sample t test (see Table 3). Paired sample test gets Sig. value 0.032, in which it is smaller than α significance value, thus there is difference in critical thinking skills of students between before and after given inductive learning

model assisted mindmap MindJet MindManager. In other word, inductive learning model assisted mindmap MindJet MindManager affects critical thinking skills of students.

Critical thinking skills aspect reviewed are 1) giving simple explanation represented by item 1; 2) building basic skills represented by item 2; 3) concluding represented by item 3; and 4) arranging strategy and tactic represented by item 4. Critical thinking skills of students successfully achieved in inductive learning model assisted mindmap MindJet MindManager are three aspects as follows: 1) giving simple explanation; 2) making conclusion; and 3) arranging strategy and tactic (see Figure 8).

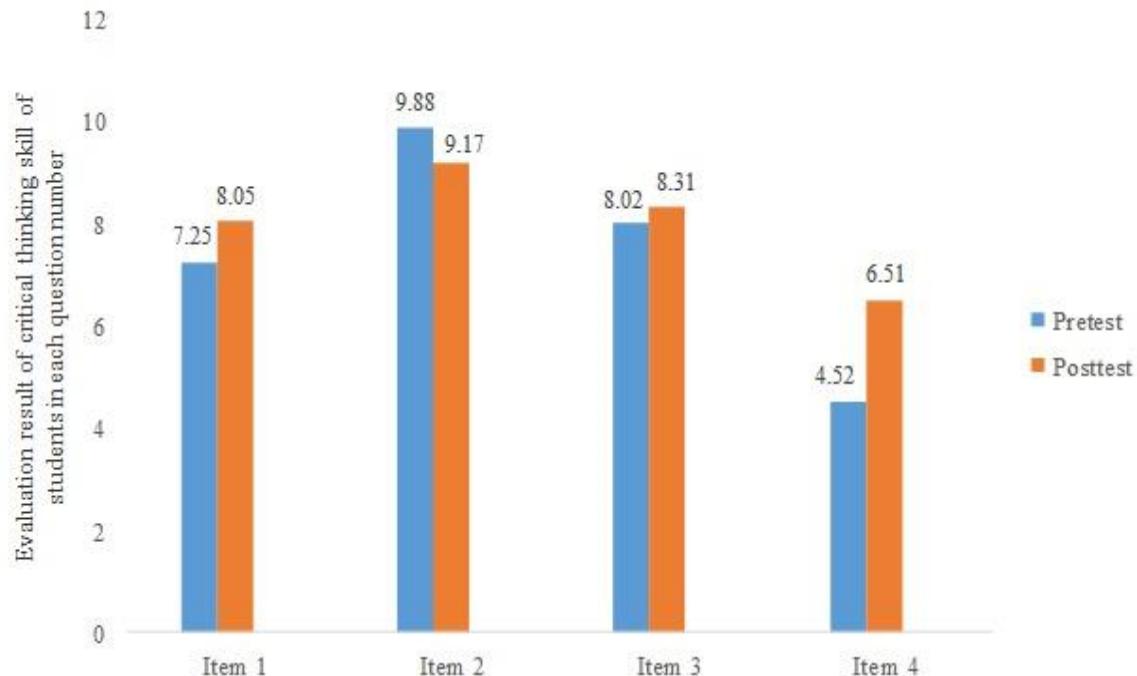


Figure 8. Evaluation result of critical thinking skills of students in each items

Figure 8 shows decreasing in critical thinking skills of developing basic skills is on item2. It is caused by item 2 in pretest relatively easier for students compared with posttest. Because in pretest, student is only instructed to correct 1 sentence that is contrary to optic eye concept in the question, while in posttest there are 3 sentences needed to be corrected. Other items have similar equal difficulty either in pretest or posttest. Item 1, 3, and 4 show that there is positive change thus there is difference in critical thinking of students between before and after given treatment with positive direction change. Improvement in critical thinking skills of students due to inductive learning model assisted mindmap MindJet MindManager 2017 can be seen in answer pattern of students directing to resolving question by implemented critical thinking. One example of concluding aspect shown in students' answer in subject X before and after given treatment on item3 is presented in Figure 11 and 12. Pretest and posttest's item 3 are presented in Figure 9 and 10.

