



# Development of Neuroscience-Based Biology Learning Media to Increase Learning Motivation and Cognitive Learning Outcomes of Tenggara High School Students

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**Abstract:** Neuroscience-based learning is a field of neuroscience study that focuses on studying educational concepts from the perspective of the brain's working system. It turns out that teachers and parents still rarely pay attention to this field of study, which has led to the emergence of a learning atmosphere that is passive and not optimal in stimulating nerve cells in the human brain. The results of initial observations carried out on 22-28 April 2021 on high school teachers and students in Tenggara (SMA Negeri 1 Tenggara, SMA Negeri 2 Tenggara, SMA Negeri 3 Tenggara) showed that there were still many (85%) It was found that teachers still relied on verbal language, image/animation media, PowerPoint and only a few (15%) were varied in their use of biology learning media, although based on interviews they said they understood audio, visual and audiovisual media well enough. Likewise with learning with neuroscience-based media, from the interview results, generally (85%) were not familiar with biology learning with neuroscience-based media and only a few (15%) were familiar with and had implemented it in biology learning. The same thing applies to students' cognitive learning outcomes from interviews that I found that students' abilities were generally moderate and low. This is because students think that biology is a rote subject and are less motivated when learning. This research method is Research and Development (R&D) Sivasailam Thiagarajan. The main objective of this development research method is to produce products and determine the feasibility of products developed in the form of neuroscience-based learning videos which are limited to the circulatory system. The research subjects included four validator experts, namely media experts, materials experts, language experts and learning tools experts. Class XI students as the research sample consisted of two classes, namely the control class and the experimental class. The results of the research show that the validity of learning media is in the valid category (79.95%), the practicality of learning media is in the very good category (83.37%), and also the effectiveness of neuroscience-based learning media in providing a high increase in learning motivation (Gain score = 0.73) and t test analysis (t count < 0.05) via the SPSS application.

**Keywords:** Cognitive learning outcomes; Learning media; Motivation to learn; Neuroscience

## How to Cite:

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## Introduction

Neuroscience-based learning is a field of neuroscience study that focuses on studying educational concepts from the perspective of the brain's working system (Anderson et al., 2006; Lim et al., 2019). It turns out that teachers and parents still rarely pay attention to this field of study, which has led to the emergence of a learning atmosphere that is passive and not optimal in stimulating nerve cells in the human brain. Teachers and parents who do not understand the biological basis of children's skills and behavior tend to educate children according to their wishes so that the child's goal in learning is aimed at pleasing the teacher and parents only and is not optimal in developing all the potential he has according to his stage of development (Bjorklund, 2022). The results of research in the field of educational neuroscience have provided a new perspective for the world of education in understanding the development of children's behavior and skills in terms of the structure and function of the nervous system in the brain. Mathematical and language intelligence is centered on the left side of the brain, musical and spatial intelligence is centered on the right brain, kinesthetic intelligence is centered in the motor area of the cerebral cortex, and intrapersonal and interpersonal intelligence are organized in the limbic system and connected to the prefrontal and temporal lobes (Shearer, 2019; Syafitri, 2019).

This is supported by evidence that students taught using a neuroscience-based approach show deeper conceptual understanding and better and broader knowledge, students are more engaged and happier and teachers who use this approach have reported much higher personal teaching efficiency as well as higher general teaching efficacy (Torrance, 2018).

Neuroscience is a field of study regarding the nervous system in the human brain (Bear et al., 2020). Neuroscience also studies consciousness and brain sensitivity in terms of biology, perception, memory, and its relationship to learning (Riva, 2018). For Neuroscience theory, the nervous system and brain are the physical basis for the human learning process (Richards et al., 2019). Neuroscience can make connections between cognitive processes in the brain and the resulting behavior. This can be interpreted as meaning that every command processed by the brain will activate important areas of the brain (Desai et al., 2021).

Neuroscience is a field of scientific research on the nervous system, especially the brain. Neuroscience is the study of the brain and mind. The study of the brain is fundamental in understanding how we feel and interact with the outside world and especially what humans

experience and how humans influence others (Salas et al., 2018).

Media is one of the factors that supports the success of the learning process in schools because it can help the process of conveying information from teachers to students or vice versa. Learning media is a tool or means that can be used in delivering material because the process of delivering material carried out by educators does not entirely use learning media. One of the benefits of media in the teaching and learning process is that it can increase student learning motivation which then has an impact on increasing learning outcomes (Fitriani, 2018). One way that can be used to increase students' learning motivation and cognitive learning outcomes is by using neuroscience-based learning media.

