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THE DEVELOPMENT OF BIOTECHNOLOGY'S LEARNING INSTRUMENTS ORIENTED HIGHER-ORDER THINKING AND THE UTILIZATION OF NATURAL RESOURCES TUNDA'S ISLAND POTENTIAL

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Abstract

Science and technology learning should not just provide a collection of facts, laws and theories but rather is a process conducted by the students to acquire knowledge through interaction with the surrounding environment. The students are trained in scientific thinking critically, creatively and independently through active and meaningful learning process, for example by using the environment as a learning resource. This study aims to develop learning equipments oriented higher-order thinking skills (critical and creative) to explore the potential of biological resources of Tunda island, as a learning resource in the subject of Biotechnology. This study used research and development (R & D) method, which consists of the stages of analysis, design, validation and revision. Learning equipments that produced are RPS (lesson plans for 1 semester), the student worksheets (LKM), and evaluation (test) instruments. The results of the validation team of experts showed that the learning equipments are good categorized, with the values 77.14 for RPS, 85 for LKM, and 94 for instrument test. Criticisms and suggestions from the experts were used as the basis of revision, so that the learning equipments are eligible for learning.

Keywords: Research and Development, Tunda Island, Critical Thinking, Creative Thinking, Biotechnology Subject

INTRODUCTION

Biotechnology is one of the courses in the Department of Biology Education of the University of Sultan Ageng Tirtayasa, which in the process of learning tends to refer more to textbooks, especially about modern biotechnology. In any concept application, biotechnology practice is still limited to the production of fermented foods commonly found in the community such as yogurt, tempe, and tape, which belongs to traditional/ conventional biotechnology. In fact, the application of biotechnology, both traditional and modern, can be conducted in various areas of life, covering the fields of food industry, health and pharmaceutical, agriculture, and environment. Limitations of facilities and infrastructure in the laboratory became one of the obstacles to the application of modern biotechnology concepts in student lab. In addition, biotechnology learning has also never touched the potential of local biological resources in Banten area that can be utilized as a learning resource. According to Johnson (2014), in order to make learning more fun and meaningful, the contextual strategies are needed, allowing learners to connect the concepts they learn with daily life, including the potential that exists in the environment.

Tunda island is one of the potential natural resources, which is administratively located in TirtayasaSubdistrict, Serang District, Banten Province. Geographically, Tunda island is located at the coordinates of 5 ° 48 '43,000 "LS 106 ° 16' 47,000" BT, with the west, east and north border is the Java Sea. Tunda island is one of 17 island clusters scattered in Serang Districtthat have three important coastal ecosystems, including mangrove ecosystems, seagrass and coral reefs (Darus, et al., 2014). The potential of biological resources has not been studied by researchers, even used as a source of student learning. In fact, the existence of Tundaisland is far from the mainland gives its own privileges of natural resources that have an important role in maintaining the balance of the environment. Marine biological resourcessuch as macroalgae and microalgae can be utilized as biotechnology products, both as alternative food ingredients and basic ingredients for cosmetics and vitamin sources in health, as well as sources of biofuels.

On the other hand, today, threats to the coastal ecosystem of the island of Tunda are increasing, both from nature and human activities (anthropogenic waste), especially on island ecosystems close to urban areas. Darus et al. (2014)

reported that coral reefs on Tundaisland at the time of observation were found to be diseased, one of which was pigmentation response. The color changes caused by the light exposure are very evident in coral reef ecosystems on Tunda island.Riska's research et al. (2015) also found that the concentration of Pb accumulated on *Poriteslutea* coral in Tunda Island, especially on windward region (averaged wind) average 9.69 mg kg-1/year, while in the leeward area (protected from wind) average of 13.33 mg kg-1/year. The condition of environmental damage that occurred in Tundaisland can be an interesting study for students in biotechnology learning. Students are expected to be able to analyze the source of the damage and provide solutions to the problem by applying the concept of biotechnology in the field of environment.

