International Journal of Innovative Research in Education

Volume 9, Issue 2, (2022) 203–211

www.ijire.eu

# The development of RBL-STEM learning materials for students' metacognition improvement in producing herbal tea from the cascara

**Nurul Komaria** *, University of Jember, Jember, Indonesia

**Suratno Suratno**, University of Jember, Departement of Biology Education Jember, Indonesia

**Sudartik Sudartik**, University of Jember, Departement of Physics Educatio, Jember, Indonesia

**Dafik Dafik**, University of Jember, Departement of Mathematics Education, Jember, Indonesia

**Suggested Citation:**

Komaria, N., Suratno, S., Sudartik, S. & Dafik, D. (2022). The development of RBL-STEM learning materials for students' metacognition improvement in producing herbal tea from the cascara. *International Journal of Innovative Research in Education*. *9*(2), 203–211 https://doi.org/10.18844/ijire.v9i2.8581

Received from August 11, 2022; revised from October 23, 2022; accepted from December 06, 2022.
Selection and peer-review under the responsibility of Assoc. Prof. Dr. Zehra Ozcinar, Ataturk Teacher Training Academy, Cyprus


**Abstract**

STEM approach in a research-based learning method that combines innovative research and learning. This research develop a research-based learning method based on STEM approach to improve students' metacognition skills in utilizing cascara fermentation with a magnetic field to produce health herbal teas. This research and development was employed the ADDIE research and development model that consisted of five stages: analysis, design, development, implementation, and evaluation. In the analysis phase, interviews and observations were carried out based on the guidelines to identify the problems. The design of the product was then determined to be developed in the development stage, followed by the expert validation in the assessment stage to measure content validity and face validity. The implementation and evaluation stages produce the final product that was tried out to gain data of students'metacognition skills. The product developed in this research is regarded valid, effective and practical. Besides easy use, the product can serve as essential lecture material.

Keyword: Research based learning, STEM approach, Metacognition Skill;

* ADDRESS OF CORRESPONDENCE: Nurul Komaria, University of Jember, Jember, Indonesia
Email address: nurulqomariah2202@gmail.com

## 1. Introduction

Education held in various parts of the world each has distinct characteristics. The education quality that can be measured based on the efficiency and effectiveness of educators reflects the development of a nation (Angrist et al., 2021). The curriculum materials often fail to assist the current situation for many aspects of education often change rapidly (Schunk DH., 1986). Educators need to apply acceptable teaching methods in delivering the teaching materials to prevent students from being reluctant to learn monotonous materials. Applying engaging teaching method is necessary in order for the materials to be properly conveyed and for learning objectives to be optimally achieved.

Cascara utilization is included in the teaching of plantation production processing courses. Cascara is a waste from coffee bean processing that often cause ecological problems, while it could have been utilized. Waste from coffee processing contains high antioxidant compounds such as caffeine, chlorogenic acid, and trigonellin which can be used as food preservatives and nutritional supplements (Dorsey BM & Jones MA, 2017). Cascara herbal tea products have been sold in international market but are consumed in Indonesia. The myriad benefits of cascara are not well-known by the community that the demand for this cascara remains low. Cascara tea has sweet taste and mango-like aroma. The addition of other ingredients also become added values to the production, technical assessment and economic value (Aristizábal-Marulanda V et al., 2017). Cascara can be processed to produce products that offer various benefits through simple steps that should be further explored by students. Therefore, students need to learn how to process cascara into innovative products. Cascara fermentation that employs a magnetic field is one of the concepts in plantation production processing course that requires the application of STEM through a research-based learning model.