Motivation comes from the Latin word, namely "movere" which means encouragement or driving force. According to Priatna et al. (2020) says that "motivation as an energizing condition of the organism that services to direct that organism toward the goal of a certain class" (motivation as a condition that moves humans towards a goal certain). According to Sadirman (2018), motive can be said to be a driving force from within and within the subject to carry out certain activities in order to achieve a goal. In learning activities, motivation is very necessary to arouse students' passion for learning so that learning activities can run well. The definition of learning motivation according to Sadirman (2018) is "The entire driving force within the student which gives rise to learning activities, which ensures the continuity of learning activities and provides direction to learning activities, so that the goals desired by the learning subject can be achieved".

This ability can be more optimal with learning motivation (Fahim et al., 2013; Semerci, 2011). Motivation is a basic impulse that moves a person to act (Uno, 2014). Motivation to learn is very much needed in the learning process. Learning that is attended by motivated students will make it easier for educators to convey lesson material and increase students' cognitive learning outcomes (Filgona et al., 2020).

The results of initial observations carried out on 22-28 April 2021 on high school teachers and students in Tenggara (SMA Negeri 1 Tenggara, SMA Negeri 2 Tenggara, SMA Negeri 3 Tenggara) showed that there were still many (85%) It was found that teachers still relied on verbal language, image/animation media, PowerPoint and only a few (15%) were varied in their use of biology learning media, although based on interviews they said they understood audio, visual and audiovisual media well enough. Likewise with learning with neuroscience-based media, from the interview results, generally (85%) were not familiar with biology learning with neuroscience-based media and only a few (15%) were familiar with and had implemented it in

biology learning. This causes students to think that biology is a rote subject. In rote learning, students try to master the material without knowing its meaning, which is different from meaningful learning where students study material by trying to understand its meaning or significance. Learning by rote will make students passive and cannot improve students' cognitive learning outcomes. In line with the opinion that the current education system only focuses on the left side of the external brain, and does not balance the use of the right brain. This left brain plays a role in processing logic, words, mathematics, and the dominant sequence for academic learning. The right brain which deals with musical rhythms, images and creative imagination has not received a proportional share of development (Hengki, 2018). To overcome this problem, it is implemented by developing neuroscience-based learning media.

## Method

### *Types of Research*

This research includes Research and Development (R&D) research. According to Sugiyono (Sugiyono, 2017), Research and Development (R&D) is a research method used to produce certain products and test the effectiveness of these products. According to Sukmadinata (2009), Research and Development (R&D) is a process or steps to develop a new product or improve an existing product, which can be accounted for. Then according to Nusa (2015), Research and Development (R&D) is a deliberate, systematic research method to find, improve, develop, produce, or test the effectiveness of superior products, models, and methods/strategies/ways, new, effective, efficient, productive and meaningful.

Based on these opinions, Research and Development (R&D) is a research method carried out deliberately and systematically to improve existing products or develop new products through testing, so that the product can be accounted for.

### *Time and Place of Research*

#### a) *Research time*

This research was conducted in the even semester from May 10 to June 10 of the 2022/2023 academic year.

#### b) *Research location*

The research was carried out at SMAN 2 Tenggara class XI MIPA.

### *Development Style*

The method used in this research is research and development. In research and development methods,

there are several types of models. The model used is a 4-D model development. The 4-D (Four D) development model is a learning device development model. This model was developed by Thiagarajan et al. (1974). The 4D development model consists of 4 main stages, namely: Define, Design, Develop and Disseminate. This method and model was chosen because it aims to produce products in the form of neuroscience-based media (video). The product developed was then tested for feasibility with validity and product trials to determine the extent to which learning motivation and cognitive learning outcomes of students increased after learning using neuroscience-based learning media (video) on the Circulatory System material.

The 4-D model was adapted by Trianto (2013) to become the 4-P model (Defining, Designing, Development and Dissemination). According to Thiagarajan et al. (1974), the define stage consists of front analysis, task analysis, concept analysis and object specification. The design stage consists of test construction, media selection, format selection and initial design. The develop stage consists of expert appraisal and development testing. The dissemination stage consists of validation testing, packaging and diffusion. Each stage of the 4D model will be explained further.

### *Define*

The definition stage is useful for determining and defining needs in the learning process as well as collecting various information related to the product to be developed. This stage is divided into several steps, namely:

#### a) *Front-end analysis*

Initial analysis was carried out to determine the basic problems in developing neuroscience-based learning media. At this stage, facts and alternative solutions are presented, making it easier to determine the initial steps in developing neuroscience-based learning media that are suitable for development.