Higher order thinking is needed to analyze the new situation (unfamiliar). This higher-order thinking capability is seen when a person obtains information and stores the information in memory and then relates it to existing knowledge and or re-arranges and digs further into the information to reach the goal or find the answers to the situation or problem faced (Herrington and Oliver, 1999). The ability of students to analyze and evaluate a problem, encompassing various components of thinking such as asking questions (digging information, seeking truth), predicting, guessing, making conclusions, making decisions and solving problems. Related to six levels of knowledge according to Bloom, which is then revised by Anderson and Karthwohl (2001), Highorder thinking skills involve the ability to analyze (C4), assess/evaluate (C5), and create/synthesis (C6).

Critical and creative are included in high-order thinking skills and are two aspects of attainment of inseparable thinking. Creativity trains the process of making or producing, while criticality is a process of judging (Paul & Elder, 2004). According to Miri, et al. (2007), to train high-order thinking skills, the learning strategies is needed to be changed from old textbook-based habits and monotonous learning into learning that includes exploration activities, inquiry-based learning that is associated with surrounding natural phenomena. The strategies that can be undertaken include linking conceptual learning with real issues, encouraging open discussion, and involving inquiry experimentation (self-discovery).

The research has been conducted by Rahyuni (2016) about the correlationof critical thinking skills as one of higher-order thinking skills with science literacy using Problem Based Learning (PBM) model. The results

show that PBM can improve the critical thinking skills. This is because the real problems raised in the learning can stimulate critical thinking skills. In this study used the learning model of Project Based Learning (PjBL), where this interesting model of learning raises the problem to be a project that can produce a certain product so that is expected to improve the ability of higher-order thinking learners.

Based on the observation results on students who have taken biotechnology courses batch 2013 of Biology Education, Faculty of Teacher and, University of Sultan Ageng Tirtayasa, students' higher-order thinking ability has not been well explored. Whereas this ability is very important to be stocked both in research activities and in activities in the community after their graduation. Many factors are the reason for the higher-order thinking ability of Biology Education students have not been well explored. One of them is learning activities conducted in the classroom or outside the class are still using the conventional methods such as lectures, discussions and presentations. Students are not directly involved in biotechnology applications as applicative courses in various fields, such as industry, food, agriculture, and many others.

Based on the above problems, it is necessary to research a development of biotechnology learning equipments that are oriented to the ability of higher order thinking by utilizing the potential of biodiversity resources of Tundaisland. In addition to, this study of learning instrument development has not been done before, this research is also expected to produce learning equipments that are used continuously in each year. So that the ability of higher-order thinking of students excavated and embeded properly in their life.

METHOD

This study develops learning instrument that are oriented to higher-order thinking skills (critical and creative) by utilizing the potential of biological resources of Tunda Island as a learning resource in Biotechnology courses. The research method used is research and development (R & D) which consists of analysis step (identifying problem and potency, collecting data), designing learning equipments, learning equipments validation, and revision of learning equipments(Sugiyono, 2008). Learning equipments produced in this study are RPS (semester learning plan), student worksheets (LKM) and instrument questions.

In the early stages of the study, an analysis of the potential of biological

resources found on Tunda Island, Serang, Banten was conducted. Data were collected through direct field observation and interviews with environmental activists and surrounding communities. At this stage of analysis is also conducted literature review of the results of previous studies have been done on the Tunda island. Based on the result of the analysis of the potential of the biological resources, it is necessary to analyze the need for learning, adjusted to the curriculum in Biotechnology course.

The next stage is designing learning instruments consist of RPS (semester learning plan), student worksheet (LKM) and instrument questions. The designs made are conditioned to the learning achievements and the student's final capabilities must be achieved in the course of Biotechnology. The graduate's learning achievementexpected are to enable students to explain and compare the basic principles of conventional and modern biotechnology, benefits, applications and products produced in various fields, such as medicine and pharmacy, agriculture, food and environment industries. In this course,students are also expected to have the final capability of creating a product of the application of the concept of the role of biotechnology in various fields.

