

OPTICAL ILLUSION DESIGN BASED ON FOUR CONVEX LENSES SYSTEM AND CLOAKING AREA CHARACTERIZATION

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ABSTRACT

A set up of optical illusion based on 4f system and characterization of cloaking area have been carried out. The cloaking area is an area where the object is placed on the area as if it disappears from view; the set-up of cloaking area is located at the top of the third lens. The distance between the lens and the cloaking, which is generated from 4f system, depends on the size of the focal point and the size of the lens used. The larger the focal point of the lens used the wider the distance between the lenses and the larger the size of the diameter of the lens, the cloaking range will be increasingly wide, and vice versa. From the experimental results that we obtained that the cloaking area for set up using FL (focusing lens) 100, 50, 50 and 100 mm with a diameter of 3.6 cm lens is ± 2 cm, whereas for the set up using lens FL 150, 100, 100 and 150 mm with lens diameter 2.54 cm is ± 1 cm.

ABSTRAK

Telah dilakukan set up desain ilusi optik berbasis sistem 4f dan karakterisasi area cloakingnya. Area cloaking ini adalah daerah dimana objek yang ditempatkan pada daerah tersebut seolah-olah menghilang dari pandangan, pada set up ini area cloaking terletak pada 1/3 bagian atas lensa. Jarak antar lensa dan area cloaking yang dihasilkan pada sistem 4f ini bergantung pada besarnya titik fokus dan ukuran lensa yang digunakan. Semakin besar titik fokus lensa yang digunakan maka akan semakin lebar jarak antar lensanya, dan semakin besar ukuran diameter lensanya maka range cloakingnya juga akan semakin lebar, demikian sebaliknya. Dari hasil penelitian diperoleh besarnya area cloaking untuk set up dengan panjang fokus lensa (*focusing lens*) 100, 50, 50 dan 100 mm dengan diameter lensa 3,6 cm adalah ± 2 cm, sedangkan untuk set up dengan panjang fokus lensa 150, 100, 100 dan 150 mm dengan diameter lensa 2,54 cm adalah ± 1 cm.

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Keywords: Cloaking area; Lenses; Optical illusions; 4f

INTRODUCTION

Cloaking devices are system that utilize transformation theory and illusion technology. In principle, cloaking devices aim to totally or partly hide objects, so that the objects become invisible. (Fridman, Farsi, Okawachi & Gaeta, 2012). This basic technologies used by stealth aircraft, such as radar-absorbing dark paint, optical camouflage devices and other devices that require to minimize surrounding electromagnetic field (Fridman et al., 2012; Green-

leaf, Kurylev, Lassas, & Uhimann, 2009; Lai, Chen, Zhang & Chan, 2009). There several types of cloaking devices are electromagnetic cloaking, spatial cloaking, space-time cloaking, far-distance cloaking, plasmonic shield, and many more as described in Schittny, Kadic, Buckmann & Wegener (2014) dan Choi & Howell (2014).

Choi & Howell (2014) demonstrated a ray optics cloak that is designed for continuously multidirectional angles in 3D. This is the first such device, for transmitting rays in the visible regime. It also uses off-the-shelf isotropic optics, scales easily to arbitrarily large sizes, has unity magnification, and is as broadband as the

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optical material used. Thus, many of the difficulties encountered in invisibility cloaking schemes so far are solved, albeit with edge effects that are present. Also provide a concise and effective formalism, using ray optics, to describe all perfect optical cloaks in the small-angle ('paraxial') limit. And apply a formalism to general optical systems up to four lenses, and show what systems can be considered 'perfect' paraxial cloaks for rays. This was the first technique utilizing visible light and portable integrated setup. In addition, they have shown that by using 4 lenses, they can generate perfect cloaking system in visible light.

In case of optical cloaking, several parameters that must be consider are type of lens, size of lens and focus length. These parameters are crucial in building optical cloaking system, especially in 4f (4 lenses) system. Size of object and image quality are also affected by those parameters. Figure 1 describes cloaking area on two, three and four lens configuration.

Choi & Howell (2014) stated that a 'perfect' cloak was applicable generally. We will now develop a formalism using geometric optics, to quantify this definition in the paraxial approximation. To first-order approximation, called the "paraxial approximation," light rays are assumed to deviate minimally from the center axis of the system. Hence, it is a small-angle approximation. In this regime, also known as "Gaussian optics" (Max & Emil 2010).

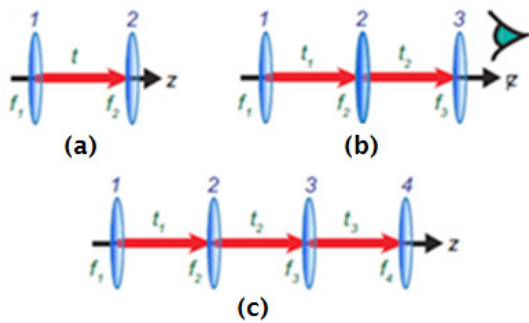


Figure 1. Area of paraxial optical cloaking for (a) two lens system, (b) three lens system and (c) four lens system. (Choi & Howell, 2014; David 2014).

The propagation of light rays through an optical system can be described by 'ABCD' matrices. Because a perfect cloaking device simply replicates the ambient medium throughout its volume, its ABCD matrix is just a 'translation matrix' as shown in Figure 2 (Bass, 2010; Choi & Howell, 2014).

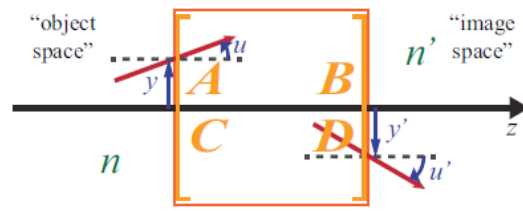


Figure 2. Illustration of ABCD matrix and optical path in paraxial approach with z-axis rotational symmetric when the light incident from left to right.

Detail explanation of "ABCD" matrix is described in Figure 2. The optical system (box in the center) can be described by an 'ABCD' matrix. This matrix maps the initial position (y) and paraxial angle (u) to those exiting the system (y', u'). The "object space" is the space before the ABCD system, with index of refraction n . Likewise, the "image space" is the space after the system, with index of refraction n' . In this diagram, value of $y > 0$, $u > 0$, $y' < 0$ and $u' < 0$ (Choi & Howell 2014). Since perfect cloaking system only replicate ambient media along the volume, ABCD matrix is called translation matrix (Max & Emil 2010; Choi & Howell 2014), as shown in Equation (1)

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix}_{\text{perfect cloak}} = \begin{bmatrix} 1 & L/n \\ 0 & 1 \end{bmatrix} \tag{1}$$

where L is length of cloaking system, and n is medium refractive index. This condition will help in designing cloaking system (Choi & Howell 2014). Since ABCD matrix has determinant = 1, thus Equation (1) must have three conditions, $B = L/n$, $C = 0$, $A = 1$ and $D = 1$. In perfect cloaking system value of $C = 0$ (afocal). In this case the system has no power in the focus point, so that an infinite object in that area will be imaged as infinite object. This will help us in design, since afocal condition can be easily measured (Choi & Howell, 2014).

Choi & Howell (2014) mentioned that it is not obvious that an optical system can satisfy Equation (1), despite containing a cloaking region. The discussion and conditions for a 'perfect cloak' may have little meaning unless a physical solution actually does exist. We will now carefully build general optical systems, to see whether a perfect paraxial cloak can be designed with rays. We attempt to find the simplest nontrivial solution, so we will only consider rotationally symmetric systems with thin lenses, and in free space with $n = 1$. The ABCD

matrix for one thin lens is given by

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix}_{\text{lens}} = \begin{bmatrix} 1 & 0 \\ -1/f & 1 \end{bmatrix} \quad (2)$$

where f is the focal length of the lens. In order to define the ABCD matrix value for two lens system as in Figure 1, the form of the matrix equation is written as

$$\begin{bmatrix} 1 & 0 \\ -1/f_2 & 1 \end{bmatrix} \cdot \begin{bmatrix} 1 & t \\ 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} 1 & 0 \\ -1/f_1 & 1 \end{bmatrix} = \begin{bmatrix} 1 & t \\ -(f_1 + f_2 - t)/(f_1 f_2) & 1 - t/f_2 \end{bmatrix} \quad (3)$$

While on a system using three lenses, the equations for ABCD matrices can be written as follows

$$\begin{bmatrix} 1 & 0 \\ -1/f_3 & 1 \end{bmatrix} \cdot \begin{bmatrix} 1 & t_2 \\ 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} 1 & 0 \\ -1/f_2 & 1 \end{bmatrix} \cdot \begin{bmatrix} 1 & t_1 \\ 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} 1 & 0 \\ -1/f_1 & 1 \end{bmatrix} \quad (4)$$

The value of t can be determined by setting (Choi & Howell 2014), so

$$f_2 = -\frac{(f_1 - t_1)(f_3 - t_2)}{f_1 + f_3 - t_1 - t_2} \quad (5)$$

Similarly, in the three-lens system, cloaking cannot yet be formed, as the approximate approach is used, so Equation (5) becomes

$$f_2 = (t_1 - f_1)/2 \quad (6)$$

To set up four lenses as in Figure 1c, several conditions such as t_1 and t_2 in matrix ABCD must be fulfilled, so that

$$t_1 = f_1 + f_2 \quad (7)$$

Using the Equation (7), the matrix ABCD becomes

$$\begin{bmatrix} 1 & f_1(-2t_1^2 + f_1(2t_1 + t_2))/(f_1 - t_1)^2 \\ 0 & 1 \end{bmatrix} \quad (8)$$

We can now set t_2 and solve for

$$t_2 = 2f_2(f_1 + f_2)/(f_1 - f_2) \quad (9)$$

Based on Equation (9), we have finally found an exact solution for Equation (1). At least four lenses are required for a perfect para-

xial cloak, for a rotationally symmetric lens-only system. With Equations (7) and (9), the total length is

$$L = 2t_1 + t_2 = 2f_1(f_1 + f_2)/(f_1 - f_2) \quad (10)$$

with

$$f_1 = (1 \pm \sqrt{2})f_2 \quad (11)$$

The purpose of this experiment is to design a continuous cloaking set up based on optical with a four lens system (4f), by arranging the spacing between lenses to form cloaking and characterizing the cloaking area.

METHOD

The experimental set up which used to create the optical illusion based on a four lens system (4f) is shown in Figure 3.

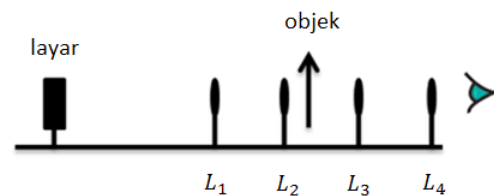


Figure 3. Set up an optical illusion experiment with a four lens system (4f)

In this set up the lenses are used there are two, namely convex lens with focal length of 100, 50, 50 and 100 mm with a diameter of 3.6 cm lens and lens with focal length of 150, 100, 100 and 150 mm diameter lens 2.54 cm. For lenses with a diameter of 3.6 cm set up $(-)$ = 14,5 cm, $(-)$ = 11,5 cm and $(-)$ = $(-)$. As for the lens 2.54 cm set up the distance is $(-)$ = 18,5 cm, $(-)$ = 15,5 cm and $(-)$ = $(-)$. Set up the spacing between the lenses is the set up that produces the clearest shadow focus on the screen, such as the set up in Figure 3.

Once the experimental set up is obtained, that is, it produces the clearest focus of the shadow on the screen. The object to be observed is placed between the lens and , and the observation of the object is taken from the front of the lens . If the experimental set up is successful then the object is placed between the lens and at the third part of the lens, as if the object covering the lens will not appear on the screen (missing) or there is no object blocking the lens seen on the screen. To see the detail of the focused beam on each lens,

place a laser pointer in front of the lens by adjusting its position from top to bottom to obtain when the groove or the direction of the light beam refracted to each lens.

RESULTS AND DISCUSSION

Based on the theory, the requirement of optical cloaking is to use four lenses with similar materials. The lens used should be of the same diameter as the minimum requirement, so that the refraction of the resulting light can be evenly distributed by the same size. The second condition is the value of t_1 and t_2 . The illustration of the light beam passing through the cloaking system with four lenses ($4f$) is shown in Figure 4.

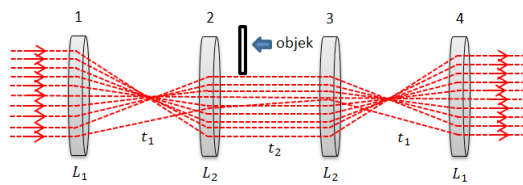


Figure 4. Illustration of light beam on a perfect paraxial cloak that passes through four lenses.

The lenses used in this system’s set up are convex lenses, since convex lenses are refractory in nature, unlike diverging concave lenses. The light rays that come parallel to the axis of the convex lens will be biased toward the focal point. The rays form a real image that can be captured on the screen and are positive. The amount of light refraction in a lens depends on the refractive index of the lens material, the magnitude of the focal length of the lens and the surface curve of the lens, whereas the refractive index depends on the fast ripple of light in the lens material. The thick convex lens will refract larger light than the thin convex lens. The focal length of the thicker convex lens is shorter than the length of the thin convex lens.

In this experiment used two types of convex lenses with different diameters, namely 3.6 cm and 2.54 cm. The distance between the lens depends on the size of the lens and the material or lens making material used, the larger the focal length of the lens used then the distance between the lens t_1 , and t_2 will be wider, and the larger the diameter of the lens used then the cloaking area will be even greater as shown in Figure 4 and the experimental simulation results performed by (Choi & Howell,

2014), as shown in Figure 5.

Area cloaking with convex lens is limited to certain areas only, not 100% of the object to be observed can disappear (Kildishev & Shalaev, 2008; Chen et al., 2013). This is due to the limitation of the lens size and the magnitude of the focus of each lens after being incorporated into a set up of this optical cloaking system as well as the angle of observation (Chen et al., 2013).

Based on the illustration of the light trajectory in Figure 4 for this optical cloaking set, the light entering at the bottom of the lens and forwarded to the second lens is not about the upper third of the lens, this area is called the “cloaking region” where the object or object is placed on the area seems to be lost from the eye when viewed from the first lens. The limitation of cloaking is formed around the upper third of the lens diameter only in the region between $(L_2 - L_3)$, or \pm as shown in Figure 4.

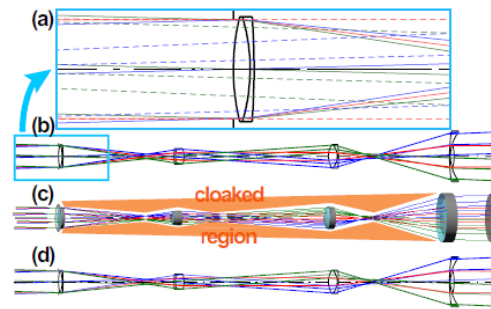
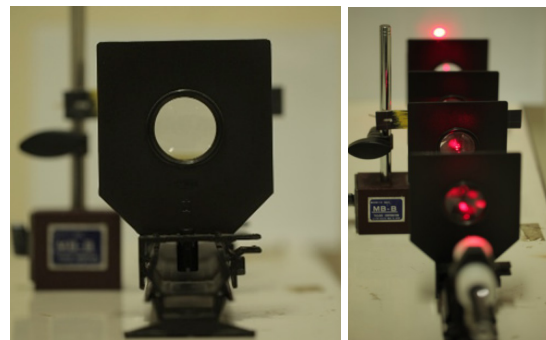


Figure 5. The result of simulating perfect paraxial cloak, using four lenses ($4f$) (Choi & Howell, 2014).



(a) (b)

Figure 6. Set up optical illusions with $4f$, 3.6 cm diameter (a) with objects in area $L_2 - L_3$ (b) with laser beam pointers in front and fixed objects on $L_2 - L_3$.

The results of some observations for the set up of the optical illusion design based on

the 4f system are shown in Figure 6 and Figure 7. In Figure 6 shows the result set up of the optical illusion of 4f system with a diameter of 3.6 cm lens.

From Figure 6a it appears that a rectangular paper object 15x1 cm in size (such as ruler size 15 cm) which is placed on the upper third of the lens (± 2 cm), as if missing or invisible when viewed from the front of the lens. Shooting is focused on the first lens. This proves that the set up of the 4f system by setting the distance according to the maximum focus scale has succeeded in forming a cloaking. The position of the observation angle also affects the resulting image (David, 2014).

In Figure 6b it is also shown that the same object as in Figure 6a, which is placed in the area - does not block the laser beam being fired, the fired laser beam can penetrate to the back of the screen. This event occurs because the laser beam is fired the path turns in accordance with the fall of the focal point of each lens that has been combined, so that the laser beam can penetrate to the screen without being blocked by the object on the cloaking area that is in the region between (- or \pm . The pointer fired on the lens as shown in the illustration of Figure 4, in the upper third of the lens is not crossed by the light of the laser beam, so that the object is not exposed to laser light.

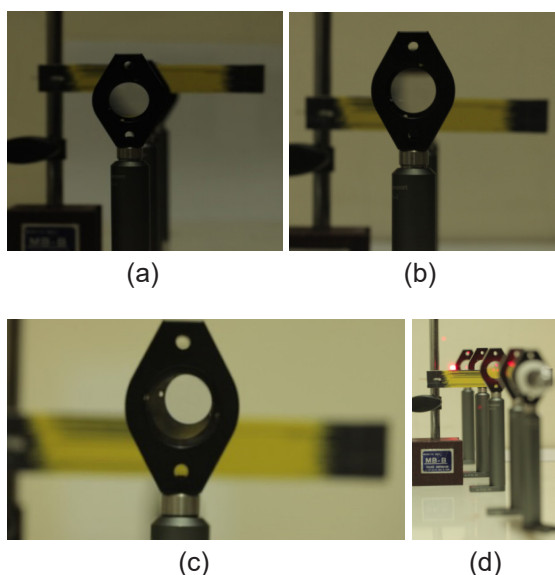


Figure 7. Results cloaking with 2.54 cm diameter lens (a) - (c) object position variation and shooting angle (d) laser pointer ray path on cloaking system

As for the set up with 2.54 cm diame-

ter lens shown in Figure 7. In Figure 7a - 7c is shown the results of several variations of cloaking system image angle and object position variation.