#### b) *Learner analysis*

Student analysis is very important to do at the beginning of planning. Student analysis is carried out by observing the characteristics of students. This analysis is carried out by considering the characteristics, abilities and experiences of students, both as a group and individually. Analysis of students includes characteristics of academic ability, age, and motivation towards subjects.

#### c) *Task analysis*

Task analysis aims to identify the main tasks that will be carried out by students. Task analysis consists of

analysis of Core Competencies (KI) and Basic Competencies (KD) related to material that will be developed through neuroscience-based learning media.

#### d) *Concept analysis*

Concept analysis aims to determine the content of the material in the neuroscience-based learning media being developed. Concept analysis is created in a learning concept map which will later be used as a means of achieving certain competencies, by identifying and systematically arranging the main parts of the learning material.

#### e) *Analysis of learning objectives*

Analysis of learning objectives is carried out to determine indicators of learning achievement based on material analysis and curriculum analysis. By writing down learning objectives, researchers can find out what studies will be displayed in neuroscience-based learning media, determine the question grid, and finally determine how much the learning objectives have been achieved.

#### *Design*

The aim of this stage is to design a prototype of teaching materials. This phase can begin once a set of behavioral objectives for the teaching materials have been established. Selection of media and format for materials and production of initial versions are key aspects of the design stage.

After getting the problem from the definition stage, the design stage is then carried out. This design stage aims to design a neuroscience-based learning media that can be used in biology learning. This design stage includes:

##### a) *Criterion-test construction*

Preparation of instrument tests is based on the preparation of learning objectives which become a benchmark for students' abilities in the form of products, processes, psychomotor skills during and after learning activities.

##### b) *Media selection*

Media selection is carried out to identify learning media that are relevant to the characteristics of the material and suit the needs of students. Media are selected to suit student analysis, concept analysis and task analysis, target user characteristics, as well as dissemination plans with varying attributes of different media. This is useful for helping students achieve the expected core competencies and basic competencies.

##### c) *Format selection*

Format selection is done in the first step. Format selection is done so that the format chosen is appropriate to the learning material. The choice of presentation form is adjusted to the learning media used. Choosing a format in development means designing learning content, selecting approaches and learning resources, organizing and designing pop-up content, creating pop-up designs, which includes layout design, images and writing.

##### d) *Initial design*

The initial design is a pop-up media design that has been created by the researcher and then given input by the supervisor. The input from the supervisor will be used to improve the learning media before production. Then make revisions after receiving suggestions for improving learning media from the supervisor and later this design will be carried out in the validation stage. This design is Draft I of neuroscience-based learning media.

#### *Develop*

This development stage aims to produce learning media that has been revised based on expert input and trials with students. There are two steps in this stage, namely as follows:

##### a) *Expert validation*

This expert validation functions to validate the content of Biology material in neuroscience-based learning media that is developed before trials are carried out and the validation results will be used to revise the initial product. The learning media that has been developed will then be assessed by material expert lecturers and media expert lecturers, so that it can be seen whether the neuroscience-based learning media is suitable for application or not. Expert assessment is a technique for obtaining material improvement suggestions. A number of experts were asked to evaluate the material from instructional and technical viewpoints. Based on their feedback, the materials were modified to be more appropriate, effective, usable, and of high technical quality. The results of this validation are used as improvement material for the perfection of the learning media being developed. After draft I was validated and revised, draft II was produced. Draft II will then be tested on students in a limited field trial stage.

##### b) *Product Trial*

After expert validation, a limited field trial was carried out to determine the results of the application of media in classroom learning, including measuring students' learning motivation and measuring students'

cognitive learning outcomes. The results obtained from this stage are in the form of revised neuroscience-based learning media.

#### *Disseminate*

After testing (small class and large class) and the instrument has been revised, the next stage is the dissemination stage. The aim of this stage is to disseminate neuroscience-based learning media. In the research, dissemination was carried out, namely by disseminating and promoting the final product of learning media to students and biology teachers at SMA Negeri 2 Tenggarong.

#### *Research Variable*

A research variable is an attribute or trait or value of a person, object or activity that has variations determined by the researcher to be studied and conclusions drawn. This variable will then be used in the effectiveness test.

#### *Independent Variable*

The independent variable in this research is learning with a neuroscience-based approach.

#### *Dependent Variable*

The dependent variables in this research are students' learning motivation and cognitive learning outcomes in the Biology subject, Blood Circulatory System material in class XI SMA 2 Tenggarong.

#### *Population and Sample*

This population and sample are used for effectiveness testing.

#### *Population*

Population is a complete set of units or individuals whose characteristics you want to know. From this understanding, the population used in the research or which will be the object of the research is class XI high school students.

