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### RESEARCH ARTICLE

#### THE EFFECTIVENESS OF TEXTBOOK DEPENDS ON BRAIN-BASED LEARNING (BBL) MATERIALS ON EXCRETORY SYSTEM TOWARD STUDENTS' HIGHER-ORDER THINKING SKILLS (HOTS) IN SENIOR HIGH SCHOOL

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#### Abstract

The implementation of effective learning materials has become a fundamental need in the process of teaching biology at school. Brain-based learning (BBL) materials in 21st-century learning need to be supplemented with analytical and evaluation skills or the so-called higher-order thinking skills (HOTS). Thus, this study aims to examine the effectiveness of the implementation of brain-based learning materials on the excretory system toward student's higher-order thinking skills. This study was a research and development which applied the 4-D model Thiagarajan by using a test to measure the effectiveness of the materials developed after being used in three meetings from four classes in different schools with a total of students 125 people. The result of this study revealed that students from four schools had good higher-order thinking skills with average scores respectively 81.8 (Class A), 80.7 (Class B), 80.4 (Class C), and 81 (Class D).

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#### Introduction:-

Biology learning is commonly planned to practice and develop students' memorizing skills, or the so-called memorization (Veselinovska, 2015). However, the highest skill of human beings compared to other creatures in this world is thinking skill (reasoning) and creativity, not memorizing. Higher-order thinking skills (HOTS) are such an ideal approach for learning which does not only strive to excel the learning materials and memorization. Learning should not only be designed to ask what, but also why or how an issue can be addressed depends on students' reasoning skills. HOTS is a concept of thinking ability that is developed depends on Bloom's taxonomy. Students must have higher thinking skills to make them able to give solutions on complex problems through critical thinking and rationale. They should also be prepared to face future challenges which may be more complex than nowadays. High school students which are generally above 15 years old have been able to accept a learning design that employs HOTS approach. According to Piaget in Aini (2017), adolescents who are above 12 years old have entered a formal operational phase which is remarked by the shift from concrete to an abstract way of thinking. The ability of abstract thinking can be seen from students' competence in discovering ideas, predict an event that will probably happen, and think scientifically i.e. finding hypotheses and a move to prove its validity.

The main purpose of 21<sup>st</sup> -Century learning is how to improve students' thinking skill to a higher level than before, particularly ones related to an ability to think critically in absorbing various information, think creatively in solving problems by using their background knowledge as well as make decisions in complex situations (Anggrainy, 2016).

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As explained by Wahidmurni (2018), HOTS will be actualized if someone could relate new information with their background knowledge. Further, they could connect or rearrange and develop the information to reach a goal or to find a solution from a difficult situation.

Today, learning materials that can create a learning atmosphere which depends on students' brain ability are needed. To date, many have ignored brain ability and how to make the brain more active and make it as a reference for learning. Complex learning is a process that better reflects the natural construction of the brain for learning (Tarwiyah, 2018). In implementing the BBL approach, several points should be noted as it will strongly affect the learning process, such as environment, movement and sport, music, games, mind-map, and teacher's performance (Indriyana, 2019). Left brain functions in a logical, sequential, linear, and rational manner. This is a highly well-organized work. Contrastly, in reality, it could interpret abstraction and symbolism. The thinking method is relevant to a sequential task such as verbal expression, writing, reading, auditorial association, locating facts and details, phonetics and symbolism (Hales, 2015). However, the right brain works in a random, irregular, intuitive, and holistic manner. The way of thinking is relevant to figuring out the non-verbal attributes such as feeling, emotion, feeling-related consciousness, spatial, shape and pattern recognition, music, art, color sensitivity, creativity, and visualization (Larsson, 2017).

During the learning process in the classroom, the left brain loads the knowledge or facts mentioned by the teacher, while the right brain observes how the knowledge is spoken. This goes the same with a situation when we are listening to music (Corballis, 2012). The left brain will analyze the lyrics of the song while the right brain will work on analyzing the melody (Corballis, 2014). Directly and indirectly, do the left and right brain actively take part in the learning processes. Thus, if an utterance or sayings is merged with music or pictures, or if an utterance is expressed emotionally, it will be easily remembered or digested (Hickok & Poeple, 2015). Learning does not only engage one part of the brain. If it happens so, an imbalance will likely happen in students' brain actualization. Faidi (2015: 29) stated that the work of only one brain will be potentially weak and weaker than two brains. Hence, teachers are strongly suggested to use a strategy that engages the left and right brains while teaching. HOTS, as stated by Halili (2015), is perceived as a skill that is essentially needed by each individual in the educational milieu. HOTS are actualized when somebody grasped new information which is further stored in a memory and is intertwined in terms of rearranging and widening the information to reach a certain goal or discover an answer from a bewildering situation (Hugerat, 2017).