The learning process designed in RPS are contextual, active, and independent, and is oriented towards the development of high-oder thinking skills (critical and creative). The learning model used is project-based learning. To support the learning process, the student worksheet (LKM) is designed where it contains guidance or guiding questions about project implementation, while still prioritizing the development of students' critical and creative thinking principles. The evaluation of students' critical and creative thinking skills inBiotechnology learning is measured through open-ended questions. The test instrument is based on learning indicators to be achieved by the students.

All designed learning instruments are then assessed and validated by a team of experts. RPS (semester learning plan) and LKM (student worksheet)were assessed based on aspects and indicators of component completeness, content feasibility, presentation, and language, while evaluation instruments are assessed on the aspects and indicators of content feasibility, presentation, and language. Validation was conductedby the educational experts and the biologists. The technics of data analysis of the validation result of learning's equipment assessment instrument was

conducted by calculating the validity percentages of the valid items. The dataanalysis of learning's equipment assesment result were conducted by determining the average score from the criteria in every aspect. The assesment score uses theLikert scalewith categories as shown in Table 1 (Riduwan, 2013).

Table 1. Criteria for Assessing Properness of Learning Equipment

Score Category	Score
Excellent	5
Good	4
Enough	3
Less	2
Very less	1

Data obtained from the assessment sheet, then calculated the percentage of each indicator assessed by the formula (Riduwan, 2013) as follows:

$$\text{Percentage} = \frac{\text{Total Score x 100\%}}{\text{Maksimum Score}}$$

The percentages obtained are interpreted into the following criteria (Riduwan, 2013):

Table 2. Interpretation Score Criteria

No	Percentage	Interpretation
1	0%-20%	Not proper
2	21%-40%	Less
3	41%-60%	Sufficient
4	61%-80%	Eligible
5	81%-100%	Very feasible

The criticism and suggestion from the judgment expertsbecomes the basis of the researcher in revising or improving the initial design of learning equipments so that can obtain the appropriate learning equipment used in the learning of Biotechnology courses.

RESULTS AND DISCUSSION

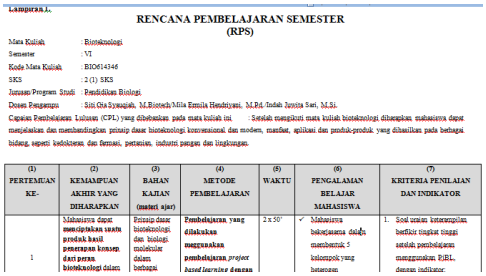
1. Learning Equipment Design

The learning equipments designed in this research are oriented towards the development of students' high-order thinking skills in Biotechnology courses. In the learning, students were trained to be able to think critically and creatively in exploiting the potential of biological resources of Tunda island as a learning resource. The results of field observations indicate that the abundant biodiversity resources in Tunda island are sea products such as seaweed, lawi-lawi, *Halimeda* sp., various types of marine fish, lobster, shrimp, sea cucumber, octopus, and terrestrial vegetation such as coconut trees, Albasia and mangroves. Through project-based learning, students were expected to be able to design a study/ study of the potential utilization of biological resources in Tunda island into biotechnology products that are beneficial to human life.

On the other hand, based on the literature review, it is known that coral reefs on Tunda island at the time of observation were found to be diseased, one of which was pigmentation response. The color changes caused by light exposure are very evident in coral reef ecosystems on Tunda island (Darus

et al., 2014). The research from Riska, et al. (2015) also found that the concentration of Pb that accumulates on *Poritesluteа*coral in Tunda island, especially on windward areas, averaged 9.69 mg kg^{-1} /year, while in the leeward area (sheltered Of wind) averaged 13.33 mg kg-^{1}/year. The condition of environmental damage that occurred in Tunda island can be an interesting study for students in Biotechnology learning. Students were expected to be able to analyze the source of the damage and provide solutions to the problem by applying the concept of biotechnology in the field of environment.