In Figure 7a the observed object is placed at the top of the lens, while the objects in Figure 7b and 7c are at the bottom of the lens with the difference of the image taking position (photo) of the system. The object used is the same as the object to set up in Figure 6. The cloaking area that is formed is in the same area as the set up of the system with 3.6 cm lens diameter, differ only in the distance between the lenses due to the different focal length of the lens used. While Figure 7d shows the path of laser light passing through the system, the same as the treatment for the lens with a diameter of 3.6 cm. From this result can be said that the design of optical illusion with 4f system is proven to eliminate the object, in accordance with the purpose of research that will be done. Objects observed (between -) seem to disappear from the sight of the eye. Below is an experiment data table.

Table 1. Observation data of cloaking area

d lensa (cm)	$L_1 = L_4$ (mm)	$L_2 = L_3$ (mm)	$(L_1 - L_2)$ (cm)	$(L_2 - L_3)$ (cm)	$(L_3 - L_4) = (L_1 - L_2)$ (cm)	Cloaking area (cm)
3,6	100	50	14,5	11,5	14,5	± 2
2,54	150	100	18,5	15,5	18,5	± 1

The observed object position is placed on the upper or lower third of the used lens called the "cloaking region" located in the region between (- or \pm , with the maximum limit of objects that can be stacked to set up the system with a 3.6 cm diameter lens of ± 2 cm, and for lenses with a diameter of 2.54 cm of ± 1 cm. The results of this experiment is in accordance with that has been done by Choi & Howell (2014), in their experiments explains that the cloaking object is only in certain parts only as shown in Figure 5.

The cloaking area for the set up using four lenses is between lens 1 and lens 2, and not all parts of the lens can remove objects, only in certain areas as seen in the light path in Figure 5.

CONCLUSION

The optical illusion design (cloaking) based on four lenses (4f) can be produced on condition of using lenses with similar materials, in this system using a convex lens with the same lens diameter and focal length value

and The cloaking area occurs in the intermediate area - or \pm in the upper third of the lens, the minimum constraint of cloaking formed for the convex lens with a diameter of 3.6 cm in this experiment is 2 cm, and for the lens with a diameter of 2.54 cm the cloaking area is 1 cm. The distance between the lens and the cloaking area generated in this optical cloaking set depends on the amount of focal point of the convex lens used.

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IMPACT OF LEARNING EARTH LITOSPHERE USING INTERACTIVE CONCEPTUAL INSTRUCTION ON LOGIC THINKING, CONCEPTUAL UNDERSTANDING, AND SPIRITUAL ASPECT EMBEDDING

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ABSTRACT

The aim of this study is to explore the impact of interactive-conceptual-instruction with visualization on logic thinking, conceptual understanding and spiritual aspect embedding. The sampling technique used in this research was convenience sampling. This research used mixed methods with embedded experiment design. The data of logic thinking and conceptual understanding was collected through pre-test and post-test. The questionnaires were used to collect data on spiritual attitudes and were analyzed qualitatively. The results showed that logic thinking-ability improves from no logic thinking to inductive-deductive logic thinking. The improvement of logic thinking abilities was in the medium category. Understanding the concept shifted from incompetent to conceptual understanding with improvement, in the medium category. The questionnaires analysis showed that the students got spiritual values related to the awareness of God believing behind the natural phenomena that impact on their spiritual attitudes. This study also tried to apply the results of pure science research to support learning activities. Based on the result of the research, it can be concluded that the learning process using interactive conceptual with visualization can improve logic thinking, conceptual comprehension, and spiritual attitude embedding.

ABSTRAK

Penelitian ini bertujuan untuk mendeskripsikan pengaruh pembelajaran litosfer menggunakan interaktif konseptual berbantuan visualisasi dalam meningkatkan kemampuan bernalar, pemahaman konsep, dan untuk menanamkan aspek spiritual. Teknik sampling pada penelitian ini menggunakan *convenience sampling*. Penelitian ini menggunakan *mixed methods* dengan *embedded experiment design*. Data penalaran dan pemahaman konsep dikumpulkan melalui pretes dan postes. Kuisisioner digunakan untuk mengumpulkan data tentang sikap spiritual dan dianalisa secara kualitatif. Hasil penelitian menunjukkan bahwa kemampuan penalaran bergeser dari tidak ada penalaran menuju penalaran induktif-dedukti. Peningkatan kemampuan bernalar berada pada kategori sedang. Pemahaman konsep bergeser dari tidak kompeten menuju paham konsep dengan peningkatan berada pada kategori sedang. Analisis kuisisioner menunjukkan mahasiswa mendapatkan nilai spiritual terkait kesadaran akan sifat Ketuhanan yang ada dibalik fenomena alam yang berdampak pada sikap spiritual mereka. Penelitian ini juga mencoba untuk mengaplikasikan hasil penelitian sains murni dalam mendukung kegiatan pembelajaran. Berdasarkan hasil penelitian maka dapat disimpulkan bahwa proses pembelajaran menggunakan interaktif konseptual berbantuan visualisasi dapat meningkatkan penalaran, pemahaman konsep, dan menanamkan sikap spiritual.

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Keywords: Conceptual understanding; Conceptual interactive; Logic thinking; Lithosphere; Spiritual attitudes

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INTRODUCTION

Learning everything about nature is important. Earth and Space Science (ESS) is one branch of science that studies many things about nature and its various phenomenon. Studying the ESS including the earth lithosphere can help understanding the various natural phenomena. In addition, learning ESS can help to determine the appropriate natural disaster mitigation rescue, raise awareness in the use of nature source, act wisely to nature, and realize the greatness of God as the creator of nature (Bayong, 2014). The concept of earth is imaginary, in another sense it can not be observed directly (Sunderlin, 2009), including the concept of the earth lithosphere. Character of the concept that most difficult to observe directly makes the learners difficult to understand and redistribute the concept. This difficulty affect learners' conceptions so that there are various alternative conceptions other than scientific conception (Miller & Brewer, 2010; Joley *et al.*, 2012). Explaining the concept of the earth lithosphere can utilize various visualizations *e.g.* in the form of animation.

Earth Lithosphere concepts that can not be observed directly require right constructed learning in order to train the ability in logic thinking. Beside analogy, several research results suggests conceptual thinking can be developed during the exploration process of concept representation, for example in the image and animation visualization (Prain, Tytler, & Peterson , 2009 ; Smith & Bermea, 2012). Analogy, scientific models and graphic representations have been used in geology learning to improve students' logic thinking (Smosna & Bruner, 2007; Sibley, 2009; Jee *et al.*, 2010). Visualizing the concept of lithosphere using animation and videos can be done to facilitate students' logic thinking on the concept. Visualization can

also utilize the results of authentic data analysis from the results of research in the field of pure physics science. The literature study shows that there has not been much reported on research collaboration in science research and learning research, especially in Indonesia.

Various natural phenomena that occur in the lithosphere can be felt and it shows great of God then learning of the earth lithosphere can be constructed by using various visualization to build logic thinking in understanding the concepts at the same time for embedding a religious attitude as more aware of the Majesty and the existence of the Creator, the responsibility for maintaining nature and become a mercy for nature and all other living things. Based on literature studies have not been widely reported on the integration of spiritual values, especially the attitude of belief in God in science learning .

Pavio said that according to the *dual coding theory*, human cognition system consists of two stems of cognition namely verbal system and visual system (Soesanto, 2009). Representations that belong to the visual class are images (including virtual simulations), graphs, tables, and mathematical formulas. Representation of images, simulations, graphics, tables nor a mathematical formula in the text or in learning can improve brain memory because of the existence of such representation facilitates to the power of *dual coding memory*. Facilitating learners to explore their representational skills can lead them to understanding science conceptually (Bowen, 1998). According to Presseisen, thinking is a cognitive process including perception, logic thinking, and intuition (Costa, 1988).

Visualization media, especially animation, is needed to help to visualize the concepts of earth that can not be observed directly. Logic thinking can be developed by analyzing concepts with a scientific model to understand a

Table 1. The basic process of thinking skills according to Presseisen in Costa (1988) .

Skills thinking	Explanation	Ability
Cause and effect	Establish cause and effect	Predict, infer, decide, evaluate
Transformation	A known character relationship with an unknown character	Analogy, metaphor, logical induction
Correlation	Detects regular operations	Ability: partial and overall, pattern, analysis and synthesis, sequence, logical deduction
Classification	Determining quality in general	Similarities and differences, grouping and selecting, comparing
Qualification	Getting unique characteristics	Unique on basic identification, definition, fact, repetition

concept (Sibley, 2009). Beside analogy, some research suggests analogy of logic-thinking-concepts can be developed during the process of exploration of the concept representation (Prain et al., 2009; Smith & Bermea, 2012).

Analogy, scientific models, and graphic representations have been used in geology learning to improve student logic thinking (Sibley, 2009; Jee *et al.*, 2010; Smosna & Bruner, 2007). According to Presseisen, thinking is cognitive process that is a mental activity to build knowledge (Costa, 1988). Those cognitive processes are perception, logic thinking, and intuition. The basic process of thinking can be seen in Table 1 .

Science can bring a changing in life of materially and religion can bring about a spiritual changing. Science certainly can not replace religion. However, if science and religion are combined then it can perform the task scientifically as well as improve the spiritual attitude so as to form a whole person. The separation of science from religion can lead to a loss of value and control over the axiom aspects of science. This can cause losses. Studying the explicit knowledge in Islamic religious teaching can be approached with science, it is growing rapidly in European Countries. They think Islam is a scientific study (Bayong, 2012). Thus, it can be said that religious teaching, especially Islamic can get closely related to science .

Some ways which can be done to teach concepts to prospective students teachers are: using the form of analogies. The teacher's ability on representation supports to be able to create more meaningful learning in order to train logic thinking. The results also reveal that the use of various right representation can train logic thinking-skills (Ainsworth, 1999; Meij & Jong, 2003); the shifting of learners' concepti-

on can be seen and explained through graphic representation (Wittmann, 2006); technology can be used as a bridge between concepts practically (Newhouse, Lane, & Brown, 2007).

Based on these descriptions, the research aimed to describe the influence of lithosphere learning using conceptual interactive visualization aid in improving logic thinking-ability, concept comprehension, and spiritual aspect embedding.

METHOD

This research was conducted in one of the institution in Bengkulu that conducted Physics Education Study Program. The sampling was done by means of *convenience sampling* because there was only one class for the class of 2015 which was the subject of the research. Instruments in this study consist of: test of concepts mastery in the form of multiple choice questions to know the level of students mastery to the concept of earth lithosphere, the logic thinking-abilities test in the form of essays with the criteria of reasoning refers to the reasoning criteria by Furtak (2010), questionnaires and *open-ended* test to know the students' spiritual attitude after learning Earth and Space science.

This research used *mixed methods of embedded experiment* design . The implementation stage used *one pre- and post-test design*.

The first stage was a study and needs analysis, at this stage analyzed the concept in the material earth lithosphere and animation that can be developed to support learning activities to improve the *scientific reasoning* and mastery of the concept. Earth lithosphere concepts were also explored to express the spiritual values contained within them. The second stage

Table 2. Reasoning Criteria Adapted From Furtak

Category	Score	Explanation of indicators
Logic thinking based on Inductive-deductive rules	4	Reasons consist of comprehensive data analysis supported by relevant principles, theories, laws, or definitions of data / problems solved.
Proof based logic-thinking	3	Reasons have been made based on some data (including data implicit) and applied data analysis. But not enough to solve the problem
Logic-thinking based on data	2	The statement relies on limited data or on the surface features of the problem
No logic-thinking	1	If there is a statement then it is just a repeated statement and not clear
Unidentified	0	Answer sheet empty

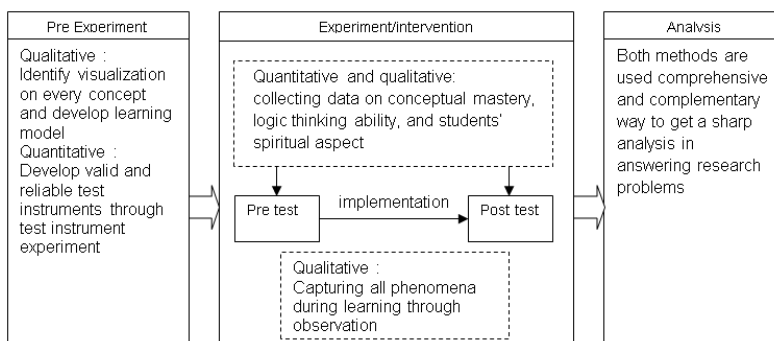


Figure 1. Design of *embedded experiment* (Creswell & Clark, 2007)

focused on the design of the program, at this stage developed conceptual interactive learning using visualization and all learning tools. The final stages of learning is given a series of questions until it cannot answered to embed belief in the nature of God. The third stage was the implementation of the program. This stage used a *one-pretest-posttest design* research design. At the end stage, performed processing and data analysis with conclusion. The results of questionnaires and testimony of student responses were analyzed qualitatively. Data analysis of the result of logic thinking ability test was done by using analysis technique developed by Furtak. The reasoning criteria of reasoning in this study refers to the analytical technique that developed by furtak (2010) where scores, descriptions and reasoning criteria can be seen in Table 2 .

The normalized gain formula (N-Gain) is used to calculate the increase that occurs before and after the learning. The formula used is as follows: (Meltzer, 2002)

$$g = \frac{S_{post} - S_{pre}}{S_{maks} - S_{pre}}$$

Notes:

S_{post} : Final test score,

S_{pre} : Initial test score, and

S_{maks} : Maximum score

Table 3. Category of N-Gain Level (Meltzer, 2002)

Limitations	Category
$g > 0.7$	High
$0.3 \leq g \leq 0.7$	Medium
$g < 0.3$	Low

After that, the value of N-gain from inc-

reasing in the final test value of the initial test score was calculated.

The learning activities in this study adapted *conceptual interactive instruction (ICI) approach*. In the research field, a special step was added at ICI approach to embed a spiritual attitude that is *Chain Till Unanswered Question*. In general, learning activities followed the design as in Table 4.

Table 4. Design of learning activities

Concept Focus:

Presentation and scientific explanation using visualization media

Use of Text:

Textbooks are used to find keywords relate to learned concepts

Research Based Materials:

Utilizing research results in the field of geophysics in learning activities

Chain Till Unanswered Question

Presented a phenomenon then students are given serial questions that can be answered scientifically to question that can not be answered scientifically so back to the statement that God is all.

Class room interaction:

Discussions were conducted throughout the learning activities

RESULTS AND DISCUSSION

The ability of reasoning and mastery of concepts

The discussion is more focused on the effect of applied learning that has been applied to logic thinking, conceptual understanding, and embedding the spiritual attitudes in the learning process. Analysis of research data for logic thinking and mastery of concepts was done by looking at differences in initial test scores before implementation and final test scores after implementation. Table 5 showed that the

increase of students' logic thinking-conditions was quite good with an average N-gain of 0.69 in the medium to upper (upper-medium) category. The improvement of students' concept mastery was also quite good with the average N-gain of 0.59 being in medium category. Based on Table 5, it can be seen that the improvement of concept mastery and logic thinking are in the same range, medium. The difference of <g> increasing logic thinking-aspects and concepts mastery for each student can be seen in Figure 2

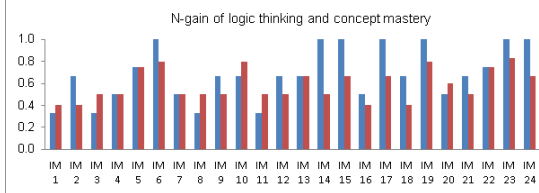


Figure 2. Improved logic thinking and mastery of each student after implementation
Notes; Blue = logic thinking; Red = concept mastery

Table 5. Average N-gain after implementation of Earth and Space Science lecture program

Aspect	Average N-gain	Category
Logic thinking	0.69	Medium
Mastery of concept	0.59	Medium

Based on Figure 2 it can be seen that the improvement of logic thinking ability and conceptual ability of each student on lithospheric material varies. Overall, there is a pattern where the improvement of both aspects is synergy. In general, students who have a good increase in logic show a tendency to increase the mastery of a good concept as well. In line with Carolan, Prain, and Waldrip statement (2008), which revealed that the learning activities that focus on the ability in thinking and logic thinking enables learners to understand concepts in more depth. N-gain distribution of each student for logic thinking ability and mastery of concept as result of implementation activity of Earth and Space science lecture program can be seen in Table 6 .

Table 6. N-Gain distribution of each category

N-Gain Restrictions	Category	Reasoning	Mastery of concept
$g > 0.7$	High	9 students	6 students
$0.3 \leq g \leq 0.7$	Medium	15 students	18 students
$g < 0.3$	Low	There is no	There is no

In the medium category of N-gain distribution for logic-thinking are: N-gain values $0.6 \leq g \leq 0.7$ of 7 students, $0.4 \leq g \leq 0.6$ of 4 students, and $0.3 \leq g \leq 0.4$ as many as 4 students. It appears that for logic-thinking ability, the largest distribution of students is in the *upper-medium* range. N-gain distribution for conceptualization is $0.6 \leq g \leq 0.7$ for 5 students, $0.4 \leq g \leq 0.6$ for 13 students, $0.3 \leq g \leq 0.4$ none. The distribution of students' concept mastery is in *medium* category. From the distribution of students in each category N-gain it can be seen that the increase in students' logic-thinking is mostly in the *medium* and *high* category. The distribution of N-gain in each category indicates that the learning of lithosphere that has been developed has a good impact in increasing the logic-thinking and mastery of student concepts. The distribution of students on post-test results for each level of logic-thinking can be seen in Table 7 .