#### *Sample*

The sample is part of the number and characteristics of the population. In this research, researchers used random samples. The sample used as the experimental class was class XI high school students in Tenggarong

#### *Data Collection*

##### *Data Type*

The data obtained from this research is quantitative and qualitative data in the form of:

Quantitative data: a) The validity of neuroscience-based learning media, in the form of validation

questionnaire scores obtained from 4 validators, namely media validator, language validator, material validator, and learning device validator. b) The practicality of the neuroscience-based learning media developed in the form of a student and teacher response questionnaire at SMA Negeri 2 Tenggarong after the learning activities ended. c) The effectiveness of the learning media developed on students' cognitive learning outcomes through pre-test and post-test as stated in the description questions.

Qualitative data in the form of comments and suggestions provided by the principal and two Biology teachers who teach at SMA Negeri 2 Tenggarong.

#### *Data Collection Technique*

The data collection techniques used in this research are observation techniques, questionnaires, documentation and test techniques.

#### *Observation Techniques*

Observation is a method of collecting data by systematically observing and recording the phenomena being studied. The things that will be observed are the learning process and data related to the extent of the influence of using a neuroscience-based learning approach in increasing students' motivation and cognitive learning outcomes. In this case, the researcher as the experimenter will observe the class directly during the teaching and learning process.

#### *Questionnaire Technique*

A questionnaire is a data collection technique that is carried out by giving questions or written statements to respondents to answer. Questionnaires can be closed questions or statements (the answers are determined in the questionnaire sheet) or open (respondents are given the freedom to answer, of course according to the instructions for using the questionnaire). This questionnaire aims to obtain data from students who are included in the experimental class.

The questionnaire used is in the form of a structured questionnaire or closed questionnaire, which is designed in such a way as to obtain data related to personal opinions regarding the learning process before and after using a neuroscience-based learning approach compared to the learning approach used by the previous teacher. In other words, the questionnaire used was to determine students' responses in taking Biology lessons using a neuroscience-based approach.

#### *Documentation Techniques*

In this case, the researcher explored the documents needed to support the data collected, including photos during teaching and learning activities and videos during teaching and learning activities.

*Test Technique*

Researchers will give two types of tests, namely pre-test and post-test, namely questions related to material that has been studied before using a neuroscience-based approach in learning and after using a neuroscience-based approach in learning, with the aim of seeing the effectiveness of using a neuroscience-based approach. This affects students' motivation and cognitive learning outcomes.

*Data Analysis Technique*

The data analysis techniques used in this research are qualitative analysis and quantitative analysis. Qualitative data analysis techniques are used to process data collected from the opinions, comments and suggestions of all validators and students, while quantitative data analysis is used to determine the suitability of the media being developed. To determine media quality, three criteria are required, namely validity, practicality and effectiveness. Quantitative and qualitative data are determined from the results of product trials.

*Media Validity Analysis*

Media validity is carried out by experts by providing responses based on several indicators, namely: media quality (technical and electronic aspects), media suitability (material/content aspect) and media attractiveness (presentation aspect). Data from media validation were analyzed using quantitative descriptive analysis, namely by calculating the average of each aspect provided by the validator, then describing it qualitatively. Media categorization criteria are as follows.

**Table 1.** Validator Assessment Weight (Arikunto, 2013)

Score	Criteria
5	Very good
4	Good
3	Enough
2	Less
1	Very less

Validator assessment percentage using the formula:

$$PP = \frac{\sum SR}{\sum ST} \times 100\% \quad (1)$$

Description:

- PP = Percentage of validator ratings
- $\sum SR$  = Number of response answers
- $\sum ST$  = Total number of responses

The results of calculating the validity of the learning media developed are then matched with the percentage range and qualitative criteria for validity tests presented in Table 2 (Sugiyono, 2017).

**Table 2.** Percentage Range and Qualitative Criteria for Validity Test

Value Scale (100%)	Criteria
81.28 - 100	Very valid (not revised)
62.51 - 81.25	Valid (not revised)
43.76 - 62.50	Valid enough (not revised)
25.00 - 43.75	Less valid (not revised)
< 25	Invalid (revised)

*Media Practicality Analysis*

Student Response Data (in the form of a Questionnaire). Neuroscience-based learning media is said to be practical if its implementation is easy and takes a relatively short time (Shodiq et al., 2021). The practicality of the media can be seen based on the results of the analysis of student response questionnaires given after learning activities. This data is in the form of a response scale to neuroscience learning media which consists of the five Thurstone scales. The five Thurstone scales can be seen in Table 3 below (Arikunto, 2013).