STEM education helps students learn the dynamic and complex science, technology, engineering and math skills in solving contextual problems (Reyza M et al., 2020). In addition, STEM education develops the characteristics of students as innovators, inventors, independent and to have strong technological literacy (Stohlmann M et al., 2012). STEM has been regarded capable in improving the value of mathematics and science in college and career (Becker K, & Park K., 2011). In addition, STEM improves students' learning motivation through project-based learning. The implementation of STEM in the classroom requires assistance from technology experts (Ntemngwa C & Oliver JS., 2018). STEM prepares students as potential workforce with scientific background to improve their skill development (Ejiwale JA., 2013). Classroom skill development can be accommodated by applying research-based method.

Research-based learning is a learning method that engages students in direct learning and research to gain contextual knowledge which will allow them to solve problems through an inquiry discovery approach (Tohir M et al., 2018). Research-based learning aims to enhance students' intellectual abilities that determine the development of their thinking skills (Maylisa IN et al., 2020). Prior research have confirmed the ability of the research-based learning to improve students' creative thinking skills (Nazula NH et al., 2019), besides it can also affect students generalization thinking (Dini RP et al., 2019). The method was also found significant in improving metacognition skills (Wangguway Y et al., 2020).

Metacognition skills need to be enhanced by proper design of learning materials, good monitoring of students' learning outcomes and evaluation on what has been learned (Azizah U, & Nasrudin H., 2018). Metacognitive skills determine ones' cognitive process of becoming independent learners (Listiana L et al., 2016). Independent learning ability can be improved by enhancing metacognition skills using effective learning strategies to improve learning achievement (Jayapraba AG.,2013). These conditions have intrigued the researchers to conduct research on the development of learning materials using STEM approaches to improve the students' metacognition in the production of cascara herbal tea using magnetic fields.

## 2. Methodology

### Research Design

The purpose of this research is to develop research-based learning tools with a STEM approach to improve students' metacognition skills in utilizing fermented cascara with a magnetic field to produce health herbal teas through Research and Development (R&D) research designs. In this research, a valid and legitimate learning method was developed to help students understand the potentials of cascara and how to utilize it.

**Development Procedure**

The development steps were adopted from ADDIE Models development model (Rieser and Mollinda, 1990). There were five stages of development: analysis, design, development, implementation, and evaluation. Analysis stage allowed researchers to gain information through needs analysis and literature review. The first stage was done using a need analysis that specifically gather information related to the implementation and to identify various problems.

In the design stage, a solution was designed to solve the problems that had been identified in the first stage. Meanwhile, in the planning stage, some aspects were prepared including the test standards, media selection, format selection and the initial design according to the chosen format. Preparation of test standards connected the analysis stage and the design stage. The preparation of this test standards was performed by compiling pretest and posttest grids. The grids were then arranged based on the level of cognitive skills and the predetermined learning objectives. Format selection included the format for learning content, learning approaches, learning methods, and learning steps. One of the most important formats in this research is selecting learning tools through a research-based learning model with STEM education to be attractively packaged. The teaching and learning activity was designed to engage students to discover learning concepts and make the goals easier to achieve with the guidance of lecturers. The design of all activities was determined in the design stage. The initial design of the teaching and learning included the design of syllabus, lesson plans, student worksheets, pretest and posttest.

The develop stage was where the product was made. Product validation and limited try outs were also parts of this stage. The expert validation consisted of content validation which included validation of all learning tools that have been developed at the design stage and content validation that was carried out by 3 experts, namely media experts, material experts and development experts. If the product needed minor revisions, the product would be directly revised to be immediately tested in small scale class. Limited try outs were carried out to obtain direct input from the field on the learning tools that had been prepared. The try out were recorded including responses, reactions, comments from lecturers, students and observers.

In the implementation stage, the final products was tried out on a wider scale audience, for example in other classes, other universities and other lecturers. This stage was performed to test the effectiveness of the product to use in teaching and learning activities.

Evaluation is a process carried out to provide value to the development of learning tools. At this stage, the product was evaluated to identify problems that occurred in the implementation stage to be developed and revised for the final product.