The average of students logic-thinking ability before implementation activities were in category of no logic-thinking. This indicates that before the implementation activity the students' logic-thinking ability is in the category of no logic-thinking. After the implementation of lecturing program, the average of students logic-thinking capability were in the category of logic-thinking based on the evidence. As for the mastery of the concept is also seen the difference between the conditions before and after implementation. These results can indicate that the learning activities have an impact in accor-

Table 7. Distribution of the number of students at each level of logic thinking

Logic thinking scores	K ategori	Before implementation	After implementation
4	Deductive-inductive logic-thinking	0	29.2 %
3	Logic-thinking with evidence	0	37.5 %
2	Logic-thinking with data	0	33.3 %
1	No logic-thinking	70.8 %	0
0	Undefined	29.2 %	0

dance with the objectives of the study.

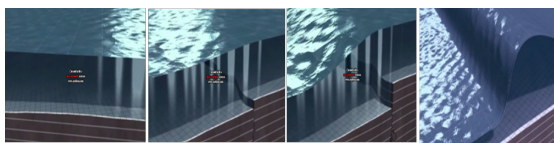


Figure 3. The animation of tsunami waves.

Based on the phenomenon captured during the learning activity through observation, the logic-thinking improvement and mastery of the concept is quite satisfactory after learning lithospheric material is thought to be caused by several factors, they are visualization media (graphs, diagrams, drawings, animations) used, interaction activities that occur in the class in the form of *questions and feedbacks* between fellow students guided by lecturers, and the use of science research as a *research based material* in learning activities.

The results of observation during the learning activities show that the visualization media used in the lecture activity is able to visualize the partial that compose a natural phenomenon in lithosphere concept. Media visualization is supposed to help students to distribute the concepts taught because it is able to explain the correlation between several concepts (Werts Scott, 2011). Visualization media, especially animation, can show clearly how concepts are interconnected in a natural phenomenon within the scope of lithosphere. In addition, it can show how a phenomenon process occurs in each stage. Animation explaining one phenomenon allegedly can help students understand several concepts simultaneously as well as require various concepts to explain a natural phenomenon. Benzen (2016) states that animation supports learning activities more effectively.

Examples of animation used in learning that helps students to more easily understanding concept is animation that visualizes how tsunami waves can be formed when the earthquake. Based on the recorded phenomenon during the learning through observation, it is known that students initially understand tsunami waves as secondary wave propagation on water medium. In fact, secondary waves are transverse waves that do not propagate in fluids. The stages in the animation that visualize the occurrence of tsunami waves help students understand the cause of the tsunami wave well. The animated footage of the tsunami wave used in the learning activities can be seen in Figure 3.

The animated trailer in Figure 3 can pro-

vide an understanding that the tsunami wave is basically a wave of water that occurs due to wear at the time of shifts and fractures. It is seen that there is a relationship between fault energy and the magnitude of the resulting tsunami wave. The greater the energy released by the fault as the source of the earthquake the greater the tsunami wave generated. In addition, there is also a relationship between the form of fault/faults on the occurrence or absence of tsunami waves. Presseisen in Costa (1988) reveals that one of thinking ability is the correlation (connected) includes partial and overall thinking ability, patterns, analysis and synthesis, sequencing and logical deduction.

The use of visualization is primarily animation that can show the relationship between variables, (eg in the animated trailer Figure 3) the strength of the fault source, the fracture shape with the magnitude of the wave is supposed to facilitate correlation thinking ability, thus giving effect to the mastery of student's concept and reasoning. This is supported by the results of research by Doyan & Sukmantara (2014) which shows that intranet web is designed by incorporating visualization and one of them is animation can improve students' concept understanding. Student response also showed similar.

Result of qualitative analysis of students' comments/response on learning activities show that according to the students, the used of animation as a media in the learning context have an impact, they are : helping students think cause and effect and relationships between concepts ; a very clear animation help simplify logic-thinking concepts and then understanding the concept for learning Earth and Space Science really need logic-thinking and imagining because it can not be observed directly; complicated concept becomes easier because it looks visualization concept; support learning activities because the visualization media is in accordance with the learning that is done; and helping think more spacious and open.

Werts & Hinnov (2011), in their research, brings its three-dimensional visualization in the form of a graph from matlab to teach insolation reported that an increase in test scores of more than 32% better than in a conventional classroom. The inclination of the angle to come will give a different image indicating the amount of insolation. Visualization is able to explain the connection of various variables. For example, based on the image of the matlab is illustrated latitut relationship to the magnitude insolation.

In addition, based on the recorded phenomenon during learning activities it is known that the animation media makes students has an appeal and curiosity so that it creates a very active class interactions in the form of *questions and feedbacks* between students and students with the lecturer.

This is in line with Ismawati *et al.* (2014), who state that visualization in the form of demonstration before the learning raises students' curiosity. This interactive activity and the visualization of various lithosphere phenomena make learning more enjoyable. This is supported also by the results of the qualitative analysis of responses/comments given by students on the learning activities, according to the student: using animation makes learning activity not bored and fun; interactive living class ; the lecturers are able to master the classroom and make the atmosphere a good one; visualization give details of the concept (phenomenon) clearly raises students' curiosity and questions from students; and shows students' interest towards learning Earth and Space Science.

This is supported by Lowe (2004) who states that visualization in the form of animation can provide situational dynamics with a very clear picture and this has the potential to support learners thinking logically. Kali (2003) shows a similar thing where virtual visualization used as a game in learning activities proved able to increase students' enthusiastic or interest learning. Supported also by the Kastens' statement (2010) which states that the learning activities of geoscience using a lot of visualization can provide motivation and encourage to like learning geosains.

The same thing is expressed by students in their responses where lithospheric learning using visualization raises enthusiasm and interest in Earth and Space science. The existence of a fun learning atmosphere, interest and curiosity about the concept of lithosphere that has been taught allegedly also contributed to concepts mastery and students' logic-thinking of lithosphere material.

The interest raised by the used of visualization media in learning activities thought to be the reason for the appearance of curiosity and questions that make learning to be very active and interactive. This is in line with the student's response to learning activities which states that the visualization in the learning activities make more spirit, interesting, not bored, and so more curious. In line with Mc Connell & Khatrien (2011) who revealed that motivation is

one of the factors supporting the success of a learning process.

In addition to the visualizations discussed earlier, improvements in conceptualization and reasoning are also influenced by the visualization media at the *research-based material* stage in the lecture program (conceptual interactive with visualization) that has been developed. Based on the predicted phenomenon in the learning activity, visualization of the science research results presented at the *research-based material* stage has the potential to facilitate the students to get a rill of subsurface conditions that represent the concept of the subsurface structure studied in the lithosphere material.

Learning experience by presenting the results of science research allegedly attract attention and curiosity and to understand more about the concept of lithosphere because it is directly related to natural conditions. In line with Ellwein *et al.*, (2014) which discloses authentic scientific data from scientific research results can provide an interesting learning experience. This interest certainly brings its own motivation to study the earth and space science, especially the earth lithosphere. As has been disclosed by Mc Connell & Khatrien (2011), motivation becomes one influence on the success of learning activities. The application of *research-based materials* can be seen in Figure 4.

The concept that can be explained through Figure 4 is the structure of the subsurface layer and the potential for ground movement disasters. Based on the phenomenon seen during the learning activity, visualization in Figure 4 facilitates the students to understand the relationship of the subsurface structure of earth, the composition of the subsurface (clay content shown by the resistivity value), the geometry of the slip to the vulnerability of earth movement disasters. Where motion of the soil is one of the important concepts in the material of the earth's lithosphere.

In line with Werts & Hinnov's expressions (2011) which states that the visualization of the data processing using matlab can help showing the interrelationship between variables in the insolation phenomenon (latitut relationship and insolation magnitude) then the visualization of geoelectric data processing in Figure 4 above can facilitate to understand several concepts simultaneously.

The visualization of Bengkulu rill condition that is vulnerable to soil movement in learning activities also provides more insight into

natural disasters and how to adapt and mitigate. In line with research conducted by Rusilowati *et al.* (2015) which states that integrated physics learning natural disaster can improve local wisdom. Kortz & Kraft (2016) stated similarly, the support of research projects (research science) in learning activities provides benefits such as improving understanding of learned concepts supported by the research experience, improving skills and motivation. The combination of scientific research and learning activity is becoming a *trend* in geoscience research.

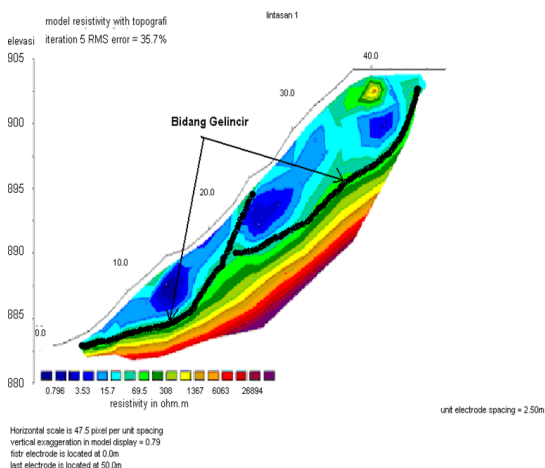


Figure 4. Visualization of subsurface cross-sectional areas prone to soil movement (Johan, 2007).

Lectures with focus on classroom interaction and conceptual visualization aided by various media can train and improve students' reasoning ability. The interactions that are formed in learning activities allegedly give a positive impact and encourage greater curiosity. Animation that visualizes concept not observed directly can present the relationship and linkages between variables and concepts in building a phenomenon related to earth lithosphere and raise students' curiosity and supported by interactive atmosphere suspected to be a collaboration that supports students to train the ability in logic-thinking and understanding the concepts during the learning process. Based on the results of the study, after the implementation, most of the students are able to explain the problems in the context of lithosphere material with comprehensive analysis supported by the relevant principles, theories, laws or definitions on the problem which becomes the question by following deductive-inductive rules. Students are able to connect the various concepts in describing a natural phenomenon.

Spiritual Attitude

The spiritual attitudes of this research are based on the competence of religious attitudes in the general description of the Indonesian National Qualification Framework which is then translated into several indicators adapted to the character of the Earth and Space science concept. Spiritual attitudes that will be implanted in this research is attitudes related to awareness and belief in the nature of the God, for examples nature of The Creator, The Almighty, The Maintainer, The Equitable, The Reckoner, etc. The questionnaire analysis used to find out the students' spiritual attitudes after the implementation of the Earth and Space science lecture program indicates the existence of spiritual attitude in the learning activities. The result of questionnaire for the attitude aspect of s spiritual attitude can be seen in Table 8.

Table 8. Questioner 1

Total response for all indicators	No		yes	
	1	8	9	10
	0	0	1.6%	98.4%

Notes: scale 1-> 10 shows the implantation of spiritual attitude in learning .

Table 9. Questioner 2

Total response for all indicators	yes no	
	100%	0

Notes: "yes" indicates the existence of spiritual attitude in learning

Based on the above questionnaire results show that more than 90% of students showed the existence of a spiritual attitude in the form of belief in the nature of God in the learning activities of lithosphere material that has been done. As for the recapitulation result of the *open ended* test about the implantation of spiritual attitude, the students feel their awareness of divine nature increases after following the EES which has been implemented. According to students the activities or things that make their consciousness increase after the learning activities in general are the values expressed through the various phenomena in the earth lithosphere and the chain questions given at the end of the learning activities. The chain question ends in a question whose answer goes back to the creator's power because of the limited human knowledge. Here are some recapitulation results of the students' spiritual attitude analysis based on answers to *open-ended* test: Earth and Space science

ce concept/natural phenomena presented in the learning activities also discuss the value and meaning behind the EES concept/natural phenomena. Conformity, complexity, and precision everything in nature raise students' awareness about God the Almighty, the Creator ; visualization shown in learning activities can visualize terrestrial phenomenon which is so great that add a sense of belief in the nature of God the Almighty ; the chain of questions that ultimately can not be answered scientifically by the students add to the awareness of the nature of the God.

Based on the results of questionnaires and open ended questionnaires conducted qualitatively shows that according to the student exploration of spiritual values in the form of belief in the nature of God gives a positive impact on the student's spiritual aspect. The implantation of spiritual values according to the students is obtained when the spiritual values on various lithosphere concepts are presented in the learning activities. The spiritual value of divinity is explored in various phenomena in earth lithosphere learning. Isnaini (2012) reveals that science teachers need to link learning with the religious side. An example of extracting these values in a learning activity can be seen in Figure 5.

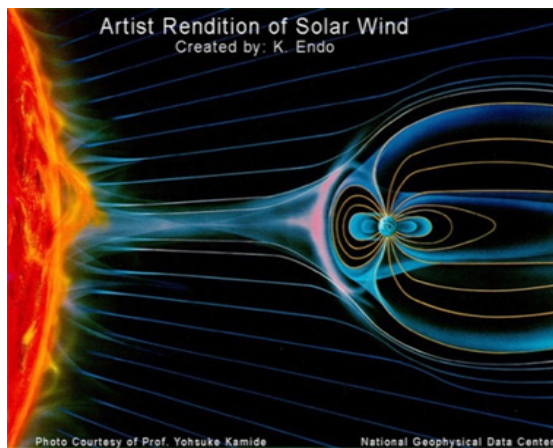


Figure 5. Example of exploration concept for the embedding of spiritual aspects (source: national geophysical data center).

The concept of geomagnet which is one of the important concepts in the earth lithosphere is explored to instill a spiritual aspect of belief in the God. The benefits of geomagnets that can be protective of the earth from various radiation and solar storms are the power of God to protect his creatures. If this is not explored it is possible students will understand the con-

cept well but not touched its spiritual aspect. This kind of activity in earth lithosphere learning is thought to have a positive impact on embedding of the student's spiritual aspect. In line with Karwadi's research (2008) reveals that the integration of science and religion in the learning activities occurrence of complementation, comparison, certification, and verification. The concept of science in the *break-down* to present the concept of divinity. In addition, the results of the analysis show that interactive activities in class to discuss a phenomenon that is done by providing chain questions from which can be answered scientifically based on the concepts that have been studied and to the questions that can no longer be answered using the concept that has been studied have a positive impact on the spiritual aspect . An example of instill the spiritual aspect through a serial question can be seen in Figure 6.

Softsolid mohorovisic layer makes the crust/plate including the mountain that is in the above can move (drifting away). The moving plate has a lot of benefits, among others, was instrumental in the formation of the topography such as mountains, valleys etc. The presence of volcanic mountain make earth rich in minerals including precious metal required. The existence of moho layer allows many activities of the plates movement can occur.

Questions that can be answered in scientific logic-thinking:
 Where does the mountain form?
 How does the occurrence of subduction process?
 Why could ocean plate be hitting the continental plate?
 Why does plates move?
 Why does moho layer form softsolid?

Questions can not be answered in scientific logic-thinking:
 Why does earth have moho layers?
 Why do the earth is layered in such a way?

Referring questions toward the spiritual attitude of nature of God implantation:
 Is there a human being even technologies that can move a mountain?
 Do you think something that can move mountains, surely have the super power?
 What do causes these things (in the previous question) can occur with very precise/precision, highly planned with great detail?

Figure 6. Example of implantation spiritual attitude through a chain questions

The chain questions in this interactive activity make students feel that there is a process that leads them to understand the natural phenomenon from the other side, that is from the spiritual side. Natural phenomena that occur or are created have a specific purpose. In general, the results of questionnaires and *open-ended* questionnaires showed that learning earth lithosphere overall not only affects increasing students' reasoning ability and mastery of concepts but also touches students' spiritual aspects. Based on the literature study, it is not often found similar reports on the integration of spiritual values in the study of science, especially earth and space science.

CONCLUSION

Based on the analysis of research results it can be concluded that after the implementation of earth lithosphere learning program

through interactive conceptual use of visualization potentially increase students' logic-thinking and mastery of concepts and instill a spiritual attitude related to belief in the nature of God. It can be seen from the N-gain value of reasoning of 0.69 in the *medium (upper-medium)* category and the concept gain N-gain of 0.59 in the *medium* category. Visualization gives the concept details (phenomenon) clearly create curiosity and questions from students. Visualization used is also capable shows relationship of various variables or concepts in a terrestrial phenomenon. Implantation of spiritual attitude in learning activity is done through exploration of divine values in various phenomena in the earth lithosphere and giving of a chain questions.

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IMPROVEMENT OF GRAPH INTERPRETATION ABILITY USING HYPERTEXT-ASSISTED KINEMATIC LEARNING AND FORMAL THINKING ABILITY

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ABSTRACT

The effectiveness of hypertext media in improving graph interpretation ability is investigated in this paper. In addition, joint ability of the formal thinking to improve the graph ability of prospective students is considered. The research design used is the one-group pretest-posttest experimental design is carried out in the research by taking 36 students on from Physics Education Program in one institute for teacher education in Medan. The test consists of graph interpretation ability test in the topic of kinematics and Test of Logical Thinking (TOLT or formal thinking) before learning and graph interpretation ability test after learning. The data are then analysed by using SPSS based two ways Analisis of Variance (ANOVA) method. The results show that the ability to interpretate graph is significantly improved by using hypertext media assisted kinematic learning.

ABSTRAK

Pembelajaran kinematik berbantuan media *hypertext* dalam meningkatkan kemampuan interpretasi grafik diselidiki dalam makalah ini. Selain itu, kemampuan menggabungkan kemampuan berpikir formal dalam pembelajaran terbukti secara empiris dapat meningkatkan kemampuan interpretasi grafik calon mahasiswa. Desain penelitian yang digunakan adalah the *one-group pretest-posttest experimental design*. Sampel penelitian terdiri dari 36 mahasiswa Program Pendidikan Fisika di salah satu lembaga pendidikan guru di Medan. Tes yang digunakan terdiri dari tes kemampuan interpretasi grafik dalam topik kinematika dan Tes Berpikir Logis (TOLT atau berpikir formal) sebelum belajar dan tes kemampuan interpretasi grafik sebelum dan setelah belajar. Data tersebut kemudian dianalisis dengan menggunakan SPSS dengan metode *Analisis of Variance* (ANOVA) dua jalur. Hasil penelitian menunjukkan bahwa kemampuan interpretasi grafik secara signifikan dapat ditingkatkan melalui pembelajaran kinematik berbantuan media *hypertext*.

