Proceeding SYMBION
(Symposium on Biology Education)
http://seminar.uad.ac.id/index.php/symbion
2540-752X (print) | 2528-5726 (online)

Design of RBL-STEM learning model through analysis of chitosan making from crab shell waste in improving students' metacognition

H.B.A Jayawardana[1] *; Syifa Salsa Bella M.P[2]; Zulfa Nur Hakiki[3]
Biology Study Program, PGRI Argopuro Jember University (UNIPAR), Jember, Indonesia
[1]hepta2011@gmail.com*; [2]sooahn35@gmail.com; [3]zulfanurhakiki50@gmail.com
* Corresponding author

ARTICLE INFO

Article history
Submission Dec 10th, 2022
Revision May 10th, 2023
Accepted May 17th, 2023

Keyword
RBL learning model
STEM approach
Metacognition
Chitosan

ABSTRACT

Metacognition skills are needed in the face of technological disruption and the current industrial revolution 4.0 era. Metacognition is the ability to control cognitive processes in one's learning and thinking activities so that they become more effective and efficient. Metacognition is generally related to the dimensions of a person's thinking which can be divided into two parts, namely the awareness he has about his thinking (self awareness of cognition) and the ability to use his awareness to regulate his thinking process (self-regulation of cognition). Metacognition can be achieved by fostering high-order thinking skills (HOTS). Therefore, a research-based learning (RBL) with STEM (Science, Technology, Engineering and Mathematics) approach is needed. This study aims to develop a learning design with the RBL model with a STEM approach through the analysis of making chitosan from crab shell waste in improving students' metacognition. The research method used is a narrative qualitative method, which develops the syntax of the RBL learning model with the STEM approach. The main result of the research is a learning activity framework in the form of a description containing learning activities that will be carried out in the classroom.

Introduction

Metacognition is a person's ability to organize and control cognitive processes in learning and thinking so that they become more effective and efficient. Students' metacognition skills are needed in welcoming the era of industrial revolution 4.0 and technological disruption like today. By improving their metacognition skills, students are expected to be able to solve problems, have awareness of their thinking process, and control their way of thinking.

Metacognition can be used by students to detect the extent of understanding a problem. In the context of learning, students can know how they can learn and know their abilities, so they can know what learning strategies are the most optimal for learning more effectively and efficiently. However, the facts in the field, especially in biology learning carried out so far, only emphasize mastery of material, while the space for metacognition is less considered, so students tend to learn by remembering or memorizing only. As a result, when students are faced with problems, they will have difficulty solving them and cause low student learning outcomes[1].

In relation to the independent curriculum that has been implemented by the government today, learning must be able to motivate students to work and take real action in everyday life, so that not only mastery of material is the main goal, but what is far more important is the metacognitive ability of students in solving real-life problems. One of the learning models that can improve students' metacognition skills is the RBL (Research Based Learning) learning model which is integrated with the STEM (Science, Technology, Engineering and Mathematics) approach. According to the STEM approach, the four elements in STEM must be involved because they are important elements in improving students' metacognition skills[2].

Therefore, this study will analyze the making of chitosan from crab shell waste in improving students' metacognition. Chitosan is a derivative compound of chitin substance in crab shells[3]. Chitosan can be obtained by processing chitin through a process of demineralization, deproteination, and deacetylation[4]. Metacognition skills are one type of high-level thinking skills (HOTS) that students need in the 21th century[5]. Based on research results, students who have been taught metacognition skills have better learning outcomes[6]. According to the metacognition skills can be divided into metacognition knowledge and metacognition organization[7]. Metacognition knowledge includes declarative, procedural, and conditional knowledge while metacognition settings consist of three main components, namely planning, monitoring, and evaluating. Furthermore, how the results of this analysis are applied in the classroom, the RBL-STEM learning model will be developed in the form of an analysis of making chitosan from shrimp shell waste in improving student metacognition.

Method

This study used a narrative qualitative research method. This research started from collecting some literature to review related to RBL and STEM. This research also explored the STEM problematics. Furthermore, the syntactic framework of integration between the RBL learning model and the STEM approach in solving the STEM problematics was developed. Then it will be learning outcomes, learning objectives, indicator development related to metacognition are presented. The research continued by describing the role of four STEM elements consisting of Science, Technology, Engineering and Mathematics in solving the problems that have been determined. The next step is to describe each stage of RBL complete with learning activities and complete metacognition indicators.