Danis adalah mahasiswa di Yogyakarta yang cerdas dan berbakat menulis novel. Di sela-sela padatnya jadwal kuliah, dia selalu menyempatkan waktunya untuk menyelesaikan *sketsa* komik yang bertajuk "Si Pinokio Masuk Hutan". Sayangnya, baru-baru ini Danis sering mengeluh bahwa Ia sering merasa:

1. Sakit kepala saat mata lelah;
 2. Sulit melihat saat berkendara di malam hari;
 3. Tampak tidak menyadari adanya benda yang jauh.
- Setelah berkonsultasi dengan seorang dokter, hasil diagnosa menunjukkan bahwa Danis hanya dapat melihat objek yang jauhnya tidak lebih dari 100 cm. Setelah itu, dokter Paijo menyarankan kepada Danis untuk menggunakan kacamata. Namun, karena harga kacamata di klinik dokter Paijo cukup mahal, Danis memutuskan untuk membeli kacamata di toko optik dekat rumahnya. Disana, Danis dilayani oleh asisten pemilik toko yang bermama Ferry. Berdasarkan keluhan dan hasil diagnosa penyakit Danis, Ferry menawarkan kepada Danis sebuah kacamata berlensa cekung dengan kekuatan lensa -3 dioptri dengan harga Rp. 700.000,-.
- Berdasarkan bacaan di atas, jawablah pertanyaan berikut ini!**
- a. Hasil diagnosa dokter menunjukkan bahwa Danis menderita....
 - b. Menurut Anda, haruskah Danis memutuskan untuk menerima tawaran tersebut? Jelaskan!

Figure 9. Pretest item 3 (concluding aspect)

Rio adalah mahasiswa di Yogyakarta yang cerdas dan berbakat menulis novel. Di sela-sela padatnya jadwal kuliah, dia selalu menyempatkan waktunya untuk menyelesaikan *draft* novel yang bertajuk "Pinang dibelah lima". Sayangnya, baru-baru ini Rio sering mengeluh bahwa Ia sering merasa:

1. Sakit kepala saat mata lelah;
2. Sulit melihat saat berkendara di malam hari;
3. Tampak tidak menyadari adanya benda yang jauh.

Setelah berkonsultasi dengan seorang dokter, hasil diagnosa menunjukkan bahwa Rio hanya dapat melihat objek yang jauhnya tidak lebih dari 100 cm. Setelah itu, dokter Paijo menyarankan kepada Rio untuk menggunakan kacamata.

Berdasarkan bacaan di atas, jawablah pertanyaan berikut ini!

- a. Hasil diagnosa dokter menunjukkan bahwa Rio menderita....

Harga kacamata di klinik dokter Paijo cukup mahal sehingga Rio memutuskan untuk membeli kacamata di toko optik dekat rumahnya. Disana, Rio dilayani oleh asisten pemilik toko yang bermama Ferry. Berdasarkan keluhan dan hasil diagnosa penyakit Rio, Ferry menawarkan kepada Rio sebuah kacamata berlensa *bikonveks* (cembung) dengan kekuatan lensa +2 dioptri dengan harga Rp. 300.000,-.

- b. Menurut Anda, haruskah Rio memutuskan untuk menerima tawaran tersebut? Jelaskan!

Figure 10. Posttest item 3 (concluding aspect)