In every teaching opportunity, a teacher should consider a balanced stimulus of the left and right brain (Saleh, 2011). The use of teaching media such as the HOTS-depends worksheet has positive and significant impacts on students' learning motivation and output in a natural science major (Karsono, 2017). The appropriate selection of media (easily implemented, communicative and informative) is such a solution in solving an actual problem commonly happened during the teaching and learning process (Syahroni et al., 2016), such as higher-order thinking skills (HOTS). A solution is needed so that the use of learning materials could create a maximum learning result during the teaching and learning process and able to increase students' comprehension skill towards a certain conception by using fun methodology through optimizing brain potentials and students' higher thinking skills. The purpose of this research is to uncover the effectiveness of BBL materials development on the excretory system towards students' HOTS in biology learning in senior high school. High school students experience difficulties in understanding the concept of biology materials related to physiological organ systems such as the excretory system.

Depends on a survey conducted in this study, 17 out of 18 students confessed that they experienced difficulties in comprehending the physiological excretory system, for instance, the process of urine formation, sweating, and bile formation. The physiology process that happens in the excretory system cannot be directly observed as it is abstract in nature. Most of the students perceived that Biology is the subject of memorization so that during the teaching and learning process students tend to take notes and listen to the teacher's explanation. The learning result earned by the students were affected by at least two factors, e.g. internal and external factors (Sudjana, 2010). The process that happens inside the human body is marked by the organization, interaction, complex components, and dynamic process (Assaraf et al., 2011).

### **Research Method:-**

This study is a research and development (R&D). The learning material which was developed in this study is a coursebook which BBL learning approach on the excretory system for the eleventh graders in senior high school. This study used prototyping steps as adapted from 4-D (Four Ds) covering (1) define, (2) design, (3) develop, and

(4) disseminate. The participants of this study were 125 students from grade XI of Indonesian senior high schools majoring in natural science from SMA Negeri Kalisat (Class A), SMA Muhammadiyah 3 Jember (Class B), SMA Negeri Arjasa (Class C), and SMA Negeri 2 Jember (Class D) cohort 2020/2021. The measurement of students' higher-order thinking skills (HOTS) depended on the test result. It was conducted three times in three meetings in each class. Higher-order thinking skills were measured by using an essay consisting of 5 items with indicators as shown in Table 1. HOTS was measured from the score of HOTS.

$$V = \frac{\sum \text{achieved score}}{\text{Total score}} \times 100 \dots\dots\dots (1)$$

**Table 1:-** Value category of Higher Order Thinking Skills (HOTS).

No	Values	Category
1	20 - 35	Poor
2	36 -51	Less
3	52- 67	Enough
4	68- 84	Good
5	85- 100	Very Well

The HOTS questions were administered in every meeting, after that the score was used to be analyzed by using HOTS score. Next, the score is summed in the form of the score by using formula 1. After that, the explanation was constructed depends on the categories. The evaluation of every aspect used Likert scale ranging from 1 to 5.

### Findings and Discussion:-

Looking the result at Table 4 can be inferred that the category of students' higher-order thinking skills from class A, B and C is good. This means that the learning materials which have been developed BBL learning approach on the excretory system is effective to practice students' higher-order thinking skills. It happens because the process of delivering the materials which combine the concept of how the left and right brain work in balance could train students' analytical skill. This can be carried out by implementing the principles of the BBL approach as explained in the following.