**Table 3.** Student Response Questionnaire Scores

Score	Criteria
4	Strongly agree
3	Agree
2	Disagree
1	Strongly disagree

Data resulting from student responses to learning were analyzed using quantitative descriptive with the following formula 2 (Widoyoko, 2014).

$$PP = \frac{\sum SR}{\sum ST} \times 100\% \quad (2)$$

Description:

- PP = Percentage of validator student responses
- $\sum SR$  = Number of response answers
- $\sum ST$  = Total number of responses

The practicality score interpretation criteria are shown in Table 4 below.

**Table 4.** Practicality Score Interpretation Criteria

Percentage of Student Responses (%)	Criteria
81 - 100	Very practical
61 - 80	Practical
41 - 60	Quite practical
0 - 40	Less practical

*Analysis of the Effectiveness of Learning Media on Cognitive Learning Outcome Skills*

The effectiveness test was carried out to determine the extent of the role of neuroscience-based learning media in helping students understand the material being taught. The media developed can be said to be effective if after participating in learning activities students

experience an increase in critical thinking skills as measured by the results of the pretest and posttest which are then analyzed using the SPSS data program with the following steps.

1) *Homogeneity test*

A test carried out to determine that two or more groups of sample data come from populations that have the same variance (homogeneous). This test is a requirement before carrying out the T test. This test is used to ensure that the data group does come from a population that has the same variance (homogeneous).

2) *t-test*

Data analysis of the influence of the media developed on cognitive learning outcomes was obtained from students' pre-test and post-test scores in the form of a t test, namely the paired sample t-test and the independent sample t-test using the SPSS application. The paired independent sample t-test was used to determine whether there was a difference in the average learning effectiveness of two groups in pairs. A paired sample can be interpreted as a sample with the same subject but experiencing 2 different treatments or measurements, namely measurements before and after a treatment.

The basis for decision making is: a) If the Sig (2-tailed) value is <0.05, then there is a significant difference between the experimental class and the control class. b) If the Sig (2-tailed) value is > 0.05, then there is no significant difference between the experimental class and the control class.

Before carrying out the independent sample t-test, a homogeneity test and normality test were first carried out using the program, SPSS. If the data in both samples is normally distributed and homogeneous then an independent sample t-test can be carried out.

Furthermore, to support learning effectiveness data, researchers used data obtained from pretest and post-test scores. Analysis of students' pre-test and post-test scores is in the form of gain score analysis. The gain score analysis of the students' pre-test and post-test scores is based on Hake's opinion (Hamidah, 2012), which is as follows.

$$g = \frac{Sp_{post} - Sp_{pre}}{Smaks - Spre} \tag{3}$$

The symbol <g> is the gain score value obtained. The levels of gain score are categorized as high ((<g>) > 0.7), medium (0.3 < (<g>) < 0.7) and low ((<g>) < 0.3). Learning is said to be effective if the gain score is at a medium or high level, which means that the learning media has a positive influence on students' cognitive learning outcomes.

**Result and Discussion**

*Research Result*

Learning media is a very important component in the learning process. The neuroscience-based learning media developed in this research uses a development research approach with a 4-D (Four D) development model. This model was developed by Thiagarajan (1974). The 4D development model consists of 4 main stages, namely: Define, Design, Develop and Disseminate.

*Validity of Neuroscience-Based Learning Media Development*

The learning tools along with Neuroscience-Based Biology Learning media to Increase Student Motivation and Cognitive Learning Outcomes that I have developed are then validated by a team of validators or experts. The experts in this research are adjusted to their respective backgrounds or abilities so that the accuracy of the assessment obtained is in accordance with the competence of the validator. In this research, only four teams of expert validators were used, namely learning device validators and material validators by Mrs. Elsj Theodora Maasawet, M.Pd, language validators by Mr. Dr. Yusak Hudiyono, M. and media validator by Mr. Ir. Haviluddin, S.Kom., M.Kom., Ph.D. Product validation can be seen in the attachment.

The results of the validation assessment summary of neuroscience-based biology learning tools and learning media to increase students' learning motivation and critical thinking skills can be seen in the attachment.

**Table 5.** Assessment Result Data by Validator

Description	Validator assessment	Criteria
Learning devices	78.6	Valid
Matter	78.6	Valid
Language	84	Valid
Media	78.6	Valid
Average	79.95	Valid

The data from the recapitulation results were obtained based on the sum of each item assessed and tabulated based on 5 assessment criteria, score 1 (very poor), score 2 (poor), score 3 (fair), score 4 (good), score 5 (very good ). The tabulation results are converted into a total average score using the following formula.

$$K = \frac{F}{N \times l \times R} \times 100\% \tag{4}$$

Description:

- K = Device validity (%)
- F = Number of respondents' answers
- N = Highest score
- l = Number of items
- R = Number of respondents

The validity of the learning tools is determined by matching the results of the total average score with the percentage range and qualitative criteria for testing the validity of the learning tools in accordance with table 3.2 in chapter 3, obtaining an average total score of 79.95 so that it is converted to valid (can be implemented without revision).