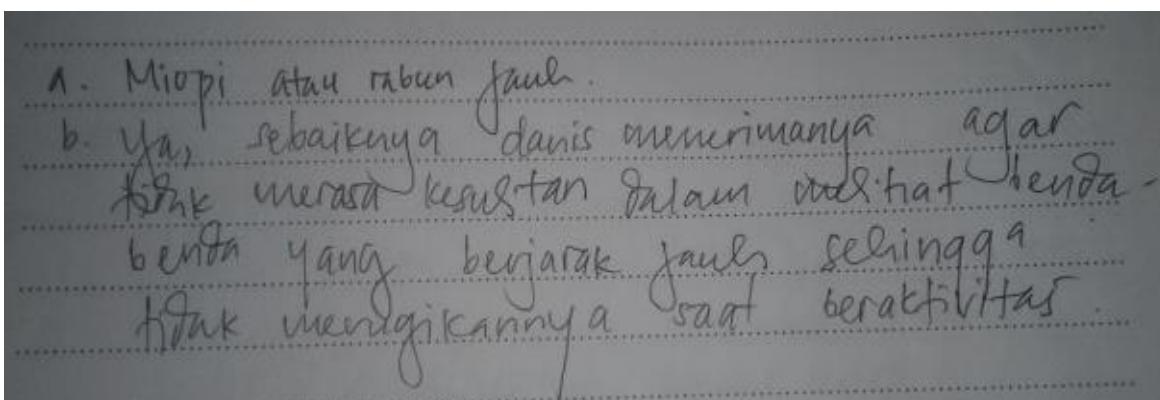


Figure 11. Students' answer before treatment

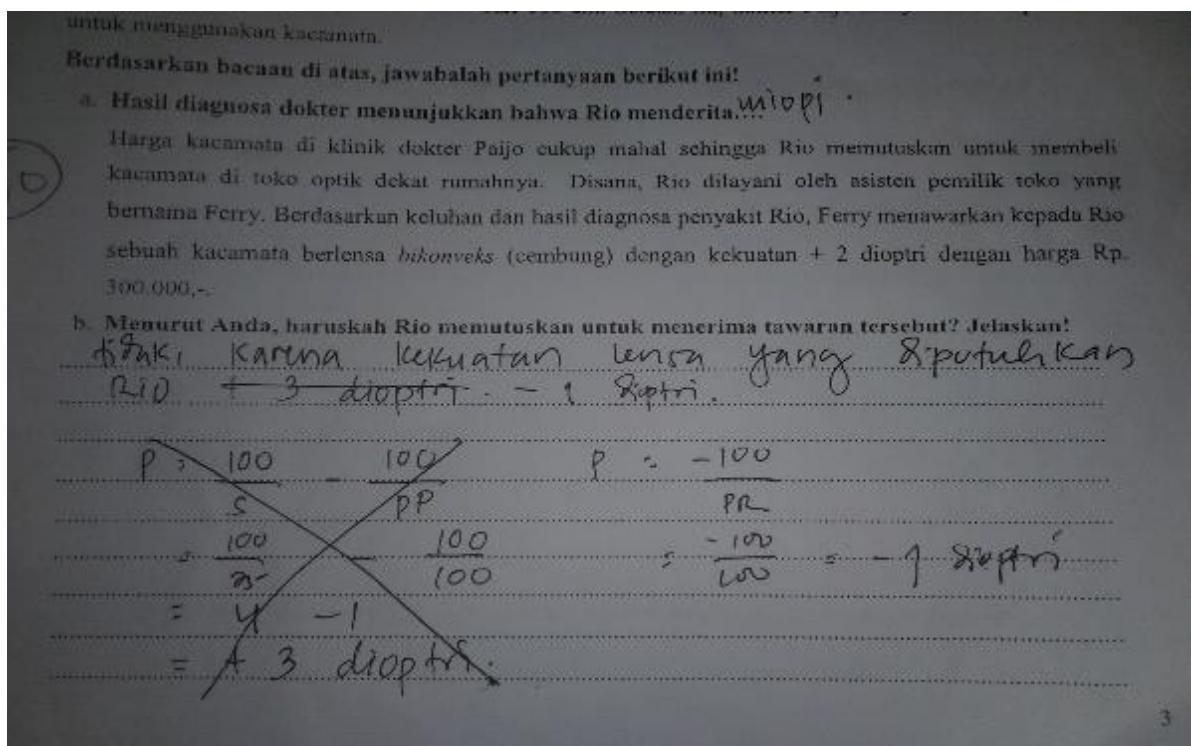
**Figure 12.** Students' answer after treatment

Figure 11 shows students' answer before given treatment. Students' response to the question shows that they had known that the patient suffered myopia, but they were mistaken in making decision without going through consideration by analyzing power size of lenses of glasses that must be used by the patient. Figure 12 shows students' answer after given treatment. Students' response to the question shows that they had known the patient suffered myopia and should wear concave lenses of glasses by considering power size of lenses of glasses based on patient's complaints.

Students create assumptions for eye defect patient's problem from cases in the questions. The assumptions is analyzed by analysis result of computation that they understand. Students give reasons to support their assumptions as computation result that they obtain. During this process students show that their critical thinking skills has been trained. Inductive learning model trains students for gathering information from numerous sources, testing and computing data, classifying analyzed data up to testing the assumptions and creating conclusion, thus it influences students' method in answering question.