**Table 2:-** BBL Learning Materials based on Learning Material Structure and Principles of BBL.




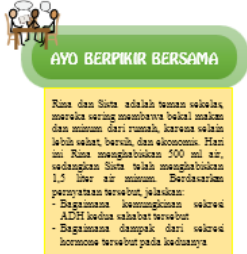
Structure of Learning Materials (National Education Department, 2008)	The Principles of BBL Approach	BBL Learning Materials
Learning Instruction (A guide for students/teacher)		Containing book manual
Learning Competence		Containing the targeted basic competencies and learning goals
Learning content or materials	Meaning construction from pattern formation	Containing clues and concept mapping
	Meaning construction as an innate capacity	
	Learning how to engage the whole body physiology	Containing <i>Brain Gym</i> activity that provides stimulus for the whole body to make the students active
	The brain is seen as a parallel processor capable of running mutual activities	Containing <i>Let's Think Together</i> activity that encourages the students to discuss current issues
	Learning how to engage the focus of attention perception and peripheral	
	The fragment of the left and right brain will simultaneously organize information	Containing <i>Remember Me</i> activity that provides acronym for the students to help them memorize keywords
	Each part of the brain is unique. Learning activity should	Containing <i>Playful Time</i> activity containing fun materials in the form

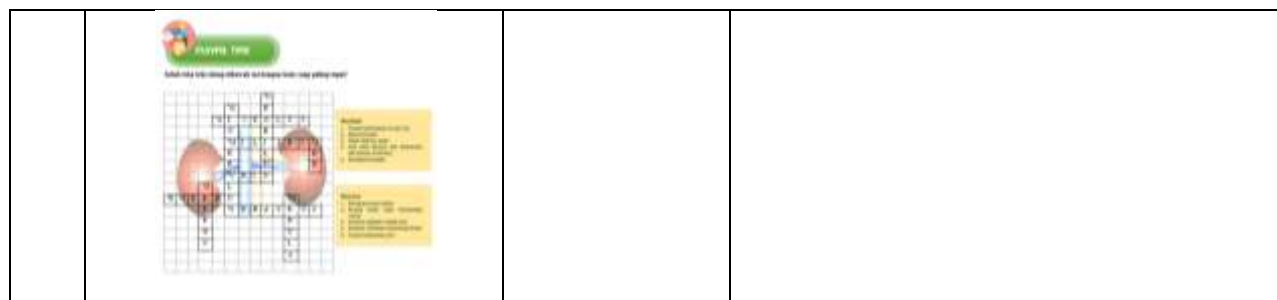
	accommodate students' visual, tactile, emotional, and auditory preferences	of song and games that aims to deepen the comprehension of the materials
	Learning is carried out to increase challenges and decrease threats	
	Emotion is a pivotal role in a shaping learning model	
Supporting Information		Containing <i>Science Break</i> activity that loads information aiming at enriching students' insights related to the excretory system
Exercises		Containing <i>Critical Reflection</i> encouraging students to solve a problem related to the excretory system
Work Instruction can be in the form of a Worksheet	Spatial memory can be ideally constructed if the learning activity implement experimental methods	Containing <i>Fun Science</i> activity that encourages students to experiment with the excretory system
	Learning always engages a conscious and unconscious process	
Evaluation	2 types of memories are such as spatial memory and memorization	Containing HOTS evaluation questions
Feedback		Containing answer key

The learning materials developed in this study is explained in the following:

**Table 3:-** The learning materials developed using the BBL characteristics.

No	Screenshots as the Sample of Book Sections	Characteristics of each section	The uniqueness of BBL and HOTS
1		<i>Brain Gym</i>	Brain Gym is an activity that could optimally stimulate the work and function of the brain by emphasizing the activation of the capability of the left and right brain so that the collaboration of left and right brain's fragment intertwined.
2		Acronym or <i>The Donkey's Bridge</i>	It is a method to memorize or remember something which is commonly used in the field of education. It often appears in the form of words or syllables which were added up to the word arrangement which is intended to memorize so that it becomes an interesting and logical sentence that is easily remembered.
3		<i>PlayfulTime</i> containing songs whose lyrics have been changed with learning content	Music could stimulate the work of the brain in delving into an issue stored in somebody's mind. It remains unclear how this mechanism work yet there is a theory that affirms that it is similar to the synesthesia phenomenon where somebody's brain could show a perception in the form of image and emotion when listening to music or song. According to several studies, several