*The Practicality of Developing Neuroscience-Based Biology Learning Media*

Student response data was obtained from student response questionnaires given after the media was used in the learning process, both at the trial and implementation stages. This response data is used to assess student responses regarding the practicality of the media being developed. Details of student response data results in small class trials and large class trials can be seen in the table below.

**Table 6.** Practical Results of Media Development

Development stage	Student response (%)	Category
Small class trial (15 people)	83.27	Very practical
Large class tryout (33 people)	86.45	Very practical
Average	84.86	Very practical

From the results of student responses in small and large scale trials, it can be concluded that the final product is neuroscience-based learning media which was developed very practically, namely 84.86%.

*Effectiveness of Developing Neuroscience-Based Biology Learning Media*

*Small class trials*

To determine the effect of neuroscience-based learning media on learning motivation and cognitive learning outcomes, it was tested using the t test. Before carrying out the t test, you must carry out a homogeneity test. The results of testing using the t test in small class trials show that learning using neuroscience-based learning media has an influence on the effectiveness of learning in treatment classes. This is proven by the calculated t value of  $0.000 < 0.05$  (Table 4.3 and table 4.4) and by the N-gain score of 0.49 (medium category). This means that neuroscience-based learning media can have an impact on increasing learning motivation and students' cognitive learning outcomes in small class trials.

*Large class trials*

The results of testing using the t test in large class trials show that learning using neuroscience-based learning media has an influence on the effectiveness of learning in treatment classes. This is proven by the

calculated t value of  $0.000 < 0.05$  and proven by the N-gain score of 0.73 (high). This means that neuroscience-based learning media can also have an impact on increasing motivation and cognitive learning outcomes in large class trials.

*Discussion*

Researchers conduct interviews to collect data and student needs that will be used to create products. Based on the data obtained, researchers began to determine the learning model and materials that would be used to address student needs. The results of interviews conducted at SMA Negeri 2 Tenggara showed that biology teachers at that school were familiar with neuroscience-based biology learning but in reality had never used it. Teachers still use conventional methods when teaching in class using the lecture method and tend to be monotonous. Relevant to the opinion of Enggar (2012) stated that the large amount of biology material and curriculum demands that must be met cause teachers to more often use conventional approaches with lecture methods, questions and answers, and assignments in their learning.

According to biology teachers, in looking for innovative learning models, sometimes there are still many obstacles experienced, including having to create concepts, insufficient time and inadequate supporting infrastructure, so teachers tend to choose conventional methods. This is what results in students being less motivated in learning and low student cognitive learning outcomes. Based on the results of these interviews, researchers developed neuroscience-based learning media to make students more motivated in learning and can improve students' cognitive learning outcomes.

In developing the learning media created, researchers took videos from YouTube and developed the videos by adding music, concept maps, materials and puzzles at the end of the videos, all of which could increase learning motivation and learning outcomes. The development of neuroscience-based learning videos on circulatory system material has many benefits and advantages that influence thinking abilities and can increase student motivation and learning outcomes. This was proven during the learning process, students' thinking abilities increased as seen from the pretest and posttest results and students' learning motivation also increased as seen from the instruments that were distributed to students which stated that the learning process using neuroscience-based learning videos was very interesting and easy to understand.

Supported by the research results of Romi et al. (2012), it is stated that the thinking abilities of class VII middle school students have increased and students' learning motivation is very high. Student learning



motivation is greatly influenced by the way of learning and the media used by teachers when teaching in class. This research uses audio-visual and 3-dimensional media to increase student learning motivation. Based on the results of research that has been analyzed using methods with student satisfaction assessment instrument indicators, it is very clear that many students really enjoy learning using audio-visuals, making students more active in learning. Supported by the results of research by Estiteka (2014) shows that audio-visual media can increase student learning motivation. Motivation and learning are two things that influence each other. Learning is a change in behavior that is relatively permanent and potentially occurs as a result of practice or reinforcement based on the aim of achieving certain goals (Estiteka, 2014). Motivation to learn can arise due to intrinsic factors, in the form of desire and desire to succeed and encouragement of the need to learn, hope for ideals. Meanwhile, the extrinsic factors are appreciation, environment, conducive learning, and interesting teaching and learning activities.