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Keywords: Graph Ability; Hypertext Instructional Media; Improving; Kinematics; Learning Assisted

INTRODUCTION

The topic of kinematics is firstly introduced in the most of Basic Physics classes. Without solid understanding of the concepts of kinematics, students will experience a shortage of the necessary foundation to successfully understand advanced and more abstract physics concepts as stated by Beichner (1994). Graphical representation in kinematics is the most valuable and the most useful tool to represent real

world information in comparison to the use of table and algebra. The skill in creating a graph is a key factor in the study of Physics. Drawing and interpreting graphs play a key role in the understanding of science, while the lack of this ability has been proven to be a weakness and may become the factor that limits the learning of scientific concepts (Redding, 2014).

The difficulties in graph interpretation experienced by students are as follow: (1) to consider the graph as an image; (2) to distinguish the slope of the graph with the height of the graph; and (3) to consider the graph line is the motion trajectory of an objects (Kekule,

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2014; Mohammed & Yahya, 2014; Mokros & Tinker, 1987; McDermott *et al.*, 1987; Goldberg & Anderson, 1989). Kinematics graphs are often used since they offer some important verbal and algebra description and can be alternatives for students to manipulate the development of the concept (Kekule, 2014 and Beichner, 1994). Many teachers consider that the use of graphs in a laboratory setting is very important in strengthening the graph interpretation ability and developing an understanding to many topics in Physics, especially in motion. This opinion is supported by Vekiri (in Bektasli, 2006), who noted that the use of a graphical display is better than the use of text because the graphical display eases to search and to find the related information.

In the research conducted by Handayani (2014) concerning graph interpretation, there are 49 % of students who are at low criteria, 45% are at moderate criteria and only 6% are at high criteria. In the graphical representation, almost no student was able to answer correctly. In creating a graph, mature concept capabilities is required, and it should be applied in the form of graphs based on the concept.

Difficulties in connecting graphs into physical concepts as founded by Mc Dermot *et al.* (1987) are as follows: (a) distinguishing between the slope and the height of the graph; (b) interpreting the height changes and changes in the slope of the graph; (c) connecting one type of graph to another; (d) matching the narrative information of relevant graphs feature; and (e) interpreting the area under the graph. Difficulties in linking the graph with the real world according to this research has been solved by kinematic learning based hypertext media. According to Kaplan *et al.* (2014), there are misconceptions of students in understanding of histogram (Manurung, 2013).

To improve the student's abilities in interpreting graphs, therefore in this research is considered by using the hypertext media assisted of physics learning. The fundamental problem in the development of hypertext lies in the inter-relationship of the few aspects, such as nodes which are assumed to be non-linear. Some experts have dealt with the problem using macros chunking strategy (Svec, 1999). In that case, the user's knowledge about the structure underlies the knowledge enabled the user to determine the node to be visited. If the user understands the Toulmin argument (1958), it will easier to get the navigational directions. It is because the troubleshooting scheme over-

comes these obstacles through logical rules by applying the pre-structured navigation to provide navigation map which is none other than the underlying knowledge structure of hypertext.

Smith *et al.* (in Carter, 1997) perceive hypertext as an approach to information management that specializes in how to store data or information in a network node, which are connected to one another by a link. Technical description of hypertext is a group of non-linear text that will be only connected to each other if the reader clicks the labels of the text. By clicking on a node, the reader who is at a particular node will be taken directly to the clicked node. Each node can be connected according to various channels just like a network; it is different to the text in the book that only offers one specific flow of reading. Hypertext has to generate an extraordinary amount of information, in which, each node has multiple relationships (as it can be accessed from any nodes) with a variety of display forms such as text, graphics, audio, video and other data.

Learning with hypertext-based media on argumentative discourse is a kind of explanation based pedagogic teaching which is expected to overcome the difficulties in representing complex concepts of Physics (Erduran *et al.*, 2004). The hypertext can be explained as depicted in Figure 1 which shows the process of building knowledge according to the complexity of the phenomena that can be done according to user navigation. The simulation provides an opportunity for the user to reconstruct the needed information in order to improve his confidence.

Reconstruction and transfer capabilities or also the applications of complex concepts are referred to as *advanced knowledge* (Spiro & Jehng, 1990). This complexity can be reduced through a simulation study. Contribution of hypertext media assisted physics learning is to improve the ability of interpretation graph. Hypertext is a method of delivering to a computer with textual units stored at random; line readings follow the lines desired by the reader (Siregar *et al.*, 2009). "Hypertext" thus offers a reading with the "jump" capabilities from one point text to another text point or from one topic to another in a semantic space. Through Compiler Guide, The Win Help menu displays help text files, images, links hypertext, keyword search indexes etc; and are similar to the function of hypertext is the key document folder that will help the reader to explore the contents of a particular file.

Based on the above explanation, it is necessary to perform a certain Physics learning development in order to observe the ability of the students in accepting or rejecting the evidence of a relationship with a rational justification. The study has not been further developed by using a more complex approach to match the complexity of the problem. Thus, the originality of this research lies in the theoretical findings contained in the development of learning programs with the ability to express the abilities of students in solving ill-structured problems.

METHOD

In the development of hypertext media on the basis of story board, it is conducted as described in Figure 1.

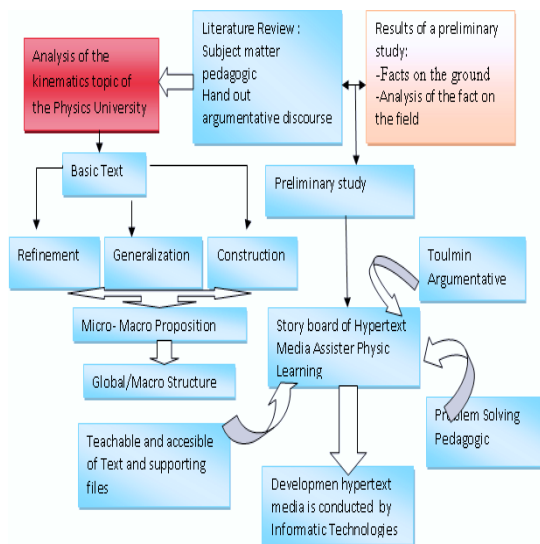


Figure 1. Philosophical grounding of development of hypertext media

Argumentative discourse based Hypertext program design is established from the analysis and findings at the stage of preliminary studies, literature review, and the global/macro structured. The global/macro structured is derived from three ways, namely: refinement, generalization, and construction. At first, the development of the story board of argumentative discourse and pedagogical problem solving based hypertext media is constructed. Beginning with the original text quoting from a textbook entitled *Fundamentals of Physics* by Halliday *et al.*, 2011; topics of kinematics subsequently are imparted to establish and to sharpen the discourse meaning. Refinement is done according to the criteria of accuracy and clarity. Clarity refers to terminology that does

not exceed or reduce the text's meaning that confirms or denies the truth of phenomenon. Clarity also passes on to the using of verbal action with respect to the main predicate that controls a proposition (Siregar, 1994).

The second application of those criterias is carried out through deletion and/or insertion of the words or phrases. Removal is done on a word or phrase that is excessive and does not favor any particular proposition. It is also made to remove words that have the same meaning as the others. The words that make waste sentences which are difficult or possible to be understood by readers are deleted or inserted into brackets. One word might be removed so that it can be inserted a word or a sentence in order to create sharper proposition without departing from the reference sentence before. Interpolation of words or sentences can also be performed without removal of the first in order to increase the accuracy of the subject matter. Therefore, there is a story board that is charged of argumentative discourse, problem solving pedagogic and global/macro structured of subject matters that are not only easy to learn but also accessible.

Hypertext allows users to realize the potential that there is no longer a passive audience of readers, but as co-author also determines its own sequence of readings. It is the potential with the ability to assemble knowledge with respect to the conditions of complex knowledge. For example, the phenomenon of harmonic motion of a pendulum is usually considered to be simple. Actually, it is not an easy case because it involves a number of representations: (1) the object of phenomena, (2) measurement representation, for example the position of the pendulum on a particular cycle of oscillation, (3) a graphical representation of the phenomenon pendulum according to time and speed. Figure 2 shows the overall inter-relationship of these representations as a complex phenomenon (non-linear).

The above illustration shows the process of building knowledge according to the complexity of the phenomenon that can be done according to user navigation. Simulation provides an opportunity for users to construct and to reconstruct as needed in order to improve his confidence. Reconstruction and transfer capabilities or applications are complex concepts referred to as advanced knowledge (Spiro *et al.*, 1991) which through a simulation study is aimed to reduce the complexity.

The method of this research is quasi-ex-

periment with the design used for the quantitative research is one group pre-test and post-test (Fraenkel *et al.*, 2012). For the implementation of hypertext in the kinematics learning, the graph of the one group pre-test post-test is as follows. The subject of research for implementation is prospective students in one of teacher education in Medan of 36 students, consisting of 10 male students and 26 female students.

The data were collected by using two research instruments, namely Test of Logical Thinking (TOLT) and test of graph interpretation. Test of graph interpretation consists of 31 multiple choice questions and TOLT consists of 10 items. TOLT is originally developed by Tobin and Capie (1981) and is used to determine the formal reasoning ability of students. TOLT psychometric characteristics have been well documented by the developers. This test was translated and adapted into Turkish and its reliability was found to be 0.81. In this research, the test consists of 10 items designed to measure the proportional variables (items 1 and 2), reasoning control variables (items 3 and 4), probabilistic reasoning (items 5 and 6), correlational reasoning (items 7 and 8), and combinatorial reasoning (items 9 and 10). The test consists of problem illustration and multiple choice answers with reasons, except for combinatorial reasoning.

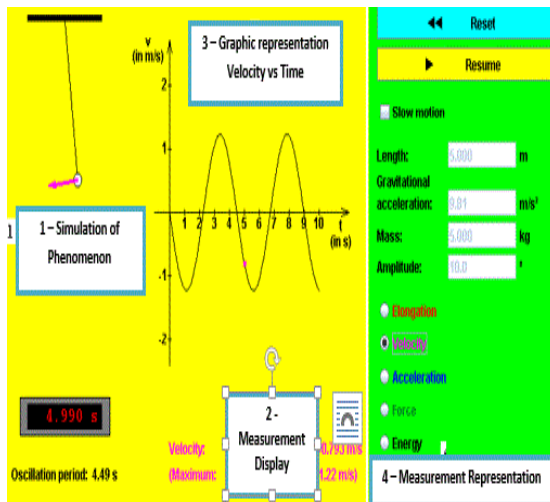


Figure 2. The pendulum phenomenon according to knowledge representation components which construct the basic knowledge about pendulum

RESULTS AND DISCUSSION

TOLT test consists of 10 items and test of

graph interpretation consists of 31 items. The maximum score on the formal thinking ability is 10, the minimum score is 4. The mean is 6.58 while the standard deviation is 1.68. The maximum score on the pre-test of graph interpretation is 12; while the minimum score is 3; the mean is 7; and the standard deviation of 1.84. The maximum score on the post-test of graph interpretation is 16; while the minimum score is 8; the mean is 12.53; and the standard deviation of 2. All the results are summarized in Table 1

Table 1. Analysis of Descriptive Statistics of the Three Variabels

Variable	N (Number of samples)	Min	Max	Mean	Std. Deviation
Formal Thinking Ability	36	4.00	10.00	6.5833	1.67971
Pre-Test of Graph Interpretation	36	3.00	12.00	7.0000	1.83615
Post-Test of Graph Interpretation	36	8.00	16.00	12.5278	2.00693

Collinearity test is conducted to determine whether there is a relationship or correlation between variables. Collinearity can be tested by using the product moment correlation. The summary of the collinearity test is presented in Table 2.

Table 2. Test of Paired Sample t Test

		Paired Differences		t	df	Sig. (2-tailed)
		Mean	Std. Deviation			
Pair 1	Pre-Test Post-Test	5.52778	1.74824	-18.971	35	0.000

The test results in Table 2 show that the Lower and Upper negative or sig (2-tailed) is $0.000 < \alpha = 0.05$, H_0 is rejected and H_A is accepted. There is a difference in the graph interpretation ability before and after the hypertext media assisted learning of kinematics is implemented. Since $t_{\text{calculation}} = -18.97 < t_{\text{table}}$ then the test of variance homogeneity between groups uses the Levene 's Test of Equality of Error Variance. The data can be taken to have the same variance if the significant number produced is greater than 0.05. The summary of the analysis of the variance homogeneity between groups of the learning model is presented in Table 3

Table 3. Test of Homogeneity of Variances

Variable	Levene Statistic	df1	df2	Sig.
PreGraphic	1.430 ^a	5	29	0.243
PosGraphic	0.849 ^b	5	29	0.527

From the output of the variance homogeneity using Levene's test, it is obtained that sig = 0.243 and 0.527 > α (0.01). The conclusion is that the variance is homogeneous. Table 3 shows that the Levene's statistics value indicates the significance number of $p > 0.05$. This indicates that the null hypothesis which stated that the variance between different groups of learning model was not different is accepted. In other words, the variance between groups of learning model is the same (homogeneous), both for formal thinking skills and for the graph interpretation ability at the pretest and posttest.

Two-way ANOVA test is used to test the hypothesis in this research. Two inter-column main effects are obtained as the treatment variable and inter-row major influence as attribute variables (simple effect) and the column-row major influence as interaction effects. The independent variables are hypertext learning and formal thinking skills, while the dependent variable is graph interpretation ability. The interaction and the significance between main effects of hypertext learning and the formal thinking skills can be obtained in the analysis of variance above, then the test is continued by using the Tukey test between pairs of data in order to determine the group with higher average, as the pairs shown in the following Table 4.

Table 4. The analysis of 2 way ANOVA (Tests of Between-Subjects Effects)

Dependent Variable: Post-test of Graph Interpretation				
Source	df	F	Sig.	
Corrected Model	21	3.244	0.014	
Formal Thinking Ability	6	2.084	0.121	
Formal Thinking Ability *				
Pre-Test of Graph Interpretation	9	2.390	0.070	

a. R Squared = 0.830 (Adjusted R Squared = 0.574)

The ANOVA test results formal thinking ability are sig = 0.121 and 0.121 > α (0.05), and thus H_A is accepted. It can be concluded that the graph interpretation ability not increased for both student with high and low formal thinking ability. ANOVA results of the posttest scores of graph interpretation ability indicate that formal

thinking skills are not significant predictor for determining the level of graph interpretation ability. The ANOVA test results in pretest of graph interpretation are sig = 0.002 and 0.002 < α (0.05), and thus H_A is rejected. This result also says that pretest of graph interpretation affects the score of the respondents in graph interpretation test, especially in the posttest condition. However, it is different for both of formal thinking ability and pretest of graph interpretation and is not significant predictor for determining the level of graph interpretation ability.

The results of the research showed that there was similar result of graph interpretation ability for students of high and low formal thinking skills. Furthermore, ANOVA results with formal thinking skills as the independent variable, for the posttest scores of graph interpretation ability, indicated that formal thinking skills was not a significant predictor in determining the level of graph interpretation ability. ANOVA results pre-test of graph interpretation affected the score of the respondents in graph interpretation test, especially in the post-test condition. However, it was different for interaction both of Formal Thinking Ability * Pre-Test of Graph Interpretation not significant predictor for determining the level of graph interpretation ability. McDermott *et al.* (1987) has examined the difficulties in connecting the graph with the physical concept and the difficulty in linking the graph to the real world. He had categorized 10 difficulties faced by students in interpreting kinematics graphs, which are divided into two main categories, namely: (1) Difficulty in connecting graphs for physical concepts: a) Distinguishing between the slope and height of the graph, b) Interpreting height changes and changes in slope, c) Connecting one graph type to another, d) Matching narrative information of relevant graph features, e) Interpreting the area under the graph and (2) Difficulty in linking the graph to the real world: a) Indicating a continuous motion as the same as a continuous line, b) Separating the form of a graph of the motion trajectory, c) Showing a negative speed on a speed vs. time graph, d) Showing the acceleration constant on an acceleration vs. time graph. Some other difficulties related with graphs were noted by Mokros & Tinker (1987), Goldberg & Anderson (1989) showed that students consider graphs as images. They were confused between the slopes and the height of a graph, and also the form of graphs and trajectories

CONCLUSION

Learning through hypertext with object motion simulation as a virtual laboratory was presented in this research. Students can perform measurements and observations of the shown phenomenon. The simulation in this hypertext also showed the graph of movement vs. time. The kinematic concepts in Physics were modeled using algebra, graphs, and motion maps. It was noticed if many appropriate representations were used, then the students showed strong attention in solving kinematic algebraically. The students were expected to solve the problem using graph representation before they solved it using algebraic method. The results showed that sample students preferred the solving method by using graphs and showed a strong improvement in the overall understanding of kinematics concept compared to students who did not receive the treatment

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DEVELOPMENT OF GUIDED INQUIRY-BASED PHYSICS TEACHING MATERIALS TO INCREASE CRITICAL THINKING SKILLS OF HIGHSCHOOL STUDENTS

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ABSTRACT

This study aims to produce teaching materials based on inquiry physics to improve the critical thinking skills of high school students. This type of research is Research and Development and refers to the 4-D development model. This study was tested in class X. The results of this study obtained some findings include: 1) the validation of teaching materials obtained categories are very valid and reliable; 2) test legibility of physics teaching materials categorized high readability; and 3) *N-gain* improves students' critical thinking skills. Based on the results of this research, it can be concluded that the guided inquiry-based physics teaching materials worthy of use in learning and can improve the critical thinking skills of high school students.

ABSTRAK

Penelitian ini bertujuan untuk menghasilkan bahan ajar fisika berbasis inkuiri terbimbing untuk meningkatkan keterampilan berpikir kritis siswa SMA. Jenis penelitian ini adalah *Research and Development* dan mengacu pada model pengembangan 4-D. Penelitian ini diujicobakan di kelas X. Hasil penelitian ini diperoleh beberapa temuan diantaranya: 1) hasil validasi bahan ajar memperoleh kategori sangat valid dan reliabel; 2) uji keterbacaan bahan ajar fisika berkategori keterbacaan tinggi; 3) *N-gain* peningkatan keterampilan berpikir kritis siswa berkategori sedang. Berdasarkan hasil ujicoba ini dapat disimpulkan bahwa bahan ajar fisika berbasis inkuiri terbimbing layak digunakan dalam pembelajaran serta dapat meningkatkan keterampilan berpikir kritis siswa SMA.