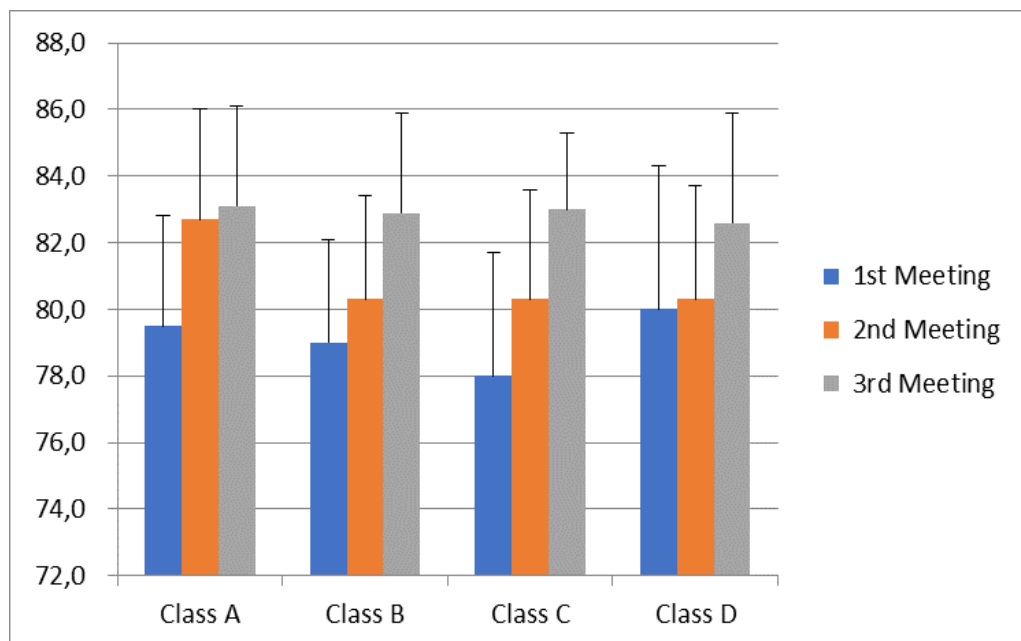
			researchers agreed that a series of tones could help patients with a dimensional disorder or traumatic brain injury which makes the sufferer hard to remember things better.
4		Supporting Information	It contains a kind of "science break" which aims to present information that is expected to increase students' insights related to the material of the excretory system
5		Critical Thinking	Critical reflection asks the students to relate new information with their background knowledge which has been stored in their mind and relate and/or rearrange and develop the information to reach a certain goal or discover a solution from a difficult situation.
6		Let's Think Together	It collaborates the way of thinking of several students to improve their thinking skill to a higher level, particularly ones that are related to critical thinking as a response toward receiving various kinds of information, creative thinking in addressing a problem by using their background knowledge as well as decision making in complex situations.
7		Crossword Puzzle	Playing a crossword puzzle could increase brain ability in general. Filling the gap in the crossword game demand the students to unstoppably think and analyze. Besides, playing this game could help the students to sharpen their memory, particularly short-term memorization.



Higher-order thinking skills (HOTS) are measured from the HOTS score. The questions of HOTS are administered in each meeting and then the score was analyzed by using HOTS score. After that, the score was summed in the form of a score (Formula 1). Then, the score was explained depends on the category. The HOTS questions were administered in every meeting, after that the score was used to be analyzed by using HOTS score. Next, the score is summed in the form of the score by using formula 1. After that, the explanation was constructed depends on the categories. The evaluation of every aspect used Likert scale ranging from 1 to 5. The Likert scale for HOTS scoring can be seen in Table 2. The category of each score of higher-order thinking skills can be seen in Table 1 while the result of higher-order thinking skills can be seen in Table 4. Student's higher-order thinking skills are considered effective if they reached 68 as the minimal score (good).

**Table 4:-** Results of the average value of student's higher-order thinking (HOTS).

Meeting	Class A		Class B		Class C		Class D	
	N	Values	N	Values	N	Values	N	Values
1	32	79.5	33	79	30	78	30	80
2		82.7		80.3		80.3		80.3
3		83.1		82.9		83.0		82.6
<b>Mean</b>		<b>81.8</b>		<b>80.7</b>		<b>80.4</b>		<b>81</b>
<b>Category</b>		<b>Good</b>		<b>Good</b>		<b>Good</b>		<b>Good</b>



**Figure 1:-** The value of the student's Higher Order Thinking Skills (HOTS).

Table 2 and Figure 1 showed the average score of the higher-order thinking skills. The score of higher-order thinking skills in Class A was 81.8; Class B 80.7; Class C 80.4, and Class D 81. The score for Class A, B, C, and D can be categorized as good. Further, the frequency of category of students' higher-order thinking skills can be seen in Table 5.