**Data Collection Instrument**

Data of this research were collected through interviews and observation. The problems before and after the research as well as the obstacles faced by students and lecturers are outlined in the interview guide while the observation sheet contained a checklist of learning implementation sheets in plantation product processing courses, particularly for the chapter on cascara fermenting using magnetic fields to produce health herbal teas. Based on the results of interviews and observations, problems arose in lectures regarding the comprehension of the concept of cascara production. At the development stage, data were collected, including data on content validity and face validity from expert validators.

**Validity**

Validation sheets were used to obtain the data and to determine the effectiveness of the product. The validation sheet was used to measure the validity of the learning device in terms of its content and construction based on a strong theoretical rationale and was internally consistent between the components of the learning device. The validation sheets that were assessed in this study were syllabus validation sheets, semester learning plans, student worksheets, pretest and posttest. Three validators that included material experts, linguists and development experts were involved to assess the product. The assessment of learning tools consisted of four categories, namely Poor (1 point), Fair (2 points), Good (3 points), and Very Good (4 points). Validation sheets were sent to the validators. The validators then assessed the products based on the validation sheets.

**Comprehention Test on The Utilizing of Cascara Concept**

The test for understanding the concept of using cascara measured conceptual questions related to the learning objectives achieved after using the tools developed in the learning process. The answers were then scored based on the scoring rubric that has been made. Students' metacognition skills were assessed using two methods: questionnaires and essay questions. Students' metacognitive skills were assessed based on the questionnaire and the MAI (Metacognitive Awareness Inventory) consisting of 52 items covering 2 components, namely knowledge about conditions and regulation of cognition. Students provided responses based on the following options: "always (SS)" score 5, "very often (SS)" score 4, "often (SR)" score 3, "rarely (JR)" score 2, "very rarely (SJ)" score 1 and "never (TP)" score 0. The scores were then summed up to be converted into a scale of 0-100.

**Data Analysis**

The average score of the indicator given by each validator was determined. Based on the average value of the indicators, the average value for each aspect is determined. The average value of the total aspects was determined by the average value for each aspect. The criteria for learning devices showed a good degree of validity, if the minimum level of validity achieved is a valid level. If the level of attainment of validity is below valid, thus it is necessary to revise it based on the input (corrections) of the validators. The validation again was conducted again to develop ideal learning methods and tools.

The practicality of the product was measured based on the observation sheet during the learning process using a four-point Likert scale. The percentage of observer and user responses was calculated using the following formula :

$$\%\ of\ Practicality = \frac{The\ number\ of\ implemented\ descriptors}{Total\ of\ Descriptor} \times\ 100\%$$

The practicality percentage of the device developed and assessed by observers and users was then converted into qualitative data: very good (81.25 ≤ x <100), good (62.5 ≤ x < 81.25), Fair (43 .75 ≤ x 62.5), and fair check (25 ≤ x < 43.75).

The effectiveness of the product was assessed based on the results of the metacognition skills obtained from the pre-test and post-test scores. The metacognition skills can be calculated using the following formula:

$$Value = \frac{\text{final score} - \text{initial scorel}}{\text{max score} - \text{initial score}}$$

The categorization of students' metacognitions kills based on the rating scale as presented in Table 1.

Tabel 1. Categorization Metacognition Skills

| No | Category Choice | Score | Description |
|---|---|---|---|
| 1 | *Super* | 85 ≤ x ≤ 100 | Regularly using metacognitive awareness to rule their thinking process. A person with strong metacognition skills |

| | | | |
|---|---|---|---|
| | | | objects to understand the art of learning. There are many alternatives to the thinking and speaking skills that can be used to reflect the process. |
| 2 | *Ok* | 68 ≤ x ≤ 85 | Growing awareness will allow our readers that students can perform the input-elaboration-output. |
| 3 | *Development* | 51 ≤ x ≤ 68 | Can facilitate thinking skills when adequate support is given. |
| 4 | *Can not really* | 34 ≤ x ≤ 51 | How a person things |
| 5 | *Risk* | 17 ≤ x ≤ 34 | Seeming not to have a process |
| 6 | *Not yet* | 0 ≤ x ≤ 17 | No sign of metacognitive |