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Keywords: Critical Thinking Skills; Guided Inquiry; Physics Teaching Materials

INTRODUCTION

The development of the era of globalization as well as science and technology demands qualified human resources, one of them through an educational process. Education is a process that aims to influence learners to adapt to their social environment which resulting in a positive change in their habits so that enabling them to function well in society (Hamalik, 2013). Education is functioning to develop life

skills and to form a dignified nation character in order to educate the nation's generation. Therefore, the government is obliged to provide the best education system so that the potential of learners can be optimized and in the future they can become human resources that have good morality and honesty; intelligent, creative, and skilled in decision making, devotion to God; as well as become a democratic and responsible citizen (Sisdiknas, 2012).

One of the life skills need to be developed through the education process is critical thinking skills. In terms of Chance's critical thinking skills (1986), developing students' cri-

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tical thinking skills means training them to have the ability to analyze facts, find and organize ideas, defend opinions, make comparisons, draw conclusions, evaluate arguments and solve problems. According to Krulick & Rudnick (1999), critical thinking is a way of thinking that tests, connects, and evaluates all aspects of a problem situation, including the ability to gather information, remember, analyze situations, read and understand and identify things required. Therefore, the process of critical thinking trained to students will shape their tendency to thoroughly consider a problem arising from experience so that they are able to make the right decisions. At the time of proceeding in the decision-making, it is seen that the process of scientific inquiry also occurs in students. Students will endeavor to develop the fact-finding process and relate it to the problems they experience as a basis of decision-making. Based on these definitions and facts, it appears that critical thinking is a well-organized mental process in the decision-making process to solve problems that can be trained through scientific inquiry activities.

In general, inquiry activities can be done in every subject, at any time by the teacher in the classroom, and to any student regardless of age. In this research, the subjects of the study are high school students who are considered essential to be familiarized in making important decisions for their future. They need to be trained to find the most important thing to do to solve the problem and find the most effective way to solve it. One of the intermediate media in trained critical thinking skills of high school students is the subject of physics. Physics is a part of science that plays an important role in improving the quality of life. Teaching physics not only trains the quality of thinking in analyzing natural phenomena logically and systematically but also how to apply them in everyday life. Critical thinking skills can be applied in the study of physics both in studying procedural knowledge so that the facts contained in each stage are easily understood, as well as conceptual knowledge that requires higher-order thinking to connect the facts so that the intended concept can be well conveyed (Arends, 2012). High school students who master critical thinking skills will be able to understand the factual knowledge that forms a conceptual knowledge and then apply it in everyday life. Conversely, when high school students face an important social phenomenon in society, they can respond appropriately and even contribute real

and original thoughts. Therefore, it is important to design learning activities as well as to create a more conducive learning environment to guide students to learn by involving high order thinking skills so that critical thinking skills of high school students can be trained optimally.

Based on a preliminary study of students' critical thinking skills conducted in SMA Negeri 1 Tarik on sample 33 students of class X on Hooke Law topic, it was found that critical thinking indicator which includes giving argument, induction, evaluating, and deciding an action is still low. This data concluded from the students who have not mastered the four aspects, namely to provide arguments of 72.73%, induction of 84.85%, evaluate 66.67% and decide an action of 90.91%. While on the aspect of formulating the problem, the average student is good enough in mastering the aspect is reaching 63.64%. Based on observation result, it is found that some causes have not been done maximally effort to trill critical thinking skill in physics study, they are: (1) physics subject teacher difficulty to handle student with low ability, so that active and motivated to learn physics; (2) students have difficulty using critical thinking ability because they are not used yet; (3) time limit of physics subject teachers to be able to provide teaching materials in training students' critical thinking skill; and (4) teaching materials used in the form of conventional teaching materials.

Based on the observation results it is obtained that the learning materials used can not guide students to find the concept of physics on their own. The results of research that examines similar problems indicate that to provide a direct learning experience that can help students to find the concept of physics on their own, then on the learning process, guided inquiry-based physics learning materials to support students' activities can be used. Teaching materials are a set of learning tools that contain learning materials, methods, limitations, and how to evaluate systematically designed and interesting in order to achieve the expected goal of achieving competence or subcompetence with all its complexity (Widodo and Jasmadi, 2008). Guided inquiry-based physics teaching materials are teaching materials containing scientific steps, ie orientation, formulating problems, formulating hypotheses, collecting data, testing hypotheses, and formulating conclusions. This is consistent with the opinion of Eggen (2012) that the learning model can provide opportunities for students and helping students gain an

understanding of the scientific method to develop critical thinking skills, self-regulation, and understanding of specific topics is an inquiry learning model. In addition, Bilgin (2009) states that guided inquiry as a student-centered approach has an influence on students' academic success and develops students' scientific process skills. Thus, teaching materials that can train critical thinking skills are teaching materials that contain the steps of guided inquiry learning model.

Steps of guided inquiry learning models contained in the teaching materials to give students the opportunity to train their critical thinking skills. Systematic of the teaching materials are designed to train students in formulating problems, giving arguments, inducing, evaluating, and determining an action (Wahyuni, 2015; Hermayani, Dwiastuti, and Marjono, 2015; Fauziah, 2014). In the learning process, inquiry learning model is a learning model that fosters students' ability to think and work scientifically and has a scientific attitude (Permendikbud No. 58, 2014). Guided inquiry learning is designed to train students' skills in conducting research and asking questions based on facts. Inquiry-based learning is guided in implementing five learning stages: 1) identifying a question or problem; 2) formulating the hypothesis; 3) collecting data; 4) test the hypothesis; and 5) formulate generalizations (Kardi, 2013). Learning activities using guided inquiry will familiarize students to actively seek information by conducting an experiment in solving a problem. Students will be accustomed to answering questions provided with accurate analysis so that will affect the achievement of maximum learning results.

The teaching materials are important in the learning process. The use of teaching materials will be easier for teachers in implementing the learning process and students will be more helpful and get ease in learning. Teaching materials can be made in various forms according to the needs and characteristics of teaching materials to be presented (Dharmasraya, 2008). Oktafiana (2015) argues that guided inquiry-based physics teaching materials on motion topic can improve students' creative thinking ability with an average creative gain of 0.69. Similar research conducted by Wahyuni (2015) on the development of teaching materials of science, states that the science materials that developed it is feasible to be used in learning for junior high school because it scored 3.88, 3.74, and 3.70 of 4 scale from

the results of expert validation. In addition, developed science teaching materials can also improve students' critical thinking skills.

Widodo and Jasmadi (2008) revealed that there are five characteristics of teaching materials: (1) self instructional, (2) self contained, (3) stand alone, (4) adaptive, and (5) user friendly. Teaching materials are said to be self instructional if they meet the following requirements: (a) There is a clear purpose; (b) Materials packaged into specific units; (c) There are examples and illustrations that support the clarity of the exposure of learning materials; (d) There are exercise questions, tasks or exercises; (e) Presented with a contextual approach; (f) Simple and communicative language; (g) Present a summary of instructional materials; (h) Provide self assessment based assessment instruments; (i) Instruments used by users to measure or evaluate the degree of mastery of the material; (j) Provide feedback on the assessment, so that its users know the level of mastery of the material, and (k) Available information on reference / enrichment that supports the intended learning materials. Self contained is a form of printed and written information deliberately presented for study by students containing all the materials or theory of lessons, and grouped in one page or one unit of competence and also accompanied by sub-competence. Stand alone teaching materials will be fulfilled if the teaching materials can survive alone, ie do not need help from other teaching materials. Good teaching materials already cover all the subject matter so it does not require other teaching materials to complete it. If the learner still uses and relies on other teaching materials other than the teaching materials used, the teaching materials are not categorized as stand-alone teaching materials. Adaptif good teaching materials not only can survive alone, but also can keep up with technology. It is said to be adaptive if the teaching materials can adapt the development of science and technology, flexible to use in various places, and the contents of learning materials and software can be used until a certain time. Good teaching materials, not only contain the source of science alone, but also created in a way higher quality. User friendly perfect teaching materials should be able to facilitate users when they want to use them. Every instruction and exposure of information will appear to be helpful and friendly with the wearer, including ease of user in responding, accessing as you wish. The use of simple language,

easy to understand, and use of commonly used terms is one form of user friendly.

Based on the background and identification of the problem, the goal to be achieved in this research is to develop physics teaching materials that can improve the critical thinking skills of high school students.

METHOD

This research is Research and Development. The design of this study modifies the procedural model adapted from the development of 4D model devices ie define, design, development, and disseminate (Thiagarajan and Semmel, 1974). In this study the development stage will only be implemented in the defining, designing, and developing phases only. The depth stage is not implemented considering the limited time available in this research.

The subjects of this study are guided inquiry-based physics teaching materials on static fluid material developed and tested on 15 students in class X IPA 1 in SMAN 1 Tarik in Odd Semester Academic Year 2016/2017.

Data collection is done using validation sheet, legibility sheet, and test of critical thinking skill. To measure the feasibility of learning materials obtained by using the instrument validation sheet by two lecturers of Physics as expert testers. The effectiveness of the teaching materials was identified from the results of the reading material readability analyzed using the legibility test and improvement of students' critical thinking skills through pretest and posttest analyzed using N-gain calculation.

The development procedure in this study was adapted from 4D development model according to Thiagarajan and Semmel. The steps taken in the development procedure with the 4-D model are as follows.

Definition Stage

This stage consists of five activities, namely: (1) needs analysis done as initial study about the need of development of teaching materials to improve the quality of learning which means also will be able to improve the quality of human resources in Indonesia. The development of students' competencies based on the need for future competence is the ability to communicate, think critically and creatively by considering the values and morals of Pancasila to become a democratic and responsible citizen, tolerant in diversity, able to live in a global society, have a broad interest in life and rea-

diness to work, intelligence according to talent / interest, and care about the environment. The ability to think critically, creatively, and innovatively is needed to adjust to the development of science and technology; (2) student analysis is done to know the characteristic of student which include academic ability, background of knowledge, and level of cognitive development of student. Results of student analysis can be used as an overview to develop teaching materials; (3) task analysis is carried out by detailing the content of teaching materials in the form of an outline of main content that includes an understanding of the task in learning. This step is done by analyzing the basic competence and the indicator of critical thinking skills of the selected material that is static fluid; (4) concept analysis is conducted to identify the main concepts to be taught; systematically arranging; and detailing relevant concepts to form a concept map; (5) the formulation of learning objectives is based on core competencies and basic competencies in accordance with the 2013 curriculum.

Design Stage

The design stage is done to design the initial form of teaching materials for students. Teaching materials are student learning manuals used in learning activities. The teaching materials contain the lesson material that was adopted from several sources of physics textbooks.

Development Stage

The development stage is done to produce the revised teaching materials based on input from the experts. The results of the design are then developed with the steps (1) validation of teaching materials is useful to refine the initial design of learning materials, then ready for use by students. The teaching materials that have been made are then validated by two experts in the field of Physics education for advice and revision; (2) the readability test of the learning materials is used to assess the legibility of the revised teaching materials based on input from experts before being trialled on a broader subject; (3) limited trials are conducted to test the quality of teaching materials on selected subjects for the purposes of modification and effectiveness of teaching materials.

RESULTS AND DISCUSSION

This research development of physics

teaching materials uses development procedures in accordance with 4-D development steps. The purpose of this development is to produce a guided inquiry-based physics teaching material on static fluid topic that is valid and effective.

Define Stage

At this stage, initial observations are made to identify the problem; facts in schools that serve as the basis for the development of physics teaching materials of static fluid subject matter; and data collection to determine the purpose of research through observation to the school that will serve as the research base. The next step is to formulate the problem related to the object to be studied. Problems identified in this analysis are: (1) the learning process that is still dominated by teachers and students only hears and records explanations from teachers; (2) the teachers never composed their own teaching materials. Teaching materials used in schools are purchased from publishers whose competency outcome indicators are often incompatible with indicators outlined in the lesson plans. At this stage, the formulation of static fluid indicators and learning objectives is based on concept and task analysis. These indicators were used to develop a set of students' critical thinking skills tests.

Design Stage

The developed teaching material aims to improve students' critical thinking skills. In the teaching materials contains a number of issues related to the concept of static fluid that occurs in everyday life. This teaching material also contains experimental procedures that are expected to assist students in trained their critical thinking skills. Systematic teaching materials include introduction, content, and cover. In the introduction section contains illustrations or images that are expected to bring up the problem especially the problems that often occur in everyday life.

Starting from the problems presented, students are expected to be able to analyze the problems by using the critical thinking skills they had before. The content section contains learning objectives, static fluid concepts, illustrations, examples that support concepts, conceptual linkages with science / technology, and activities that support the learning process. One of the learning support activities is an investigation activity in which there is a hypothetical section that provides an opportuni-

ty for students to train critical thinking skills to construct hypotheses.

The content is made to facilitate the learning process in raising the ability that will be owned by students after reading the teaching materials. Teaching materials contain instructions to students, for example in answering practice questions; conducting practicum activities; including when observing the natural phenomena around them. Through contextual teaching materials, teachers can train students' critical thinking skills in formulating problems, giving arguments, and concluding inductively, even conducting evaluations to decide what to do in relation to the various cases given. Furthermore, the closing section contains the conclusions and references.

Development Stage

The preliminary step of the development stage is the expert validation that aims to assess the feasibility of the content of the teaching materials before being tested. Product improvements are made based on comments and suggestions from the validator, either in the form of written suggestions on the manuscript, comments on the validation sheet, or spoken suggestions obtained by discussing with experts related to the developed teaching materials. Validation activities are done by giving the script of the teaching materials and assessment instruments along with the validation sheet to the two expert validators.

The results of validation of teaching materials by two validators with a score range 1-4 are presented in Table 1.

Table 1. Expert Validation Results on Teaching Materials

Contents	Average Score	Category	Reliability (%)
Introduction	3.50	Valid	100
Contents	3.55	Valid	96.1
Characteristic	3.63	Very valid	96.43
Closing	4.00	Very valid	100
Concept development	3.57	Valid	93.88
Average	3.65	Very valid	97.28

Table 1 shows that in general the results of validation of teaching materials developed

have a very valid category with an average score of 3.65 and has an instrument reliability of 97.28% so that teaching materials can be used and reliable. The teaching material is valid if the score is above or equal to 2.6 and invalid is used if it scores below or equal to 2.5 (Ratumanan & Laurens, 2006; Sudiarman, 2015).

Experimental materials that have been validated by experts are tested its legibility. Test legibility is done to support the results of feasibility of teaching materials by expert validators. Test results legibility of teaching materials can be seen in Figure 1.

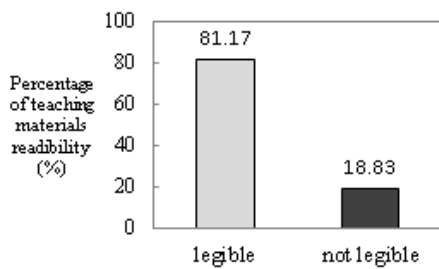


Figure 1. Result of Readability of Physics Teaching Material

Based on Figure 1, the results of the test of teaching material readability showed that the average score of 15 students' responses obtained that 81.17% of teaching materials can be read so that the teaching materials can be categorized high legibility. This means that teaching materials can be easily understood by students. In accordance with the regulation of the Ministry of National Education (2008) that one component of the material assessment is the linguistic aspect which includes the readability of the sentence; the clarity of information; the compliance with the Indonesian language rules in a good and correct way; and the utilization of language effectively and efficiently (clearly and briefly). Therefore it can be concluded that the developed physics learning materials have decent criteria to be used in learning.

In this study, the assessment is not only done on the feasibility of physics teaching materials but also on the effectiveness of teaching materials in improving students' critical thinking skills. Indicators of critical thinking skills used include: 1) formulating problems; 2) provide an argument; 3) conclude inductively; 4) conduct evaluation process; and 5) decide on an action (Ennis, 1995). Improving students' critical thinking skills is indicated from the pretest and posttest scores that have been adapted to the learning objectives as shown in Table 2.

Table 2 shows a significant increase in students' critical thinking skills classically identified a normalized gain score of 0.63 with moderate criteria. These results indicate that the teaching materials used give a significant influence in training students' critical thinking skills.

Table 2. Average Pretest and Posttest Scores

Data	Results
Pretest Score	46
Posttest Score	80
N-Gain	0.63 (moderate)

Table 3. Mean Scores of Critical Thinking Skills Indicators

Critical Thinking Indicators	Average Score of Pre-test	Average Score of Post-test	N-Gain	Categories
Formulating problems	4.73	7.13	0.74	High
Giving arguments	4.60	6.60	0.63	Moderate
Concluding inductively	3.33	6.20	0.61	Moderate
Conducting evaluation	2.93	5.7	0.5	Moderate
Deciding an action	2.47	5.40	0.53	Moderate

Improvement of critical thinking skills on each indicator is presented in Table 3. The use of developed physics teaching materials has been able to train students in improving critical thinking skills. Five aspects of critical thinking are trained in the learning process, namely formulating problems, giving arguments, inductive conclusion, conducting the evaluation process, and deciding an action. Kholifah (2015) argues that individuals who have the skills of critical thinking will be able to decide and to think rationally based on some of the views they have on a different context. This means that critical thinking is needed by everyone to address a problem faced. Kholifah further claims that a

critical thinker will be able to deduce from what he knows and know how to use information to solve problems, and seek sources of information relevant to him (Kholifah, 2015). From the test results and in line with the Kholifah opinion can be said that physics teaching materials that have been developed feasible use in learning and can improve students' critical thinking skills.