Results and Discussion

Syntax of RBL Learning Model with STEM Approach

The syntax for integrating the RBL (research-based learning) learning model with the STEM (Science, Technology, Engineering, and Mathematics) approach in improving students' metacognition skills in analyzing the problem of making chitosan from crab shell waste will be presented below. In the early stages of the syntax of the RBL learning model, students are asked to understand the problem posed, then students are encouraged to develop problem-solving strategies, collect information from various literature using search engines, collect data and at the same time analyze it, and the last step is to report it.

The current problem is that Indonesia has vast mangrove forests. These mangrove forests have enormous potential but have not been optimally utilized by the community. One of the abundant natural resources of mangrove forests is mangrove crabs (Scylla serrata). Currently, people only consume the meat, which is only 20% of the weight of the crab, while the remaining 80% of the crab shell has not been utilized so that it becomes waste. According to Mashuni, et al., the crab shell waste is still rarely utilized properly and is usually just thrown away. Crab shells contain chitin around 18% - 30% so that the chitin compounds contained in crab shells contain very high economic value if processed into a more useful compound, namely chitosan[3].

Furthermore, students are asked to develop new breakthroughs related to the processing of crab waste into chitosan through google, youtube, google scholar and other online media to find a new breakthrough. The main breakthrough that we already understand is the utilization of crab shell waste into chitosan. The following schematic presents the STEM problem and the description of its four elements in making chitosan from crab shell waste (Figure 1).

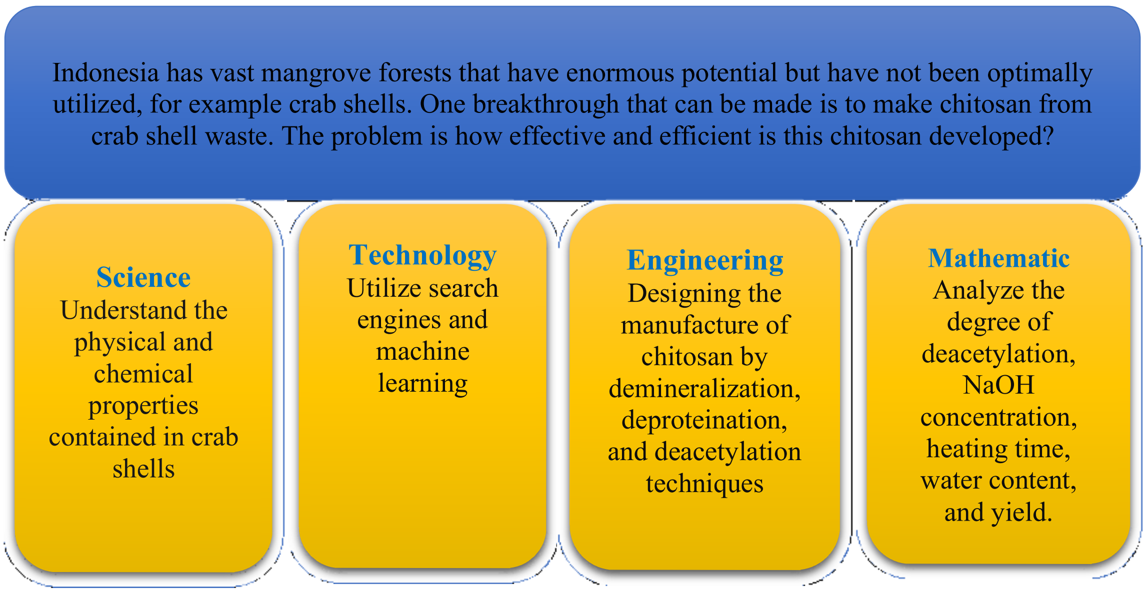

Fig 1. STEM problems in processing crab shells into chitosan

After understanding the STEM problematics in figure 1 above, then conduct a narrative qualitative research by following the syntax of RBL-STEM integration as follows: (1) The first step is to determine the fundamental problem related to the non-optimal utilization of crab shell waste; (2) The second step is to develop a solution to a real-world problem related to making chitosan from crab waste; (3) The third step is to collect data and search for references needed with the help of internet technology related to making chitosan from crab waste; (4) The fourth step is to develop the aspects needed by students in the research process (for example, the potential of chitosan; the design of making chitosan, the content of chitosan, and the benefits of chitosan); (5) The fifth step is to analyze the effectiveness and efficiency of making chitosan; and (6) The sixth step is to write in the form of a research report and present the making of chitosan. More systematically, the framework of the RBL-STEM learning model is as follows (Figure 2).