## 3. Result And Discussion

### Analyze

A need analysis was carried out in two study programs at the Politeknik Negeri Jember to identify the problems that occurred to examine which improvement should be made to make teaching and learning activities more optimal. Many lecturers were less innovative in carrying out the teaching and learning activities. In this research, Problem Based Learning using group case studies according was performed based on the procedures that have been developed. Lecturers have never developed learning tools with material on cascara utilization through a research-based learning model with a STEM approach while the materials could be very beneficial. Neither theoretical or practical studies had been conducted to develop research-based learning model with a STEM approach. When the researchers distributed the questionnaires, they were not familiar with this term due s due to the limited information they obtained, both from existing lectures and textbooks. Therefore, innovative teaching materials are needed to catch up with scientific developments. Another preliminary study was carried out in the analysis of needs in coffee plantations by distributing questionnaires to coffee farmers and direct observation of plantations. There are problems in the plantations due to coffee waste which is immediately thrown away under the coffee plants which hampered the growth of the coffee plants.

The literature study also included an analysis stage to find accurate sources of information in the form of books for the last 10 years, national journals and international journals for the last 5 years. These references were beneficial in the development of learning tools. With this literature study, it is hoped that researchers will be more innovative in developing learning tools so that students get new nuances in learning.

### Design

A research-based learning model with a STEM approach was used to complement the advantages and disadvantages of the model. Hence, the method is quite attractive in improving thinking skills as expected in the 21st century. The design stage in this research was performed to determine learning outcomes related to the cascara production concept both from content design and learning outcome indicators as seen in Table 2.

Table 2. The Relationship of Learning Outcome, Concept Analysis and Achievement Indicators

| Learning Outcome | Concept Analysis | Achievement indicators |
|---|---|---|
| Students are able to explain and practice diversification of processing products using cascara coffee | • The economic potentials should be improved | • Through RBL students are able to analyze the benefits of cascara by analyzing planning, monitoring and evaluating the concept of cascara<br>• Through RBL students are able to identify the structure of coffee cherries to obtain quality cascara |

| | |
|---|---|
| • Utilization of cascara through laboratory tests | • RBL allows the students to perform fermentation with magnets<br>• RBL allows the students to perform fermentation without magnets<br>• RBL allows the students to process non-fermented cascara |
| • Research of test on the utilization of cascara | • RBL allows students to conduct quality assurance and test the cascara product<br>• RBL allows the students to conduct presentation and to create an article about cascara |

The next stage was the identification stage where cost of developing a learning model, time, place of try out, method of data collection, data analysis and other supporting data were collected. The results of the development stage of this device were the draft of the learning devices. To produce a valid product, expert validations were conducted.

**Develop**

At this stage, the development and validation of the developed product was carried out. Improvements continued to be made until the learning tools developed include syllabus, semester learning designs, pretest and posttest student worksheets that reach valid criteria. The following is an example of developing a student worksheet draft developed through a research-based learning model with a STEM approach. The initial page on the student sheet is given a cover, student worksheet instructions and identity. The next sheet writes the science problem posing: cascara waste (Exposure stage), engineering problem posing: machine use (experience stage), Engineering breakdown (experience stage), hypothetical mathematics analysis: organoleptic (capstone stage) and projecting remark (capstone stage). To make it clearer about the design of the student worksheets developed, consider Figure 1