These results are consistent with the research of Kariawan, Sadia, and Pujii (2015) that the design of physics learning with the setting of inquiry learning model has met the valid, practical, and effective criteria for improving problem solving and critical thinking skills. In line with the results of the study, Antika, Sarwi, and Aji (2017) stated that guided inquiry learning with the help of student worksheets can improve the mastery of interpersonal skills and interpersonal skills of high school students. Ardi (2015) in his research reveals that physics-based instructional materials inquiry led to the subject matter of Temperature and Calor can improve student learning outcomes with the acquisition of N-gain of 0.71 indicating a high increase of learning outcomes. Another supporting research is the result of Desmaria (2015) research which is that the instructional materials based on inquiry are guided on the material of Elasticity and Law of Hooke is declared effectively used in the learning with the acquisition of the average value of N-gain of 0.69 in the medium category. The overall results of this study prove that the teaching materials that have been developed by each researcher has a significant influence on students' thinking ability that is now evident from the results of this study also that the physics teaching materials that have been developed can improve students' critical thinking skills significantly.

CONCLUSION

Based on the results of the research and discussion, it can be concluded that the development of guided inquiry-based physics teaching materials is feasible to use in physics learning in high school. The result of validation of physics teaching materials got the average score of 3.65 with the category of very valid and the reliability of the instrument reaches the score of 92.28%. It indicates that the teaching materials that have been developed can be used and reliable. The result of physics test readability test gets an average score of 81.17% with very high category. In addition, the

physics teaching materials can also improve students' critical thinking skills as indicated by a N-gain score of 0.63 in the medium category.

Suggestions given include: 1) guided inquiry-based physics teaching materials in this study is limited to fluid topic only. For further development it is necessary to develop teaching materials on other subjects; 2) critical thinking skills in this study only trained for several meetings only. To practice students' critical thinking skills in their entirety, the implementation of instructional material development needs to be done on an ongoing basis for all subjects; and 3) guided inquiry-based physics teaching materials that developed in this research can be used by teachers as an alternative model to improve students' critical thinking skills.

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THE POROSITY CALCULATION OF VARIOUS TYPES OF PAPER USING IMAGE ANALYSIS

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ABSTRACT

The paper porosity study has been done by observing microscopically. The purpose is provide airborne porosity data on various paper types, so that we can rank the ability of liquid absorption on the same paper type. This porosity analysis is done by using ImageJ, with converting the image to binary, set the threshold limit, and clarify the watershed limit. The result of the porosity of filter paper A=51,50586 , B=18,30719 , C=21,68076 , D=29,72028 ; tissue paper A=9,174071 , B=20,96931 , C=32,76454 ; HVS paper A=23,31616 , B=27,70944 . So it can be concluded that the ability of filter paper absorption A > filter paper D > filter paper C > filter paper B. Absorption ability tissue paper C > tissue paper B > tissue paper A. Absorption ability HVS B paper > HVS paper A. In general can be inferred that the higher the porosity value of the paper the greater ability to absorb liquids on paper.

ABSTRAK

Penelitian porositas kertas telah dilakukan dengan mengamati secara mikroskopik. Tujuan penelitian ini memberikan data porositas pada berbagai jenis kertas, sehingga dapat dibuat peringkat kemampuan serap cairan pada jenis kertas yang sama. Analisa porositas ini dilakukan dengan menggunakan ImageJ, mengubah gambar menjadi biner, menentukan batas threshold, dan memperjelas batas pengamatan (*watershed*). Hasil porositas untuk beberapa jenis kertas sebagai berikut: kertas saring A=51,50586 , B=18,30719 , C=21,68076 , D=29,72028 ; kertas tissue A=9,174071 , B=20,96931 , C=32,76454 ; kertas HVS A=23,31616 , B=27,70944 . Sehingga dapat disimpulkan bahwa kemampuan serap kertas saring A > kertas saring D > kertas saring C > kertas saring B. Kemampuan serap kertas tissue C > kertas tissue B > kertas tissue A. Kemampuan serap kertas HVS B > kertas HVS A. Secara umum yang bisa ditarik kesimpulan bahwa semakin tinggi nilai porositas kertas maka semakin besar kemampuan serap cairan pada kertas.

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Keywords: Image; Paper; Porosity

INTRODUCTION

Parameters of porosity are very important, because porosity is the primary variable to determine the magnitude of a backup of fluid contained in a mass (Bergaya, 1995). Material available in the nature had a pore or a different air cavity, this can be seen with the difference between the ability of absorbing water by the material (Ebaretonbofa & Evans, 2002). Each material has a different porosity depends on

the material structure. The high ability of material absorption makes the material absorbs water continuously during and after the process of absorption.

In previous research observation between porosity and permeability on a material performed (Zhaoqi, 2017) have been done, about the influence of the grain measurement against the porosity and permeability sandstone, indicates that there are linear relationship between permeability porosity and rocks (Haffen, Géraud, Rosener, & Diraison, 2017). As the results of the study, there is linear relationship between the cavity of the air and

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absorption ability (Li, Goldstei, & Franseen, 2017). Based on the importance of porosity calculation research to the ingredient's determine the material absorbent, this research is made. Because each paper has different uses and effectiveness. This should be noted. For example filter paper, filter paper has several types of variations / types that have their usefulness, eg tissue type A suitable for oil, filter paper type B suitable for plain water. It was on the ability to absorb paper against liquid fluid.

Another purpose of the research is to calculate the porosity of different kinds of paper, since the same kind of paper does necessarily has of absorption ability different variations.

The outcome of this research is an air cavity (porosity) data base on different variations on paper, such as different kinds paper tissue of, HVS paper, and filter paper which will be analyzed with image processing.

This research emphasizes the analysis of paper pore calculation using image processing. Image processing can be used to accurately analyze the quality of an

image (Ningtias, Suryono & Susilo, 2016). Image processing techniques in addition to generating accurate data also produce data precision (Susanto, 2009). Therefore the image processing system is very appropriate to calculate the small porosity of paper that have a size in millimeter .

The word of paper (paper) derived from the Egyptian language; papyrus, which is a material used by the Egyptians to write on. Paper was found in China for the first time by Cai Lun. It is manufactured by the process of fiber compression was derived from the fiber separation and fibrous raw materials that has been dried before hand, and some additional ingredient that stuck and connected to each other being added (Ding, Hung, Lee, & Wang, 2017). The results of compressing, drying and adding other material determine the weight of, the paper thickness and quality. The Microscopic image of paper can be seen as in Figure 1.

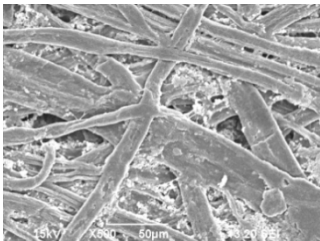


Figure 1. Filter paper pores with 500 times under the scanning of electron microscope.

(https://www.ndsu.edu/em_lab/images/sem_images/papers/)

ImageJ is a software that can be accessed in general. National Institute of Mental Health, Bethesda, Maryland, USA. The software was developed by Wayne Rasband and now in research branches of the National Institute of Mental Health, Bethesda, Maryland, USA. The software can run on various systems supported by Java 1.1 or version software. This software can be downloaded for free from the website <http://rsb.info.nih.gov/ij/>. Downloaded ImageJ can be paired with a computer by running the program package. In this case, there are three versions of the 8-bit version, 32-bit version and 64-bit version, in this research use 8-bit version, which in the ImageJ software contains sub-files that we can select as needed. ImageJ Software can we upgrade the latest version by opening ImageJ then clicking Help> Update or by opening link <http://rsb.info.nih.gov/ij/upgrade/>.

Porosity is important physical nature to declare the characteristic of the texture and the of material quality (Cui, Huang, & Liu, 2017). Porosity is an empty space between material and the small part of the empty volume space within the total volume. The value of porosity defined the amount of fluid contained in the material which is very important to making paper. By means of mathematics, porosity is a comparison between the volume pores percentage and the total material volume as present in equation:

$$\Phi = \frac{V_p}{V_{tot}} \times 100$$

where Φ is porosity, V_p is volume pore, and V_{tot} is volume total.

METHOD

The methodology is conducted by observing the pores of paper under the light of the microscope, various paper was filter sed in this work are HVS paper , tissue and filter paper. The paper to be observed will be cut into several thin sheets before doing the observations from the microscope. The results of the analog images observed on the microscope are converted into digital images to be analyzed using ImageJ. ImageJ program will be used to measure porosity or extent image of air cavities for various types of paper used. The process of image processing can be seen in Figure 2. The

first step was done with the scale of the image of the arrangement, to adjust the scale of the image of the scale with basically implemented by clicking on straight; and draw, a line in accordance with long image pictures the scale that we want to know. Analyze; set scale, to see how pixels that reads within a range of 1 mm.

The next step is the stage of image clarification. The stage of image clarification is done with the purpose of getting a black white image (binary) (Collins, 2007). This process will get through several stages: first set the limit of the analysed image beforehand (find edge) (Haeri, 2015). Then, sharpen the image of the process of thresholds, change into 8 bits, binary. The purpose of this process was to achieve the level of firm overcast on image observation. The surface analysis is made out of the image-ry result (Grove & Jerram, 2011).

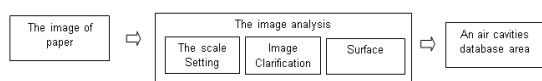


Figure 2. The calculation image of paper

RESULT AND DISCUSSION

From the image of arrangement of scales obtained the value of size pixels, 14100.0000 pixels /mm. This scale is obtained by analyzing a line image that has been known to measure along 0.14 mm. By converting the length of the line image still in mm by the number of pixels read in the digital image that has been enlarged 100 times, get the value of the scale. This scale will be used to analyze all images of 100 times the magnification of the light microscope. Process analysis of the image of the pores of the paper is done in stages which can be seen in below.

Stage of paper image clarification

The original image of the paper before being analyzed.

Figure 3, is an original image filter paper C of true paper pores and wood fibers, which have not been analyzed by image processing

The image clarification

This step is done by changing the image to binary (binary or automatic threshold) with a view at figure 4 to clarify the paper image to be measured.

Figure 4, shows an image filter paper C with an 8 bit brightness level to start analyzing. The next step is to clarify the holes measured.

Process binary fill holes what needed to be done in Figure 5.

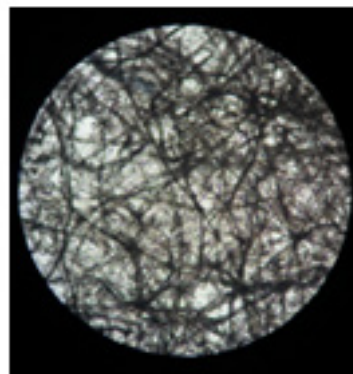


Figure 3. Original image filter paper C

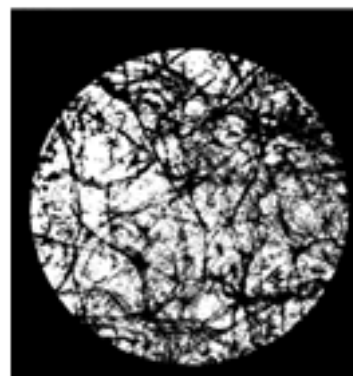


Figure 4. Binary Image filter paper C

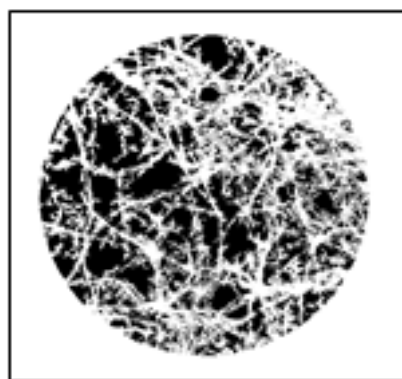


Figure 5. Binary image fill holes filter paper C

The next step is watershed used to clarify the limit to be measured, so it forms segmentation. Binary image had watershed what needed to be is. The result in Figure 6.

Analysis image

The next stage is the analysis in Figure 6. Figure 7 is the magnification of some of the image area of Figure 6 to further clarify the ob-

servation

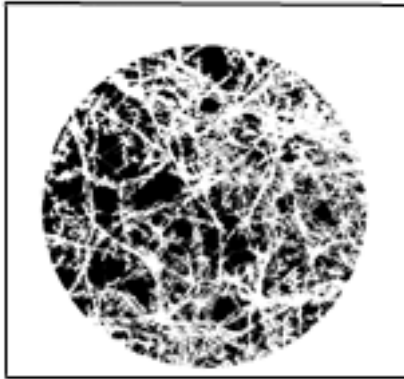


Figure 6. Image filter paper C after watershed step

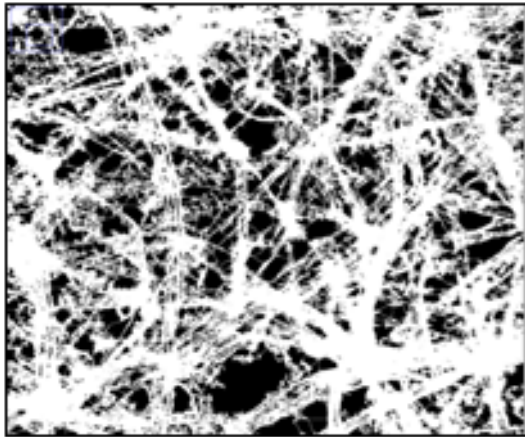


Figure 7. Before image analysis filter paper C

Using the scaling that have created, it is 14100.0000 pixels / mm and calculates the number of pixels contained in each black image. The resulting image as in figure 8

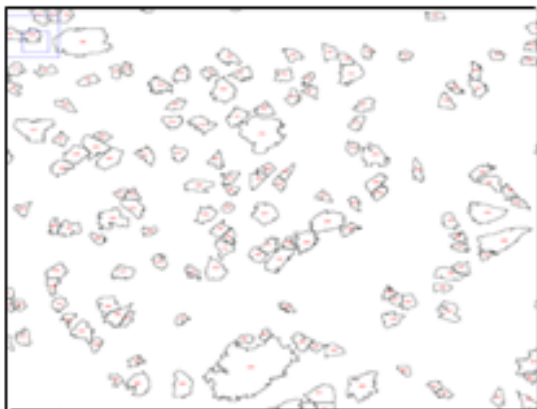


Figure 8. After image analysis filter paper C

From Figure 8 it is seen that each cavity

has been identified by numbering. To see more clearly Figure 8, will be magnification 75% and give the result like figure 9 and figure 10.

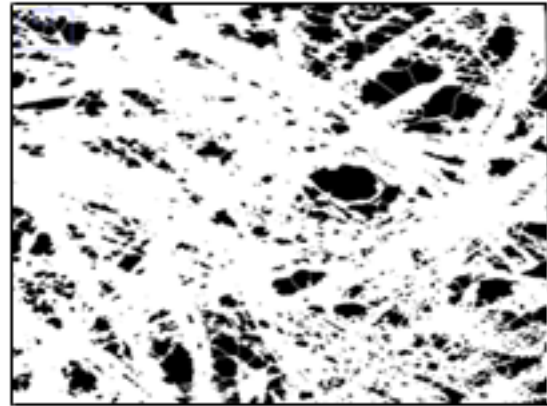


Figure 9. Before image analysis filter paper C

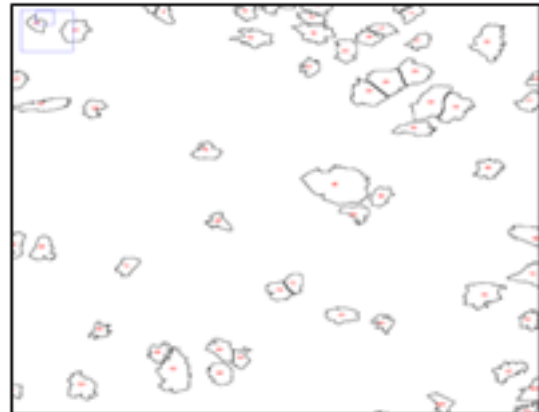


Figure 10. After image analysis filter paper C

The image area is read in Figure 10. Table 2 is a table of each piece of image analysis results in each piece of paper.

The area of the paper pores is the area of the air cavity on the paper. While the wide area is the whole area of the image observed both the pores of paper and wood fiber. Thick paper each piece was measured using a micrometer. By multiplying the area of the air cavity with the thickness of the paper then get the volume of each piece of paper cavity. By multiplying the area of image of both fiber and cavity with the thickness of paper, then get the total volume of paper cut. The total volume of cavities of each paper type can be calculated by summing the volume of each piece of paper. The total volume of paper both cavities and fibers is calculated by summing the cavity and paper volumes of each piece for the same type. So get the volume of paper cavity and total paper volume

as Table 3. The results of the analysis porosity image on obtained value as Table 3, of various sample.

Table 2. The Total Volume of Hole

Paper	Pore Area V _p (mm ²)	Total Area V _{tot} (mm ²)	Thick (mm)
Filter Paper A			
Slice 1	0.008	0.133	0.03
slice 2	0.017		0.01
slice 3	0.019		0.01
slice 4	0.019		0.02
slice 5	0.022		0.005
slice 6	0.027		0.005
slice 7	0.011		0.04
slice 8	0.01		0.03
Filter Paper B			
Slice 1	0.02	0.086	0.005
slice 2	0.019		0.005
slice 3	0.019		0.005
slice 4	0.015		0.005
slice 5	0.006		0.005
slice 6	0.007		0.05
Filter Paper C			
Slice 1	0.013	0.136	0.005
slice 2	0.025		0.005
slice 3	0.014		0.005
slice 4	0.012		0.01
slice 5	0.014		0.005
slice 6	0.027		0.005
slice 7	0.022		0.005
slice 8	0.009		0.03
Filter Paper D			
Slice 1	0.02	0.201	0.015
slice 2	0.026		0.005
slice 3	0.031		0.005
slice 4	0.024		0.005
slice 5	0.017		0.005
slice 6	0.025		0.016
slice 7	0.023		0.005
slice 8	0.027		0.005
slice 9	0.008		0.06
Tissue A			
Slice 1	0.007	0.007	0.06
Tissue B			

Slice 1	0.016	0.016	0.01
Tissue C			
Slice 1	0.025	0.025	0.015
HVS A			
Slice 1	0.005	0.066	0.045
slice 2	0.01		0.02
slice 3	0.017		0.01
slice 4	0.024		0.02
slice 5	0.01		0.02
HVS B			
Slice 1	0.008	0.034	0.03
slice 2	0.006		0.04
slice 3	0.012		0.005
slice 4	0.008		0.025

Table 3. The porosity for different types of paper

Paper Type	The Total Volume Of the Hole (mm ³)	Volume Total (mm ³)	Porosity (%)
Filter Paper			
Filter A	0.001965	0.003815	51.50586
Filter B	0.000745	0.004069	18.30719
Filter C	0.000965	0.004451	21.68076
Filter D	0.001920	0.006460	29.72028
Paper Tissue			
Tissue A	0,000420	0,004578	9.174071
Tissue B	0,000160	0,000763	20.96931
Tissue C	0,000375	0,001145	32.76454
Paper HVS			
HVS A	0.001275	0.005468	23.31616
HVS B	0.000740	0.002671	27.70944

Table 3 presents the results of porosity for the same type paper that has a different porosity. If we want to use a kind of paper with a good absorbent ability, filter paper a the other, paper is tissue C better than is the best amongst paper tissue A and B, and HVS paper B is better than HVS paper A. It's just that in the conducted research, for the type of paper tissue the pores not are being seen per slice (the thin part again) but seen as an intact unity under the light of the mikroskop because of the nature of the tissue it self is indeed very thin and hard to split into thinner parts.