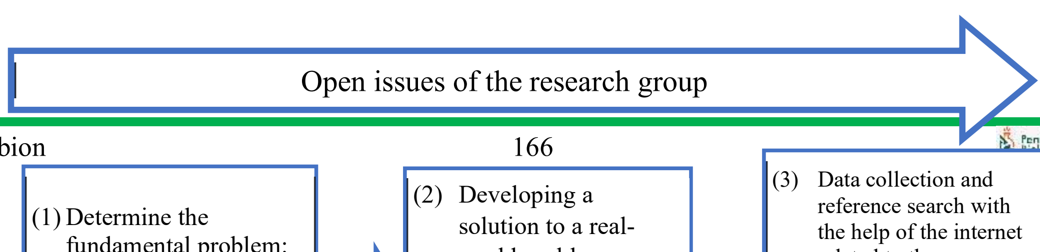

Fig 2. Framework of RBL-STEM learning model in chitosan manufacturing

Student learning outcomes and objectives

The expected learning outcomes in this research through the RBL learning model with a STEM approach are that students can improve their metacognition in solving problems of making chitosan from crab waste. Students know the technique of making chitosan through semineralization, deproteination, and deacetylation techniques. Students can also test whether the chitosan obtained is effective and efficient. Effective means that it can be used as needed while efficient is the cost needed to make it affordable, so that it can help solve problems in society. Students are also expected to know the content or composition of chitosan so that it can be useful in everyday life.

The learning objectives in this study are that learning the RBL model with the STEM approach allows students to develop knowledge and skills in Science, Technology, Engineering, and Mathematics. Each element in the STEM model has its own learning objectives. The learning objectives in the four elements of STEM can be described as follows.

Science - after carrying out the research process, students are expected to be able to:

- Identify crab shell waste as a material for making chitosan.
- Understand the physical and chemical properties of chitosan.
- Understand how to make chitosan
- Know the benefits of chitosan.

Technology - after carrying out the research process, students are expected to be able to:

- Utilize the internet, google scholar, or youtube tutorials to find out how to make chitosan.
- Utilize software to analyze the effectiveness and efficiency of making chitosan using artificial neural network analysis techniques.

Engineering - after carrying out the research process, students are expected to be able to:

- Design the manufacture of chitosan from crab shell waste.
- Perform the chitosan manufacturing process based on the design that has been made.

Mathematics - after carrying out the research process, students are expected to be able to:

- Make calculations, analyze the degree of deacetylation, NaOH concentration, heating time, moisture content, and chitosan yield.
- Perform calculations for chitosan production on a larger scale using machine learning Artificial Neural Network.

STEM Elements in the Preparation of Chitosan from Crab Shells

Science Element

Crab shells contain chitin around 18% - 30% so that the chitin compounds contained in crab shells contain very high economic value if processed into another compound that is more useful, namely chitosan. Chitosan is a derivative compound of chitin substances in crab shells. One of the benefits of chitosan is as a natural preservative in food[8]. Chitosan is a polysaccharide consisting of N-acetylglucosamine and D-glucosamine monomers with the general formula $(C_6H_{11}NO_4)_n$ or β-(1-4)-2-amino-2-deoxy-D-glucopyranosa[3]. Chitosan can be obtained by processing chitin through demineralization, deproteination, and deacetylation processes[4].

Fig 3. Crab shell waste that can be processed into chitosan

Technology Elements

Information technology, computers, and the internet are currently developing very rapidly, especially with the 5G internet network and the industrial revolution 4.0 allowing everything to be connected to the internet (internet of things). With artificial intelligence technology, Google, and YouTube can be used as the main media for students to learn material related to chitosan (Figure 4).