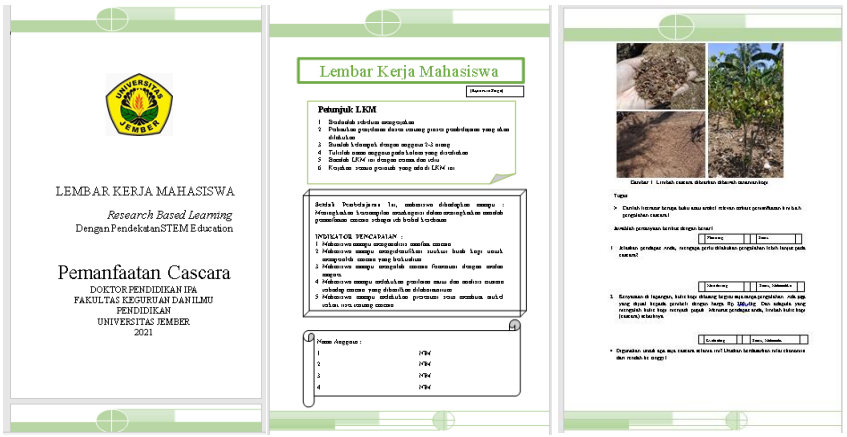


Figure 1. RBL Worksheet using STEM approach

The product developed in this stage was then validated by the experts as shown in Figure 2.

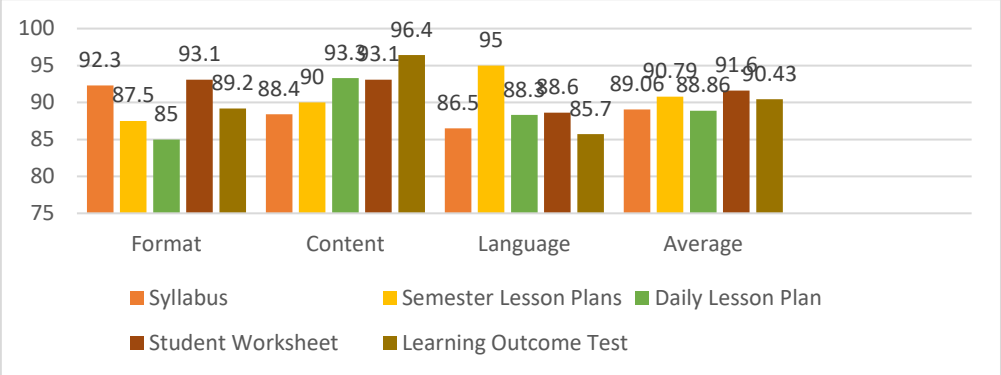


Figure 2. Content Validation

As seen in Figure 2, there are several components including syllabus, semester learning plans, daily learning plans, student worksheets, and learning outcomes which are developed and categorized highly valid followed with positive comments from the validator. The instrument for data collection, including the pretest and posttest questions have been tested for validity and reliability as well. The validity of each item tested using SPSS shows a significance (2-tailed) below 0.05. Whereas, the reliability of the questions shows a Cronbach's alpha of 0.801, thereby all the questions have met the validity and reliability criteria.

The practicality of the developed device was also measured. The device is regarded practical if it meets predetermined criteria. The results of the practicality test showed a percentage of 85% for students' responses, 89.1% for observing student activities, and 91.6% for observing the implementation of learning tools. Furthermore, the effectiveness of the developed learning tools were analyzed based on the outcomes of the pretest and post-test. The pretest and post-test questions were developed based on the indicators of metacognition skills. The sig (2-tailed) of 0.001 shows a significant influence on the implementation of research-based learning tools with the STEM approach in improving students' metacognition skills (see Table 3). To ensure the effectiveness of the product, responses of users were analzyed, resulting in an average score of 93%.

Table 3. Paired SampleTest

**Paired Samples Test**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference Lower | Upper | | | |
| Pair 1 | Pretest - Posttest | -1,94207 | 3,34291 | ,52208 | -2,99723 | -,88692 | -3,720 | 40 | ,001 |

If the product has been regarded valid, the product could be tried out in small group. The small group test/limited test was carried out in 3 meetings. There was one lecturer who acted as observer. There were 12 students in the room consisting of 4 students with moderate abilities and 4 students with high abilities. The first step taken by the researcher during the small group test/limited test was to provide pretest questions of initial metacognition skills.