The nature of porosity material affected each other and being affected by another fisis

and the nature of termal. For example porous material which has low density, larger surface area, low heat conductivity and forth. Porosity comes because the pores are open, closed and the space between particles. In addition, there are the relationship between the material density and porosity (Li, Goldstei, & Franseen, 2017). The bigger the density, the smaller the material porosity. The bigger the density means having large density. The rapid the material, the less the pores within the material. Because of that, it is concluded that the connection between density and porosity is the reverse (Cui, Huang, & Liu, 2017).

It can be concluded that the filter papers absorption $A > \text{filter paper D} > \text{filter paper C} > \text{filter paper B}$. For the tissue paper absorption $\text{tissue paper C} > \text{tissue paper B} > \text{tissue paper A}$. Absorption HVS paper $B > \text{HVS A}$. General conclusions that can be giving a result on research, the higher the porosity value of the paper the greater the ability to absorb fluid on paper.

CONCLUSION

The author has done research on porosity calculation of various types of paper, the results of research is the higher the porosity value of the paper the greater the ability to absorb fluid on paper, it means paper had large air cavities and has more fluid than other types of paper, but have the lowest density.

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INFLUENCE OF PROBLEM BASED LEARNING MODEL ON STUDENT CREATIVE THINKING ON ELASTICITY TOPICS A MATERIAL

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ABSTRACT

The phenomenon in the classroom where teachers are still limited space to train and to improve students' creative thinking skills (CTS) on the topic of material elasticity is the main reason for this research. Information on improving students' creative thinking skills in material elasticity topics by implementing problem based learning model (PBL) in learning is also limited. Previous research has not revealed any effort related to improving students' creative thinking skills on material elasticity topics by comparing two different learning models. Therefore this study aims to reveal differences in student learning outcomes on material elasticity materials in PBL and conventional models. Based on the research results obtained information that students' creative thinking skills scores using PBL model is higher compared with that of conventional learning. It also revealed at each meeting that the CTS indicator of students are always improve. It can be concluded that PBL is very effective in training and improving students' creative thinking skill in physics learning. Thus PBL can be recommended in improving students' creative thinking skills.

ABSTRAK

Fenomena yang terjadi di lapangan dimana guru masih terbatas ruang geraknya untuk melatih dan meningkatkan keterampilan berpikir kreatif siswa pada topik elastisitas suatu bahan menjadi alasan utama penelitian ini dilakukan. Sampai sejauh ini informasi tentang peningkatan keterampilan berpikir kreatif siswa pada topik elastisitas suatu bahan dengan model problem based learning masih terbatas. Penelitian terdahulu belum ada yang mengungkap upaya terkait peningkatan keterampilan berpikir kreatif (KBK) siswa pada topik elastisitas suatu bahan dengan membandingkan dua model pembelajaran. Oleh karena itu penelitian ini bertujuan mengungkap perbedaan hasil belajar siswa pada materi elastisitas suatu bahan dengan model PBL dan Konvensional. Berdasarkan hasil penelitian diperoleh informasi bahwa keterampilan berpikir kreatif siswa pada pembelajaran dengan model PBL lebih tinggi bila dibandingkan dengan keterampilan berpikir kreatif dengan pembelajaran konvensional. Terungkap pula pada setiap pertemuan indikator KBK siswa selalu meningkat. Dapat disimpulkan bahwa PBL sangat efektif dalam melatih dan meningkatkan KBK siswa dalam pembelajaran fisika. Dengan demikian PBL dapat direkomendasikan dalam meningkatkan KBK fisika siswa.

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Keywords: Creative thinking skills; Elasticity; PBL

INTRODUCTION

The 21st century learning program has launched significant changes in learning methods by involving students in every learning activity (Tindowen, Bassig, & Cagebas, 2017).

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To create a sophisticated learning the teacher should be able to act as a facilitator who gives the greatest opportunity to the students to express themselves in the learning process (Kim, Lee, Youn, Eom, & Lee, 2015; Eom, Youn, Kim, 2016). Dynamic learning will provide wider space for students to explore and train their skills. Skills which developed through dynamic

learning are skills related to ideas managed by memory and are poured in the form of quality products (Plucker, Beghetto, & Dow, 2004).

Over the past few centuries, the role and excellence of creativity in education has transformed the United States into a developed country. Some scientists argue that the idea of creativity since the 1960s that is so prominent in the field of education has prompted the USA education system to experience a very big revolution (Feldman & Benjamin, 2006). This proves that creative ideas have the opportunity to build a better education system. Creativity and learning skills, described as something that must be nurtured continuously (Wegerif & Dawes, 2004). In a study of technology-based learning and creativity, it shows that creativity thinking enables one to produce high-quality work and provides more creative opportunities (Loveless, 2002).

Finland as one of the best educational systems in the world, its people greatly appreciate the role of creativity and education that can transform education into higher quality for the future (Fullan, 2009). The same fact also happened in England, China, and the Republic of Kazakhstan who realized the importance of educating creative individuals in building a nation. This confirms that the developed nation from all aspects of life comes from creative people (Cox 2005; Tischler 2006; Massyrova, Sandibayeva, Kaptagai, Kopenbayeva, & Aidarbekova, 2015).

Students are the golden generation that will greatly color the order of life of previous generations. Therefore cultivation of the value of the importance of mastering the learning skills to the students greatly determines the expected gold generation profile (Chuvgunova & Kostromina, 2017). The role of teachers is necessary in fostering students' creative thinking skills. It requires enough time and effort to plan, design, implement, and evaluate learning activities (Hancer, 2013). Creative ideas can be implemented both anytime and anywhere. But, the learning process, creative thinking skills are expected to appear in students better (Ramanukulov, Usebayeva, Berdia, Omarova, Baikukhanbetova, Shektibayeva, 2016).

Creativity is shaped by the human cognitive ability to solve problems and produce new products that are rarely thought of by others (Boltz, Henriksen, Mishra, Henriksen, 2014; Hamza & Hassan, 2015). Often people think that creativity only belongs to an architect or genius. This is not entirely true. Creativity is al-

ready owned by everyone since birth. Therefore everyone has the potential to be developed creativity (Trilling & Fadel, 2009). Physics is the lesson that trains Creative Thinking Skills (CTS) students (Dambueva, 2014). Another view also suggests that CTS can improve problem-solving skills, train cognitive abilities, and students' emotional intelligence (Clinton & Hokanson, 2011; Forgeard & Eichner, 2014).

Research of collaborative learning using PBL model to improve creative thinking skill for material elasticity material is still few. Similar research examines different content, eg physics science learning (Rahayu, Susanto, & Yuliati, 2011; Panjaitan, Nur & Jatmiko, 2015) and water purification (Rev., 2016). Learning 21st century is expected to improve students' creative thinking skills and no longer use anonymous learning, but using models that can improve student CTS. One of the learning models that facilitate students to improve their CTS is the PBL model (Ersoy & Baser, 2014). In addition PBL helps students in achieving educational goals, in problem solving, peer-to-peer collaboration, and lifelong learning (Tan, 2009).

In the recent era, the most fundamental goal of physics learning is to educate individuals who can conduct research, investigate, and build correlations between physics concept by using existing environments. Physical learning is a scientific method for having problem-solving skills and having an attitude toward life from a scientist's point of view. The quality of learning in Indonesia is still low due to teachers teaching style in using traditional learning-based models and tends to be less empowering the existing environment to improve student learning outcomes (Dwijananti & Yuliati, 2010).

The syntax of PBL learning has been widely studied by educational experts. One of them is proposed by Arends (2012) as in Table 1. The learning process using the PBL model invites students to become a creative scientist in solving problems. This is marked by the problems that students and teachers can emerge; then through the process of discussion students can deepen their knowledge of what they know; and learn the steps to solve the problem; working in groups and helping each other so that they can collaborate in solving problems (Setyorini, Sukiswo, & Subali, 2011). Through the PBL learning model with heterogeneous group members; allows students to exchange ideas; work together to solve problems; and express their ideas; which ultimately can improve students'

creative thinking ability (Meissner, 2006).

Thus, this study aims to reveal differences in students' creative thinking skills on the topic of elasticity of a material with PBL and conventional models based on lectures.

METHODS

This study is a quasi-experimental study. The populations in this study are students of class X Science. The samples in this study were 77 students, those who were determined randomly. The sample of the study was selected from one of the high school schools in Malang which has status as a moderate level school. Classes used in this research are experimental class ($n = 38$) and control class ($n = 39$). The topics presented are elastic and non-elastic, the concept of stress and strain, Young's modulus, Hooke's law, and parallel series spring arrangement.

The research instrument used is a CTS test question in the form of a description of 15 items. The developed instrument has been

validated by theoretical physics and physics education experts from the State University of Malang. The instrument was developed based on four indicators of creative thinking skills, namely indicators of fluency, flexibility, originality, and elaboration (Munandar, 2002). The CTS instrument has been empirically tested, so that information about validation and reliability are 0.72 and 0.94 respectively. The rubric used to assess students' answers refers to Hart's scale (1994) with guidelines on the rubric of creative thinking skills developed. On that scale there are five categories, they are, if the students answer three aspects of the answer or more given a score of four, if the students answer two aspects of the answer given a score of three, if students answer one aspect of the answer given a score of two, if the student tried to answer but wrong answer given score one, and no answer at all given a score of zero.

The data of the research were analyzed by ancova test to reveal the difference of students' creative thinking skill in control class and experiment class. The first step before the data

Table 1. Syntax of Problem Based Learning Model (PBL) According to Arends (2012)

Steps (Phase)	Teacher Activities	Students Activities
Phase 1 Orientation of students to problems and hypotheses	<ul style="list-style-type: none"> ▪ Teacher delivers learning objectives and organizes students in questioning and problem-solving activities. ▪ Teacher invites the students to hypothesize the problem. 	<ul style="list-style-type: none"> ▪ Students listen to the teacher's explanation of the issues discussed and observe the phenomenon presented. ▪ Students develop hypotheses on the given problem.
Phase 2 Organize students to learn	<ul style="list-style-type: none"> ▪ Teacher forms groups of students consisting of 5 students in one group. 	<ul style="list-style-type: none"> ▪ Students are grouped according to teacher's instructions.
Phase 3 Guiding individual and group investigations	<ul style="list-style-type: none"> ▪ Teacher guides students in conducting experiments. 	<ul style="list-style-type: none"> ▪ Students conduct experiments, observe, and analyze experimental results.
Phase 4 Develop and present the work	<ul style="list-style-type: none"> ▪ Teacher assists students in completing reports on student worksheets. ▪ Teacher chooses group representatives to present their work to other groups to develop the results of the investigation. 	<ul style="list-style-type: none"> ▪ Students conduct group discussions in analyzing observation data and presenting the work. ▪ Students communicate the results of their experiments and conduct class discussions by commenting on the results of other groups' investigations.
Phase 5 Analyze and evaluate the problem-solving process	<ul style="list-style-type: none"> ▪ Teacher helps students to reflect on their inquiry process. ▪ The teacher guides the student toward the correct solution of the problem in accordance with theoretical physics. ▪ Teachers strengthen the learning materials related to the problem. ▪ Teacher gives a quiz. 	<ul style="list-style-type: none"> ▪ Students analyze experimental results and conduct class discussions to conclude experimental results. ▪ Students improve their problem solving solutions that are not yet compatible with theoretical physics. ▪ Students pay attention to teacher strengthening. ▪ Students associate their understanding gained during learning into quiz answers.

analysis is the prerequisite tests, the normality and homogeneity test. The results of both prerequisite tests indicate that the distribution of data in the control and experimental groups are normal and homogeneous.

RESULTS AND DISCUSSION

This research is aimed to know the difference of creative thinking skills between students who experience PBL based learning and those who conventionally taught. The prerequisite test has been met, so to obtain the information can be done by hypothesis test using single ancova statistical test as shown in Table 2.

Table 2. Results of single ancova statistical test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6267.32 ^a	2	3133.66	42.74	.000
Intercept	37140.41	1	37140.41	506.61	.000
XCreative Model	59.86	1	59.86	.82	.369
Error	6253.66	1	6253.66	85.30	.000
Total	5425.03	74	73.31		
Corrected Total	385036.11	77			
	11692.35	76			

a. R Squared = .536 (Adjusted R Squared = .523)

Table 2 shows the significance of learning model (0.000) less than alpha (0.05) which means there are differences in creative thinking skills based on PBL and conventional learning model. Information on different learning models of significance between the two models is shown by the LSD test. The LSD test is a further test to determine the magnitude of the difference in creativity between PBL and conventional learning models as presented in Table 3. The LSD test results inform the difference in average students' creative thinking skills. In PBL learning, CTS scores of the students are higher than students who experience conven-

tional learning. Associated with the percentage of CTS improvement, it was revealed that students' creative thinking skills in the classroom with PBL learning increased compared with students in the conventional learning class.

The research data shows more clearly that there are differences in CTS scores between PBL classes and conventional classes. The PBL model can facilitate students to improve students' creative thinking skills in the field of physics and improve learning (Dariyo, 2003). Figure 1 below shows an increase in CTS scores on each indicator at each meeting. In the learning process appears to be an increase in CTS score indicating that students are able to be at a very creative level.

The positive shift towards learning outcomes related to CTS scores is a thought of the formation of creative generation that has the potential to solve complex social and environmental problems (Yusnaeni, Corebima, Susilo, Zubaidah, 2017). Hotaman (2008) also revealed that CTS is the ability to make connections between concepts previously created and generate new and original thinking experiences as new patterns.

The shift of CTS based on the results gives an idea that students are beginning to change their thinking patterns better. If this continuous effort is maintained then the individual will experience a tremendous change. Creative people are very influential on the progress of a country. The advanced country depends heavily on creative people. In relation to the learning process and if this habit pattern is maintained optimally, the government will benefit from the success of education that students' thinking is already at a higher level. The results of the study (Khanafiyah & Rusilowati, 2010) reported that student CTS only at creative level were 78.3%, creative 20% and 1.7% very creative. All achievements of depend on the teacher in training students with creative thinking.

The phase in the PBL that can improve the CTS students is in the phase where students do orientation activities on the problem and create a hypothesis. In this phase students are given problems related to the phenomenon in everyday life. Teacher shows several videos related to the elasticity of a material for exam-

Table 3. LSD Test Results Differences in Students CTS Scores Based on Learning Model

Model	X-CTS	Y-CTS	df	Creative Corr.	Notation
PBL	26.32	78.73	52.41	78.78	a
Conventional	27.27	60.63	33.37	60.73	b

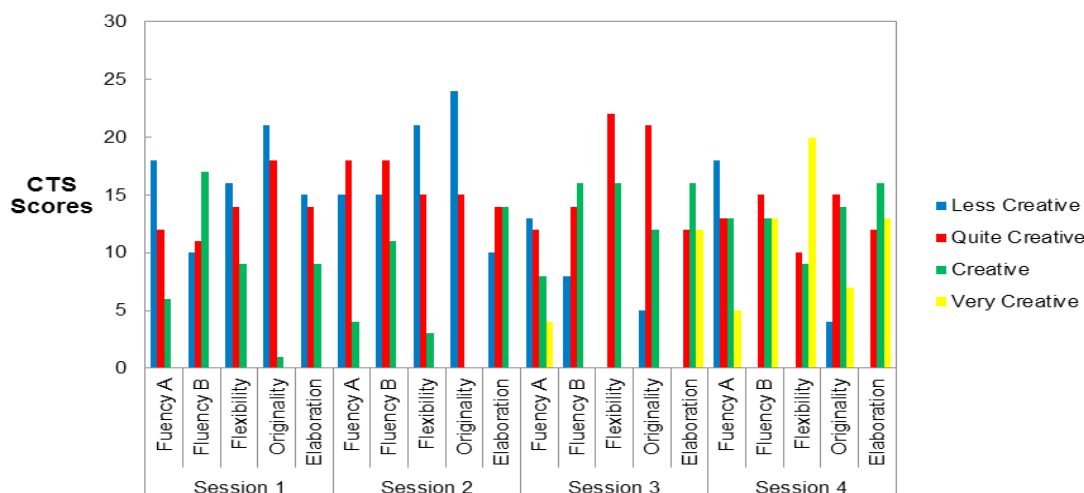


Figure 1. Improvement of CTS Scores on Each Indicators at Each Session

le in the sub topic of elastic and plastic subjects. One of the videos that aired was a high lump athlete who would make a jump using a pole to cross the ruler with a height of 4.5 m, as shown in Figure 2.



Figure 2. An athlete who is trying to get past the ruler with a height of 4.5 m using pole support.

Based on the video story, the teacher asks the students with the following questions “express your opinion about what opportunities that allow an athlete to cross the ruler”. The answer of student S1: “1) the stick used by the athlete is made of elastic material, thus allowing the athlete to pass the ruler, 2) the force given is large enough due to mass influence and instantaneous/impulse speed, 3) the position of the athlete’s grip on end of the pole so as to provide a high enough leap, 3) running speed is arranged in such a way that it can help make the jump and 5) the precision of the athlete. In this case the aspect shown by the students is on the fluency indicator. The questions given can train the students’ CTS, so students will use all their skills to answer questions from the teacher.