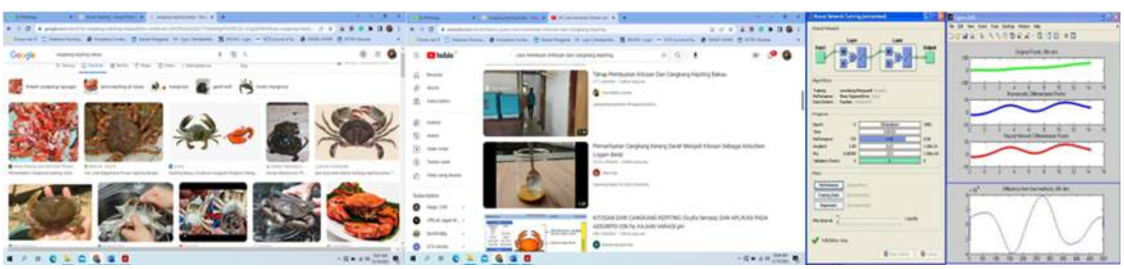

Fig 4. Use of internet information technology and machine learning

Engineering Elements

Elements in the engineering section are related to designing the manufacture of chitosan from crab shell waste based on the design that has been made before. There are several techniques for making chitosan. In this study, the manufacture of chitosan was carried out through deproteination, demineralization, and deacetylation techniques based on research conducted by Aji and Meriatna[4]. Briefly, the explanation is as follows: (1) Deproteination stage. The deproteination stage was carried out at 65°C using 100 ml NaOH solution and stirred for 2 hours. Then filtered using filter paper, washed thoroughly to take the sediment; (2) Demineralization stage. In the demineralization stage, 100 ml of HCl was added to the beaker glass and then soaked at 25-30°C (room temperature) for 2 hours. The results obtained were filtered with a Buchner filter with filter paper. Then washed with distilled water until the pH is neutral. The solids obtained were dried again at room temperature; and (3) Deproteination stage. In the deproteination stage, 10 g chitin was put into a beaker glass, 50 ml of 40% NaOH was added, heated at 100°C while stirring for 2.5 hours. The chitin solution was filtered and washed until the pH was neutral, then dried at room temperature. The resulting chitosan was weighed, analyzed for moisture content, yield and degree of deacetylation. Furthermore, the chitosan obtained was analyzed using FTIR to determine the Degree of Deacetylation (DD) through the line method by Moore and Robert (Figure 5).

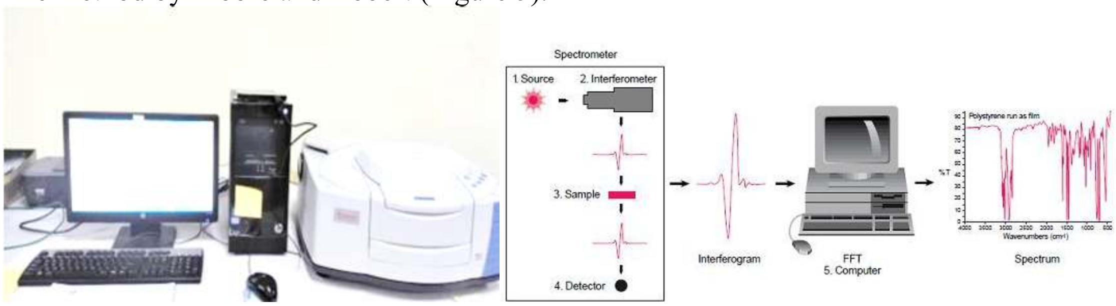

Fig 5. Engineering elements of the chitosan manufacturing process

Mathematics element

In this mathematical section, the degree of deacetylation will be calculated based on the NaOH concentration used in the preparation of chitosan.

Table 1. Degree of deacetylation calculation based on NaOH concentration

No.	NaOH concentration (%)	Degree of Deacetylation (%)
1	20	45.58
2	30	72.46
3	40	80.43