**Table 5:-** The calculation result of students' higher-order thinking skills (HOTS) score.

Values	Category	Frekuensi Siswa			
		A (N=32)	B (N=33)	C (N=30)	D (N=30)
20 - 35	Poor	0	0	0	0
36 - 51	Less	0	0	0	0
52 - 67	Enough	0	0	0	0
68 - 84	Good	20	22	21	17
85- 100	Very good	12	11	9	13
Percentage		<b>63% (Good)</b> <b>37% (Very good)</b>	<b>67% (Good)</b> <b>33% (Very good)</b>	<b>70% (Good)</b> <b>30% (Very good)</b>	<b>57% (Good)</b> <b>43% (Very good)</b>

Depends on Table 5, the result can be seen that the category of student's higher-order thinking skills about the excretory system is good with the percentage 63% (A); 67% (B); 70% (C), and 57% (D). These results show an effective textbook depends on brain-depends learning for students' higher-order thinking skills in a good category.

### Discussion:-

According to Wahidmurni (2018), HOTS will be accomplished if someone could relate new information with the background knowledge which has been stored in their mind and connect and/or rearrange as well as develop the information to gain a certain purpose or discover a solution from a difficult problem. The BBL coursebook developed in this study could facilitate this process. Delivering materials joyfully by combining the concept of visualization on the excretory system is the best quality this book could provide. BBL offers a concept in creating learning activities that are brain-oriented particularly in sharpening its potential. The concept implemented in this learning materials are 1) establishing a learning environment that challenges students' thinking skill (orchestrated immersion); (2) designing a joyful learning environment (relaxed alertness); (3) creating a learning situation which is active and meaningful for the students (active processing). The information is delivered in a fun way so that it can maintain students' both long- and short-term memory (Saparina et al, 2015). BBL helps the students to form a pattern and associate with their brain when given a problem which is rich in the learning experience (Uzezi, 2017) so that learning can sustain in students' mind (Diyah, 2019) which further affects better achievement on the higher-order thinking skills (Kartikaningtyas, 2017). This is similar to Jensen (2012) who argues that making use of distinctive pictures, diagrams, writing, and colors could practice brain to analyze and think critically.

Quality students can be realized by the teachers who choose the appropriate media which can visually accommodate the balance thinking activities that engage the left and right brain. This is in line with Devi (2016) and Duman (2010) stating that BBL activities would likely create meaningful learning for the students as it can transform students' brain physiology when they collaborate and interact in learning activities. This also echoes research conducted by Awolala (2011) and Arun (2018) revealed that BBL activities are proven more effective compared to conventional learning in terms of improving students' learning outcomes particularly in higher-order thinking skills as well as their memorizing skill towards the knowledge acquired. Learning by using BBL-depends materials could elevate students' higher-order thinking skills. The materials delivered in a learning activity should be communicative and informative as the source of knowledge. This makes the students easier in understanding compared to using the non-BBL-depends materials alone. It is relevant to Sianturi (2020) who reported that somebody needs a good creative skill to think critically yet the analytical skill could generate a different perspective. This is such an important requisite in developing HOTS. Students could think critically when they are directly engaged in creative thinking related to the information which has been obtained.

The brain (cerebrum) is constructed from two fragments the so-called right and left hemisphere which is connected to the corpus callosum (Champbell and Reece, 2008; Kalat 2020; Pinel, 2009). This is caused by the mutual contribution of the right and left fragments in running their functions (Indriyana, 2019; Khalil, 2019). From the explanation aforementioned, it is important to keep up the work balance of the brain so that the result of mind processing can be optimally generated as it has been implemented in BBL-depends learning material developed in this study. BBL is student-centered learning and puts the teacher as a learning facilitator which plays important role in supporting students' cognitive ability (Awolala, 2011). The characteristics of BBL are a relaxed class, constructivist learning, cooperative learning between students is emphasized, sufficient time for students to reflect on the materials learned, meaningful and contextual learning. This is in line with Khalil et al (2019) who stated that the BBL model can design meaningful learning for the students as it can boost students' brain system when they collaborate and interact in a learning activity.

### Conclusion:-

Depends on the result and discussion of this study, the score of students' higher-order thinking skills (HOTS) after using the BBL-depends materials on the excretory system in a learning activity is categorized good. This can be inferred that the BBL-depends learning materials about the excretory system in this study is effective in improving students' higher-order thinking skills.

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