**Implementation**

The implementation stage was carried out for 5 meetings consisting of exposure stage, experience stage and capstone stage. Each meeting was started with greetings and prayers, explaining the learning objectives, stimulating student knowledge by giving examples of pictures of coffee plants. After that, students were given questions "Do you know about the use of leaves, stems, roots or other parts of the coffee plant? Next, the pictures of post-harvest coffee (pulping process) and the reality of coffee plant waste that exists in farmers were presented. Students were then asked "What efforts should be

made so that the waste can have economic value? A link was given to allow students have a look at cascara products sold on marketplace. Students were grouped into several heterogeneous groups and they worked on a worksheet. The experience stage was carried out by observing the discussions. After that, one group was selected to present their discussion results. In the closing stag, students were encouraged to make conclusions and were given the reinforcement before prayers. Time allocation for preliminary activities was 15 minutes, 75 minute of core activity and 20 minutes for closing.

**Evaluation**

This stage is carried out by evaluating the implementation of the implementation phase and writing down any deficiencies during the implementation of material development. Based on the implementation of the development that has been carried out, the results of the material development are good even though there are some deficiencies and can be corrected in accordance with the demands of scientific developments.

**Discussions**

Teaching and learning activities indirectly enhance students' metacognitive abilities. This research and development was performed through the steps of literature review activities on the planning aspects of metacognition skills. These aspects are important for students as they need to use their previous knowledge before the learning occurs. In research-based learning activities, students are given questions that make them think and answer the questions critically. When students make questions and other students answer them, monitoring and correction occurred which determine students metacognition. Students can also enhance their metacognitive skills in the strategic aspects of information management because at this stage students organize and detail a concept. The explaining back the information also improves students' metacognitive abilities in the form of declarative knowledge. Students with the pre-existing knowledge about this matter need to re-explain their knowledge based on their understanding. This strategy was employed to raise students' awareness regarding their weaknesses and shortcomings which eventually improve their metacognitive skills.

Learning objectives will be achieved optimally through the use of right learning strategy. The ability to select proper learning strategies determines the development of metacognitive skills. The development of metacognitive skills requires guidance and support from educators considering that this ability does not appear without stimulations (Li C & Nietfeld JL., 2007). Therefore, a teacher must empower the students that will improve their metacognitive skills.

## 4. Conclusion

The expert validations conducted in this research on the product of this study showed highly valid, practical and effective results. The learning tools developed meet valid criteria and are suitable for use in the learning process so that it makes it easier for students to understand the material for using cascara

## References

Angrist, N., Djankov, S., Goldberg, P. K., Patrinos, H.A. (2021). Measuring human capital using global learning data. *Nature.* http://dx.doi.org/10.1038/s41586-021-03323-7

Aristizábal-Marulanda V., Chacón-Perez Y., Cardona Alzate, C. A. (2017). The biorefinery concept for the industrial valorization of coffee processing by-products. Handbook of Coffee Processing By-Products: Sustainable Applications. Elsevier Inc. 63–92 p. http://dx.doi.org/10.1016/B978-0-12-811290-8/00003-7

Azizah, U., Nasrudin, H. (2018). Empowerment of Metacognitive Skills through Development of Instructional Materials on the Topic of Hydrolysis and Buffer Solutions. *J Phys Conf Ser*. 953(1). https://iopscience.iop.org/article/10.1088/1742-6596/953/1/012199

Becker, K., Park, K. (2011). Effects of integrative approaches among science, technology, engineering, and mathematics (STEM) subjects on students' learning: A preliminary. *J STEM Educ*.12(5):23–38. https://jstem.org/jstem/index.php/JSTEM/article/download/1509/1394