Thinking abilities will increase if students are provided with knowledge and learning experiences in an effort to prepare students for their future in solving problems, including in making decisions in the world of work that students will face in the future and in everyday problems. This ability needs to be trained by teachers with students in their learning activities in class. Biology learning with the right methods is expected to be a means of developing thinking skills so that the learning process takes place optimally.

#### *Validity of Neuroscience-Based Biology Learning Media Development*

The validation results by a team of experts are the main determinant of assessing the suitability of this media. According to Nieveen et al. (2013) one of the absolute requirements for determining media quality is that it has gone through a validation process from experts. Validation data and student responses in the form of quantitative data are then converted into qualitative data according to table 3.1 and table 3.2 in chapter III. Meanwhile, the teacher review data is viewed from the responses given by teachers to aspects of media assessment in the form of positive responses and negative responses.

From Table 1 of the research results regarding the validity of learning media, a score of 78.6 was obtained for the learning tool aspect, a score of 78.6 for the material aspect, a score of 84 for the language aspect, and a score of 78.6 for the media aspect. If each validator assessment is converted to qualitative data according to table 3.2 in chapter III then all aspects of the validator assessment, including learning tools, materials,

language and media are within valid criteria (not revised). This is in accordance with Sugiyono (2014) who explains that the calculation of the validity of the media developed is then matched with the percentage range and validity test criteria.

From the validation results, it was then tested in small classes to see whether the media could be used in different class conditions and also as a comparison of the results of media development which continued to improve. Then from the response questionnaire, teacher review and pre-test post-test scores are used as material for improving media development and evaluation is also carried out to obtain the final product. After the product has been revised, a final validation is carried out to determine whether the final product developed can be applied or implemented. In the final validation of this research, no final revision was carried out because the media developed had been proven to be valid and there were no suggestions for improvement by the expert team. The application of the final product was carried out by researchers at SMA Negeri 2 Tenggara. At this stage, the results of the effectiveness test are obtained which are used as a reference for assessing the effectiveness of the media because the final product is applied which has experienced an increase in media quality and is declared valid by a team of experts.

The results of validation data analysis by a team of experts for each component, namely for material/content, learning tools, language and media, overall obtained percentages ranging from 75% to 100%. This shows that the qualitative value for all assessment components is very adequate or has very good quality. The results of the validation carried out by the expert team can be seen in the research results. From the validation results, the total feasibility of learning media from the entire expert team was 79.95 in the good category. This shows that the neuroscience-based learning videos provided are valid, practical and effective in increasing students' learning motivation and cognitive learning outcomes.

#### *Practicality of Developing Neuroscience-Based Biology Learning Media*

Practicality is a very important factor in media creation. Practicality is an important assessment in the research and development process. Practical media that can be used anywhere, anytime without time and situation limits. Learning media is said to be practical if the results of the teacher response questionnaire and student responses show that the learning media is in good criteria and the validator in the validation sheet states that the media can be used by teachers and students (Purwanto, 2010).

Practicality is measured by assessing student response questionnaires containing 20 questions.

Student response questionnaires were filled in by students when conducting small class trials and large class trials (field trials) while the data from the teacher's review of media practicality was reviewed from the responses given by teachers to aspects of media practicality assessment in the form of positive responses and negative responses. The feasibility assessment by students is seen from the students' responses to the learning media used in the learning process at the implementation stage, namely at this stage the final product which has been declared valid or determined to be suitable by the expert team is re-assessed for its suitability by the students through a student response questionnaire. As a comparison, the results of student responses from small class trials and large class trials are used to see whether there is an increase in responses as the media is developed.

In the small class trial, carried out on 15 students at SMA Negeri 2 Tenggarong, these 15 students were selected based on their cognitive level which represented the average. From the data obtained, the practicality of 15 students of SMA Negeri 2 Tenggarong was divided into four categories, namely less practical, quite practical, practical and very practical. Student responses in the small class trial showed an average score of 83.27%, which is in the very practical category. Students provide suggestions or comments that learning using neuroscience-based learning media makes the learning atmosphere fun, easy to understand, students feel challenged, students are more enthusiastic in learning because practice questions are included which refresh students' brains so they know more about the material.

Meanwhile, in the large class trial (field trial) consisting of 33 class XI students of SMA Negeri 2 Tenggarong, an average score of 86.45% was obtained which was in the very practical category. Student comments or suggestions are easy and effective in arousing students' enthusiasm for learning, a creative learning medium that combines learning fields and references for today's children. This learning media can also make students who are rarely active in class become involved in answering questions and discussing so that students can focus more on learning.

In small class trials, the quality of the media was said to be adequate and then increased to the implementation stage in the very feasible category. This shows that along with revisions and evaluations, the quality of the media is getting better. Based on media improvements based on suggestions and input from a team of experts and teacher reviews, the final product was obtained, neuroscience-based learning media on the subject of the circulation system.