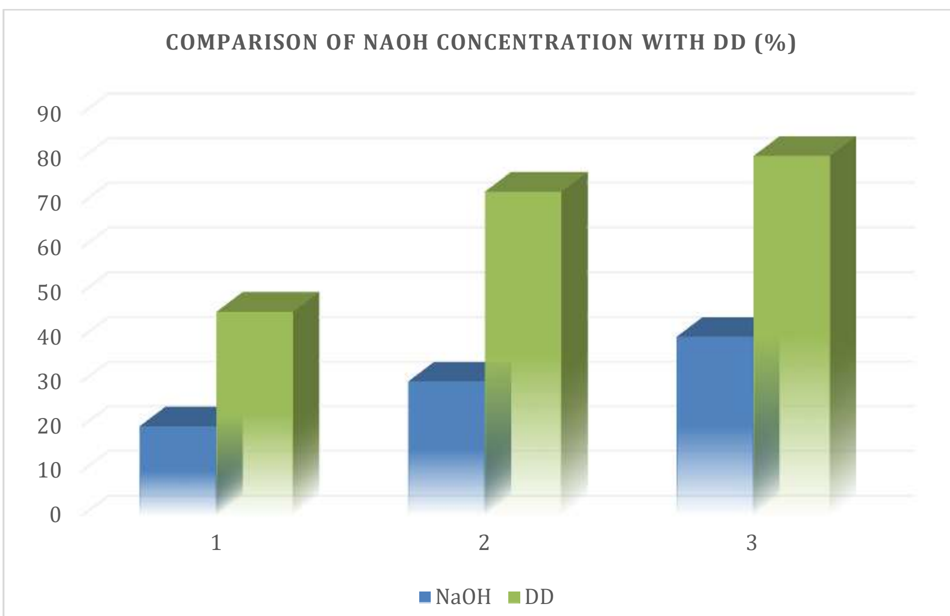

Fig 6. Comparison diagram of deacetylation degree based on NaOH concentration

Student Metacognition Ability Assessment Instrument Framework

Students' metacognition ability in the form of a framework for assessing metacognition ability instruments can be seen in table 2 below.

Table 2. Framework of Student Metacognition Ability Assessment Instrument

Indicator	Description	Test Material
Planning	The planning stage helps students recall previously acquired knowledge so as to facilitate the planning process of understanding the material being studied.	1. Identify the fundamental problem related to the lack of utilization of crab shell waste. 2. Discuss a solution to a real-world problem related to the manufacture of chitosan from crab shell waste.
Monitoring	The monitoring stage serves to monitor student activities during the learning process.	1. Search and collect data through the search for references needed with the help of internet technology related to the manufacture of chitosan from crab shell waste. 2. Identify the aspects needed in the research process (potential, content, design, and benefits of chitosan from crab shell waste).
Evaluating	The evaluate stage plays a role in improving student learning outcomes because students can evaluate and correct deficiencies during the learning process.	1. Analyze the effectiveness and efficiency of making chitosan from crab shell waste. 2. Make a report on the research results of making chitosan from crab shell waste and present it in front of the class.

Framework for Student Metacognition Assessment Instrument

The learning device development stage will use the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model developed by Raiser and Mollenda. This model consists of analysis, design, development, implementation and evaluation. The first stage, the analysis stage, is analyzing student characteristics, materials, learning processes, and learning media to be used. The second stage, the design stage, is designing the integration of the RBL model into the STEM approach. At this stage, teaching materials, namely syllabus, lesson plans, worksheets, pre-test, post-test, and other assessment instruments, are prepared by researchers. The third stage, the development stage, is testing teaching materials and instruments to check the validity of teaching materials and practicality. The validation results are content validity, format validity, language validity, and practicality level. The fourth stage, the implementation stage is to determine the effectiveness of RBL-STEM teaching materials in improving students' metacognition in solving the problem of making chitosan from crab shell waste. The fifth stage, the evaluation stage, is a reflection activity to assess whether the application of the RBL model learning material with a STEM approach can improve students' metacognition in solving the problem of making chitosan from crab shell waste.

The development of the learning activity framework of the RBL-STEM model in solving the problem of making chitosan from crab shell waste to improve students' metacognition is very useful to study. These results serve as a guideline in conducting further research. There are at least two more research activities that can be carried out further, namely: (1) developing RBL-STEM learning materials with the ADDIE development model, (2) Analyzing the implementation of RBL-STEM learning materials in improving students' metacognition in solving problems of making chitosan from crab shell waste. The RBL-STEM combination learning activity framework is very effective in realizing student metacognition when applied in classroom learning.

Conclusion

The results of this study have described how the syntax of the RBL learning model integrated with the STEM approach. The main result is the framework of learning activities with the RBL model with the STEM approach, namely making chitosan from crab shell waste as an effort to improve students' metacognition. The research results in the form of a learning activity framework in the form of learning activities carried out in the classroom. Included in the results of this study is developing a framework of test instruments related to student metacognition. With the results of this study, further research related to device development and analysis of RBL-STEM implementation can be done easily.

Acknowledgment

Thanks to all the research team, especially the NATURES (Natural Resource Education Study) research group, Biology Study Program, Faculty of Science and Technology, UNIPAR Jember who have supported this research so that this research can be completed on time.

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