Dini, R.P., Dafik., Slamin.(2019). The analysis of generalization thinking Skills on solving local super H-decomposition antimagic total coloring regarding the application of research based learning. *J Phys Conf Ser*. 1211(1). https://iopscience.iop.org/article/10.1088/1742-6596/1211/1/012080

Dorsey, B. M., Jones, M.A. (2017). Healthy components of coffee processing by-products. Handbook of Coffee Processing By-Products: Sustainable Applications. Elsevier Inc. 27–62 p. http://dx.doi.org/10.1016/B978-0-12-811290-8/00002-5

Ejiwale, J.A. (2013).Barriers To Successful Implementation of STEM Education. *J Educ Learn*. 7(2):63–74. https://doi.org/10.11591/edulearn.v7i2.220

Jayapraba Psn, A.G. (2013). Metacognitive Instruction and Cooperative Learning-Strategies for Promoting Insightful Learning in Science. *Int J New Trends Educ Their*. 15–1309. http://ijonte.org/FileUpload/ks63207/File/15.jayapraba.pdf

Li, C., Nietfeld, J. L. (2007). College students' metacognitive awareness of difficulties in learning the class content does not automatically lead to adjustment of study strategies. *Aust J Educ Dev Psychol*. 7(678):31–46. https://files.eric.ed.gov/fulltext/EJ815620.pdf

Listiana, L., Susilo, H., Suwono, H., Suarsini, E. (2016). Empowering students' metacognitive skils through new teaching strategy (group investigation integrated with think talk write) in biology classroom. *J Balt Sci Educ*. 15(3):391–400. http://oaji.net/articles/2016/987-1482422861.pdf

Maylisa, I. N., Dafik., Hadi, A.F., Wangguway, Y., Harjito, L.O. (2020). The influence of research-based learning implementation in improving students' combinatorial thinking skills in solving local irregularity vertex r-dynamic coloring. *J Phys Conf Ser.* 1538(1). https://iopscience.iop.org/article/10.1088/1742-6596/1538/1/012090

Nazula, N.H., Dafik., Slamin. (2019). The profile of students' creative thinking skills in solving local antimagic vertex coloring problem in researchbased learning. *J Phys Conf* Ser. 1211(1). https://iopscience.iop.org/article/10.1088/1742-6596/1211/1/012109

Ntemngwa, C., Oliver, J.S. (2018). The implementation of integrated science technology, engineering and mathematics (STEM) instruction using robotics in the middle school science classroom. *Int J Educ Math Sci Technol*. 6(1):12–40. https://www.ijemst.net/index.php/ijemst/article/download/426/124

Reyza, M., Taqwa, A., Ardiansyah, A.A., Nurhidayat, M.A. (2020). INDONESIAN JOURNAL OF EDUCATIONAL RESEARCH AND REVIEW STEM on Science Learning in Indonesia: An Opportunity and A Challenge. *EjournalUndikshaAcId*. 160–70. https://doi.org/10.23887/ijerr.v3i3.27660

Schunk, D.H. (1986). Experimental speculations. Vol. 322, *Nature*. 399 p. https://libres.uncg.edu/ir/uncg/f/D_Schunk_Self_1989.pd

Stohlmann, M., Moore, T., Roehrig, G. (2012). Considerations for Teaching Integrated STEM Education [Consideraciones para enseñar educación STEM integrada]. J *Pre-College Eng Educ Res*. 2(1):28–34. https://eric.ed.gov/?id=EJ1056132

Tohir, M., Abidin, Z., Dafik ., Hobri, H. (2018). Students creative thinking skills in solving two dimensional arithmetic series through research-based learning. *J Phys Conf Ser*. 1008(1). https://iopscience.iop.org/article/10.1088/1742-6596/1008/1/012072

Wangguway, Y., Slamin., Dafik., Maylisa, I.N., Kurniawati, S. (2020). The analysis of research-based learning implementation and its affect to the students' metacognition skill in solving a resolving domination number of a graph. *J Phys Conf Ser*. 1538(1). https://iopscience.iop.org/article