First, reviewed from process of inductive learning model, students' method in answering question start from gathering essential information of eye defect patient presented in the question, testing information and computing quantitative data in cases using optic formula, classifying information, creating and testing assumptions until determining precise actions such as lenses selection and determine power and size of lenses. It proves that learning syntax from data or information gathering to assumptions testing has successfully trained critical thinking skills of students.

This result is supported by Hayati's research (2015), stating that inductive learning model can improve critical thinking skills of students through class treatment research that critical thinking skills of physics subject in cycle 1, cycle 2 and cycle 3 are 61%, 70% and 73% respectively [23]. Inductive thinking learning model is very effective to develop critical thinking skills through systematically thinking [25]. Inductive thinking learning model trains students in finding concepts through concluding process with generalization thus students' interest can be encouraged because to present truthful conclusion it needs high curiosity [26]. Inductive thinking learning model can create active

learning ambience encouraging the students to focus their observation through questions based on the problems or topics reviewed, then students will be more attracted to learning [27].

Second, make a mindmap using software MindJet MindManager 2017 to inductive learning model syntax in the third step – classification step – also contributes in training critical thinking skills of students in optic eye topic. The usage of mindmap in learning can train critical thinking skills of students because mindmap media created by students is built based on their mind flow [19].

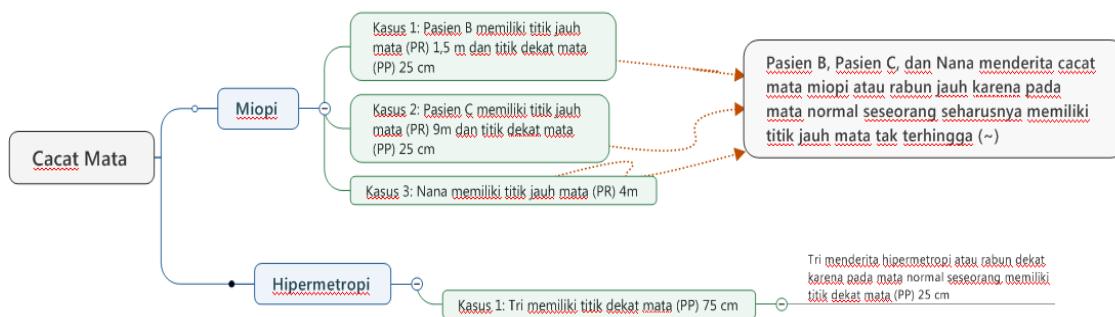


Figure 13. The results of the mindmap creations students use MindJet MindManager

The result is different mindmap creation among students. Figure 13 is an example of students' creation in creating mindmap by using MindJet MindManager 2017 software. Through mindmap, students' minds can be mapped by themselves. Mindmap creation by MindJet MindManager 2017 software involves critical ability of students poured into creation steps. It is happened in order the brain can map the concepts and information naturally and freely. Color choosing in creating mindmap until connecting information and concepts into branching form will make the brain fresh [18]. Students having good mindmap will not find difficulty in analyzing the cases and can determine the exact answers [19]. Therefore, it can be said that the usage of mindmap using MindJet MindManager 2017 in learning process influences improvement in critical thinking skills of students indirectly. This statement is supported by Santiago's research regarding creation of mindmap trains students from structuring and organizing information to connecting one concept with other concepts, thus it builds their critical thinking skills [24]. Inductive learning model is very relevant if it is combined with mindmap learning medium.

4. Conclusion

We obtained analysis result of paired samples t test of posttest and pretest $0.032 < \text{Sig. } \alpha (0.05)$. It means that there is a difference in critical thinking skills of students between before and after given inductive learning model assisted mindmap MindJet MindManager. We conclude that inductive learning model assisted mindmap MindJet MindManager affects critical thinking skills of students in learning physics in optic eye material.

Critical thinking skills successfully improved is on giving simple explanation (item 1), making conclusion (item 3), and arranging strategy and tactic (item 4). According to this result, we recommend teachers to use inductive learning model assisted mindmap MindJet MindManager in learning physics. Disadvantage of inductive learning model assisted mindmap MindJet MindManager is time consuming. Therefore, we suggest to not using this method in material with many topics. In curriculum 2013, towards scientific approach, students must be active in learning and finding concepts independently. Whereas, teachers are only act as facilitators, thus inductive learning model assisted mindmap MindJet MindManager not only is recommended to be implemented in learning process in schools with curriculum 2103 not only in optic eye topic, but also other topics such as mechanical wave, or physics measurement and unit.

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