Currently, PBL model is among the methods that provide universal benefits such as determining problems, investigating the causes, hypothesizing, testing hypotheses, obtaining information, and setting learning targets, developing problem-solving skills, and using information obtained from real life (Chin & Chian, 2004). In addition, the PBL model has many benefits such as student-centered learning; helps students to develop mindsets from different perspectives; conducting more in-depth, active, and meaningful learning; as well as improving the ability to think creatively and think critically of students (Alrahlah, 2016).

Phase of analyzing and evaluating problem-solving process. In this phase the teacher re-do reflection on the learning that has been done. The teacher displays a video about the events in everyday life as shown in Figure 3. From the case presented the teacher gives a question to the students. “In everyday life you may have experienced or seen cases of accidents like this and the result is death or disability. My question is “how to design your helmet so that when a collision happens, you will be safe” (Indicator Originality).

As for the student S25 answer “1) make an anti-concussion helmet where the structure in the helmet is equipped with elastic material such as thick sponge so that at the time of collision with hard objects such as road or other vehicle elastic material or sponge can protect the head, 2). Vibration distribution tools throughout the body, 3). The helmet is equipped with a thick Styrofoam as an elastic material to protect the head during impact. Based on existing information, this phenomenon can train students’ CTS.



Figure 3. Views of Traffic Accidents

In the phase of analyzing and evaluating the problem-solving process, students are given questions related to the learning that has been implemented. To find out the progress of the students, the teacher evaluates by giving different questions but in the studied topics of stress, strain, and Young module. The teacher questions as follows. Consider the following video, our brothers in one of the villages in East Kalimantan have to struggle through a bridge made of rope. If there are a lot of students passing through this rope, then most likely what happens is the rope will become tense and broken so they will fall into the river. If you as the head of the village with such a minimal budget explain what things you can do so that the bridge strap does not tighten and break.



Figure 4. A number of students struggling across the river with a bridge made of rope

The answer of the student S23 “1) the thing that can be done is replacing the existing rope with a large diameter steel wire. Thus, the steel wire balances the mass of passersby, 2) replacing it with a larger diameter rope, 3) limiting the number of passersby thereby reducing the load of the rope to strain, 3) assisted with the support and placed in the center, and 4) create a simple bridge made of bamboo.

Another phase that could potentially improve students’ CTS is guiding individual and group investigations. Questions given on the student worksheet will answer the questions in

accordance with the instructions on the worksheet. The problem is as follows. “Consider some of the pictures below, first the rubber in the initial state when given the style then the rubber will change shape, after the force is removed then the rubber will return to its original state as shown in Figure (a). Give a detailed explanation of the events in the picture.”

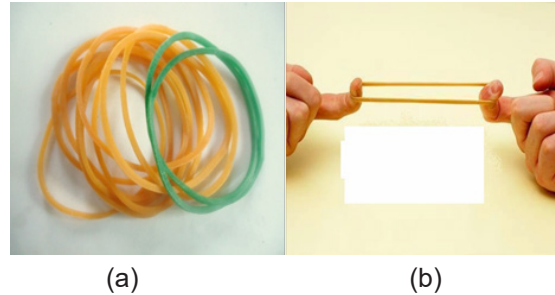


Figure 5. Elasticity of Hair Rubber

As for the answer of student S30 “1) on the phenomenon of picture A, it is seen that the rubber is still in normal condition, it corresponds to Newton’s legal theorem which states that if an object does not give the force then it will remain in normal condition 2) there is a change in the shape of rubber, this is because there is a force effect given to the rubber so that the rubber undergoes a shape change (elongated) and if the tensile force is removed then the rubber will return to its original shape is the nature of perfect elasticity. 3) based on Hooke’s legal view, if the tensile force does not exceed the elasticity limit of the rubber, the increment of rubber length is directly proportional to its tensile strength.

CONCLUSION

Based on the discussion, it can be concluded that by applying the PBL model students’ creative thinking skills on the topic of elasticity of a material can be improve. Learning using the PBL model has a great opportunity to improve students CTS better than that of conventional learning. Thus PBL can be recommended in improving students CTS in physics learning.

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THE USE OF NUMBERED HEADS TOGETHER (NHT) LEARNING MODEL WITH SCIENCE, ENVIRONMENT, TECHNOLOGY, SOCIETY (SETS) APPROACH TO IMPROVE STUDENT LEARNING MOTIVATION OF SENIOR HIGH SCHOOL

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ABSTRACT

This research was aimed to determine the increasing of students' motivation that has been applied by Numbered Heads Together (NHT) learning model with Science, Environment, Technology, Society (SETS) approach. The design of this study was quasi experiment with One Group Pretest-Posttest Design. The data of students' learning motivation obtained through questionnaire administered before and after NHT learning model with SETS approach. In this research, the indicators of learning-motivation were facing tasks diligently, showing interest in variety of problems, preferring to work independently, keeping students' opinions, and feeling happy to find and solve problems. Increasing of the students' learning motivation was analyzed by using a gain test. The results showed that applying NHT learning model with SETS approach could increase the students' learning motivation in medium categories.

ABSTRAK

Penelitian ini bertujuan untuk mengetahui peningkatan motivasi belajar siswa setelah diterapkan model pembelajaran Numbered Heads Together (NHT) dengan pendekatan Science, Environment, Technology, Society (SETS). Desain penelitian ini adalah kuasi eksperimen dengan One Group Pretest-Posttest Design. Data motivasi belajar siswa didapatkan melalui angket yang diberikan sebelum dan sesudah dilaksanakannya pembelajaran NHT dengan pendekatan SETS. Dalam penelitian ini, indikator motivasi belajar yaitu tekun menghadapi tugas, menunjukkan minat terhadap bermacam-macam masalah, lebih senang bekerja mandiri, dapat mempertahankan pendapatnya, serta senang mencari dan memecahkan masalah. Peningkatan motivasi belajar siswa dianalisis menggunakan uji gain. Hasil penelitian menunjukkan bahwa penerapan model pembelajaran NHT dengan pendekatan SETS dapat meningkatkan motivasi belajar siswa dengan katagori sedang.

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Keywords: Learning Motivation; NHT; SETS

INTRODUCTION

The result study of *Program for International Student Assessment (PISA)* in 2012, shows that Indonesia ranks 64 out of 65 countries in the field of science. It makes Indonesia far behind with other countries. It happens due

to low students' learning-motivation. The low of students' learning-motivation is supported by several studies. Among these are research conducted by Susilo (2012), which states that the problem of science learning in 01 State Junior High School at Ngadirejo, namely the lack of students' learning-motivation due to saturate and boring learning. According to Bintasari & Supardi (2012), some of the problems that exist in physics learning in Grade 8th at 08 Sta-

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te Junior High School in Kediri, that are more dominant teacher's activity which resulted in students quickly get bored and saturated with lessons being faced so that it has less students' learning-motivation. According to Siregar (2012), there are two problems of physics learning in grade 8th at 18 State Junior High School in Medan. First, physics is a lesson that seems difficult, less interesting, and less fun among students. The second problem is the lack of effective use of learning models. Students' motivation need to be improved to overcome these problems. According to Sardiman (2014), in order to learn well it takes a process and a good motivation as well.

According to Uno (2011), there are several ways that can be done to improve students' learning-motivation, one of them is by using various methods in learning. According Trianto (2013), NHT learning model is the kind of cooperative learning that is designed to affect students interaction pattern and as an alternative to the traditional classroom structure. There are four phases in NHT learning, they are numbering, asking questions, thinking together, and answering. The advantages of NHT learning model according to Lie (2010), it provides wider opportunities for learners to share ideas and considers the most appropriate problem solving, which encourages learners to improve spirit of cooperation in solving problems.

Education is not only oriented to science understanding but also understood the results of science and its effects. One approach that can be used to integrate science, the results of science and its impact is SETS approach. According to Binadja (1999), SETS approach is aimed at helping learners to know about science, its development and how science can affect the environment, technology, and society on a reciprocal basis. The research result showed that learning with SETS approach has several advantages. According to Sukaisih (2013), the application of STSE (Science, Technology, Society and Environment) approach in electric circuit learning, ohms law, and barriers can improve students' learning activities and outcomes. According to Ifadloh, Santosa & Supardi (2012), discussion method with SETS approach and media question card can give positive response for most students such as; it gives interesting and fun learning, it increases their curiosity, it can improve the ability to remember a lesson concept, student gets more active in learning, makes student not bored, and motivates student to learn more diligently.

In this study, the principal selected subjects are Work and Energy. In this subject, the concept of Work and Energy is associated with its application and impact in the environment, technology and society.

The NHT learning model with SETS approach is a lesson that connects the concept of science learned with other elements in SETS, and it is conducted in a discussion according to NHT learning steps. Lie (2010) explains that in cooperative learning, students who have high academic ability can help their friends who have low academic ability. This will give impact to the students to be more motivated and study more hard, so NHT learning model which is a cooperative learning and accompanied by SETS approach is expected to improve students' learning-motivation.

The purpose of this study is to determine the improvement of students' learning-motivation after applied NHT learning model with SETS approach .

METHOD

The design of this study was quasi experiment with *One Group Pretest-Posttest Design*. In this study, first of all, experimental groups were given an early test, then they were given treatment using NHT learning model with SETS approach, and then did the final test.

The population of this study were students of grade 8th Junior High School. Sampling is done by *purposive sampling technique* or sample determination with certain consideration. Samples taken were students of grade 8th 02 State Junior High School of Kawunganten, Cilacap Regency. The consideration of this sample determination is a condition that is generally the same in students grade 8th, which has lack of students' learning motivation.

Technique of taking data in this research used non test and test method. Non test method used was questionnaire. Questionnaire was used to obtain students' motivation score. In this study, learning-motivation indicators are facing tasks diligently, showing interest in various problems, preferring to work independently, keeping students' opinions, and students are happy to seek and solve problems (Sardiman, 2014). Questionnaire test conducted to determine the validity and reliability and to determine the scale value of each statement in the questionnaire. The test method used was a written test to obtain student cognitive learning outcomes. Questionnaires and tests

were given before (*pretest*) and after (*posttest*) treatment. Increasing students' motivation and cognitive learning result were analyzed using a gain test. The normal gain formula for improving the average motivation and students' learning result can be calculated through the following equation:

$$g = \frac{\langle S_{post} \rangle - \langle S_{pre} \rangle}{100\% \langle S_{pre} \rangle}$$

Notes:

$\langle S_{pre} \rangle$: Pretest average score of students motivation or learning result (%)

$\langle S_{post} \rangle$: Posttest average score of students motivation or learning result (%)

Criteria value gain as follows:

High if $g > 0.7$

Medium if $0.3 \leq g \leq 0.7$

Low if $g < 0.3$

RESULTS AND DISCUSSION

The stages of NHT learning model with SETS approach in this study consist of four phases. The first phase took place before the day of learning which is the phase of numbering and asking questions. In numbering phase, students divided into groups of three to five students and were numbered on each member of the group. In the phase of asking questions, teacher shared learning materials and Student Discussion Sheet (SDS) then students were assigned to read learning materials and worked on LDS independently. It is intended to train students in self-employment, facing tasks diligently, as well as finding and solving problems. The learning materials given contained concepts and materials related to SETS. One of the tasks in the SDS, students must look for an article that contained the impacts that occurred on the environment or community related to the material being studied.

The second phase took place in learning process, which consist of asking questions, thinking together, and answering questions. In

questioning phase, teacher asked questions or problems to students about the material to be studied. The question posed is the same as the questions in SDS. This step aimed to encourage students' interest in a variety of problems. In the phase of mutual thinking, students answered questions asked by the teacher by discussing in group and guided by learning materials. This phase aimed to train students finding and solving problems, and keeping their opinions. In answering phase, teacher called certain number at random by drawing. Some of the appropriate students raised their hands and answered questions. Next, the teacher guided class discussions to discuss students' answers and determine the correct answers.

The third phase was guiding students to draw conclusions with class discussions. Class discussion aimed to train students in keeping their opinions, as well as finding and solving problems.

Improving Student Motivation

Based on analysis results of *pretest* and *posttest* score about students' learning-motivation questionnaire, it obtained increasing of students' learning-motivation as listed in Table 1.

Based on Table 1, increasing of students' motivation can be seen in each of the indicators. The first indicator is facing the task diligently. Students' persistence facing tasks trained because students have to do independent tasks before the lesson start. Tasks that have been done independently are discussed during the lesson. This process will grow students' diligence in dealing with the task because the students not only once do the task but also must ensure the answer in group discussions. According Oktavianti (2013), one of advantages giving task is to train students study hard and diligently.

The second indicator is pointing interest in various issues. The second phase in this learning model is the teacher asks questions or problems to students about the material to

Table 1. Increasing of students' learning-motivation

Indicator	<i>Pretest</i> Score (%)	<i>Posttest</i> Score (%)	<g>	Criteria
Facing the task diligently	55.5	75.9	0.46	Medium
Showing interest in various issues	47.3	80.1	0.62	Medium
Keeping opinion	46.6	70.4	0.45	Medium
Preferably working independently	44.6	67.0	0.40	Medium
Finding and solving problems happily	44.7	74.7	0.54	Medium
Class Average	48.5	74.2	0.50	Medium

be studied. This is one way to encourage student interest in variety of issues. According to Slameto (2010), one way to motivate students is growing students' curiosity and desire to conduct exploration, by asking questions or problems that stimulate students to work.

The third indicator is students can keep their opinion. In this learning model, most of the learning process carried out by the discussions, both group and class discussions. In the discussion established communication among students in form of giving opinions, questions, suggestions, or arguments so that students are trained to keep their opinions. According to Rahman (2007), discussions can train students' ability to issue opinions about a problem, defend opinions, and make adjustments of others opinion based on good exchange of thoughts.

The fourth indicator is to prefer working independently. In the first phase of this learning model application, students are given learning materials and tasks in the form of SDS before the school day begins. Students are assigned to read the learning materials and do the tasks independently. Giving tasks and learning materials is important to train students working independently. According to Danial, Rahel & Dini (2013), the advantage of giving homework is more stimulating students in conducting individual or group learning activities, growing student responsibility and discipline, and developing student independence outside of teacher supervision.

The fifth indicator is to find and solve problems happily. In this learning model, students have to do the task in the form of SDS independently. In the classroom, students' answers are discussed with the group so that they get correct conclusion of the answer. When looking for a conclusion of the answer, there will be new problems again, that is when there is difference of answers between each student. After the discussion finished, some random students should present results of discussion in front of the class. It is used to encourage students so that they really understand the results of discussion that have been discussed. The whole process will train students finding and solving problems. According Hertiavi, Langlang & Khanafiyah (2010), giving questions before the learning in form of tasks, group discussions, and tests is an attempt to improve students' problem solving skills.

According to Binadja (1999), one of SETS approach characteristics is students

are taken to consider the benefits or disadvantages of applying science concepts in life. One of the tasks given before learning is students should look for articles from the Internet about the impacts of science learned on the environment and society then they presented in front of the class. This will increase students' insight more broadly about the material being studied, its application, benefits or disadvantages that occur in the environment and society so that it will motivate students to learn. According to Hotimah (2008), integrated science learning with SETS approach can make students more interested in science materials. Giving learning materials prepared using materials with SETS approach is one important factor to motivate students to learn. Based on Trisnaningsih's research result (2011), learning implementation using learning tool with SETS visionary shows students' enthusiastic and understands learning material because it deals with many things around the environment and society.

Application of NHT learning model with SETS approach can improve students' learning-motivation. This means that NHT learning model application with SETS approach gives positive impact for students' learning-motivation. This is in accordance with Zhang T, Asher, Zhang M & Yang's opinion (2017), which states that by applying SETS approach, learning is more fun so students are motivated to learn. According Hadiyanti, Kusni & Suhito (2012), through NHT learning model, learning activity becomes more interesting so that students get spirit and motivated in teaching and learning activities.

Increasing Student Cognitive Learning Results

Based on the result of analysis on *pretest* and *posttest* score, recapitulation of students' cognitive learning result as listed in Table 2.

Table 2. Score Recapitulation of *Pretest* and *Posttest*

Results	<i>Pretest</i>	<i>Posttest</i>
The lowest score	46.25	71.25
The highest score	91.25	100
Average	68.55	90.55
Percentage of mastery	43.75%	93.75%
N Gain	0.70	
Criteria	Medium	

Student learning results have improved after applying NHT learning model with SETS approach. Providing independent tasks in form of SDS and reading learning materials before the day starts to be an important factor so that students are better prepared when the learning process takes place so that the learning outcomes can increase. This is in line with Mulyani's opinion (2013), which states that readiness is an important factor in determining success in learning. Students who are ready to learn then the learning achievement will be better. In addition, giving task to read learning materials and to work on SDS can increase independence, so that students better understand the material being studied. This is in accordance with Pratiwi, Budiyo & Subanti's opinion (2013), which states that the higher the independence of student learning, the higher the student achievement.

The material that students learned in NHT learning model with SETS approach, is related material between elements of science and environment, technology and society, so that students can understand the material in more depth. According to Binadja (1999), teaching used SETS approach, students are asked to connect associate between SETS elements, allowing students to obtain clearer picture of interrelationships between these concepts with other elements in SETS both in form of their advantages and disadvantages.

Application of NHT learning model with SETS approach can improve student learning outcomes. This is in accordance with Destiningsih, Usodo & Mardiyana's research results (2013), which states that NHT learning model can improve student learning outcomes and student activeness in the classroom and make teaching and learning activities more fun. Zhang et al (2017) states that using SETS approach can help students understanding science more broadly and clearly. In addition, Hartikasami research results, Khanafiyah & Sutikno (2013) also states that the application of NHT learning model with SETS approach can develop creativity, increase individual responsibility and student learning outcomes.

CONCLUSION

The motivation of junior high school students increased after applied the NHT learning model with SETS approach. This can be shown from the average increasing in student learning-motivation, with a gain value of 0.50 in

medium criteria.

The cognitive learning outcomes of junior high school students were improved after NHT learning model was applied with SETS approach. This can be shown from the average increasing in student learning outcomes, with a gain value of 0.70 in medium criteria.

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