## *Effectiveness of Neuroscience-Based Biology Learning Media Development*

### *Motivation to learn*

Neuroscience-based learning media is said to be effective in increasing learning motivation if at the implementation stage it is able to show a calculated  $t$  value  $< 0.05$  and if  $t$  calculated  $> 0.05$  then there is no significant difference between the control class and the treatment class. Learning is also said to be effective if the gain score is at a medium or high level, meaning that in this case learning using developed neuroscience-based media has a positive influence on increasing student learning motivation.

In small class and large class trials, each showed the results that there was an influence on the effectiveness of increasing learning motivation in the use of neuroscience-based learning media with a calculated  $t$  value of less than 0.05. In the media effectiveness test using the gain score index, it was categorized as medium (average 0.49) in small class testing and high category (average 0.73) in large class testing. This proves that the neuroscience-based learning media developed has been proven to be effective in the learning process in increasing learning motivation.

### *Cognitive Learning Outcomes*

Arikunto put forward three domains of learning outcomes, namely cognitive, affective and psychomotor. The focus of implementing testing the effectiveness of neuroscience-based learning media is only on the cognitive domain. Neuroscience-based learning media is said to be effective in providing improvements in the cognitive domain if at the implementation stage it is able to show  $t_{count} < 0.05$  and if the  $t_{count}$  value is  $> 0.05$  then there is no significant difference between the control class and the treatment class. Next, to find out the increase in gain score, namely to find out the comparison of treatment and gain score test to show an increase in pre-test and post-test results with the hope that the final post-test score will be close to or equal to the maximum value. The level of gain score obtained is categorized into three categories, namely high ( $(\langle g \rangle) > 0.7$ ), medium ( $0.3 \leq (\langle g \rangle) \leq 0.7$ ) and low ( $(\langle g \rangle) < 0.3$ ). Learning is said to be effective if the gain score is at a medium or high level. If the gain score is at a medium or high level, it means that the learning media has a positive influence on cognitive learning outcomes.

In small class and large class trials, each showed the results that there was an influence on the effectiveness of using neuroscience-based learning media with a calculated  $t$  value of  $0.000 >$  smaller than 0.05. In the effectiveness test on media use using the gain score index, it was categorized as high with a value of 0.49 (medium) in the small class test. At the large class testing stage, as a result of the effectiveness test, a gain score

index was obtained of 0.73 (high category). This proves that neuroscience-based learning media has been proven to be effective in the learning process. From the comparison of the gain index at each stage, it can also be seen that there has been an increase in the gain score. This proves that from revisions and evaluations, the effectiveness of the media being developed is getting better along with the quality of the media getting better. This is proven by the results of the media feasibility analysis, especially from teacher reviews and student responses.

Students' cognitive learning outcomes will increase if students are provided with knowledge and learning experiences in an effort to prepare students for their future in solving problems, including in making decisions in the world of work that students will face in the future and in everyday problems. This ability needs to be trained by teachers with students in classroom learning activities. Biology learning with the right methods is expected to be a means of thinking skills so that the learning process takes place optimally. A well-planned learning process plays a very important role in achieving educational goals. Achieving this goal requires appropriate learning strategies, namely by using neuroscience learning media which is able to encourage students to think in learning.

The effectiveness test was carried out to determine the extent of the role of neuroscience-based learning media in helping students understand the material being taught. The media developed can be said to be effective if after participating in learning activities students experience an increase in student cognitive learning outcomes as measured by the results of the pretest and posttest which are then analyzed using the SPSS data program. Based on the description above and the research results show that the neuroscience-based learning media developed is effective in improving students' thinking abilities.

## Conclusion

Based on the results of the research and discussion, it can be concluded: The validity of neuroscience-based learning media resulting from the average score of 4 validators is in the valid category (79.95%); The practicality of neuroscience-based learning media from the results of the student questionnaire is in the very good category (83.37%); The effectiveness of the developed neuroscience-based learning media is able to provide increased motivation and student learning outcomes as proven by the gain score value of 0.73 (high) and t test analysis ( $t$  count  $<$  0.05) through the SPSS application.

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## Author Contributions

Y. R. A. S. and H.: Conceptualized the research idea, designed of methodology, management and coordination responsibility; D. T. B. and E. T. M.: Analyzed data, conducted a research and investigation process; A. and V. M. M. R.: Conducted literature review and provided critical feedback on the manuscript. All authors have read and agreed to the published version of the manuscript.

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## Conflicts of Interest

The authors declare no conflict of interest.

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