To support contextual, active, and independent learning, the appropriate learning strategies are needed, reflected in the semester learning plan (RPS) tool. The lesson plan used in this study is project-based learning (PjBL). Through the learning model, students were expected to be able to create a product of the application of the concept of biotechnology role in various fields of human life by utilizing the resources of Tunda island. The PjBL's learning stages of the students include determining fundamental questions, preparing project plans, preparing project completion schedules, testing project outcomes, evaluating the learning experience which they can gained. Here is an example of the RPS that contains the PjBL stages to improve high-order thinking by utilizing the Tunda island biological resources.



Lampiran 1.

RENCANA PEMBELAJARAN SEMESTER
(RPS)

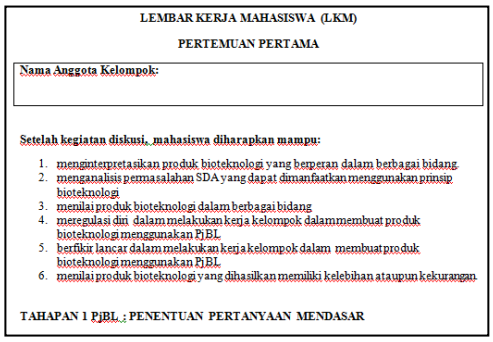
Mata Kuliah : Biotekonologi
Semester : VI
Kode Mata Kuliah : BIO614346
SKS : 2 (1) SKS
Jurusan/Program Studi : Pendidikan Biologi
Dosen Pengampu : Siti Ota Syaqiah, M.Biotech/Mila Emila Hendriyani, M.Pd./Indah Junita Sari, M.Si.
Capaian Pembelajaran Lulusan (CPL) yang dibebankan pada mata kuliah ini : Setelah mengikuti mata kuliah biotekonologi diharapkan mahasiswa dapat menjelaskan dan membandingkan prinsip dasar bioteknologi konvensional dan modern, manfaat, aplikasi dan produk-produk yang dihasilkan pada berbagai bidang, seperti kesehatan dan farmasi, pertanian, industri pangan dan lingkungan.

(1) PERTEMUAN KE-	(2) KEMAMPUAN AKHIR YANG DIHARAPKAN	(3) BAHAN KAJIAN (materi ajar)	(4) METODE PEMBELAJARAN	(5) WAKTU	(6) PENGALAMAN BELAJAR MAHASISWA	(7) KRITERIA PENILAIAN DAN INDIKATOR
1	Mahasiswa dapat menciptakan suatu produk hasil penerapan konsep dari peran bioteknologi dalam	Prinsip dasar bioteknologi dan biologi molekular dalam berbagai	Pembelajaran yang dilakukan menggunakan pembelajaran *project based learning* dengan	2 x 50'	✓ Mahasiswa bekerjasama dalam membentuk 5 kelompok yang heterogen	1. Soal uraian keterampilan berfikir tingkat tinggi setelah pembelajaran menggunakan PjBL dengan indikator

Figure 1.The Example of Learning Equipments in the Form of RPS Based-PjBL

Other equipments that support the achievement of self-directed learning are worksheets (LKM). According to Trianto (2009), the worksheet is a guide used to conduct investigation or problem-solving activities. The worksheet contains a set of basic activities that must be conducted to maximize the understanding in the effort to form the basic capabilities according to indicators of achievement of learning outcomes that must be pursued. The worksheet can be a guide for cognitive aspect development exercises as well as the guidance for developing all aspects of learning in the form of experimental or demonstration guides. In this study, LKM are designed according to the learning needs of PjBL. Through LKM,the students are directed to be able to determine fundamental questions about the potential of local biological resources in their surrounding environment and biotechnology

principles that can be applied to utilize these living resources in life. Students were also asked to analyze journal articles regarding the utilization of the Tunda island biological resources in various areas of life, such as medicine, pharmacy, agriculture, food industry, and the environment. After that, the students are guided to design a biotechnology product-making project based on local biological resources in stages and according to the implementation schedule that was made. The results of the project were then evaluated and reflected so that the students understand the advantages and disadvantages of the process being run and the resulting product.



LEMBAR KERJA MAHASISWA (LKM)

PERTEMUAN PERTAMA

Nama Anggota Kelompok:

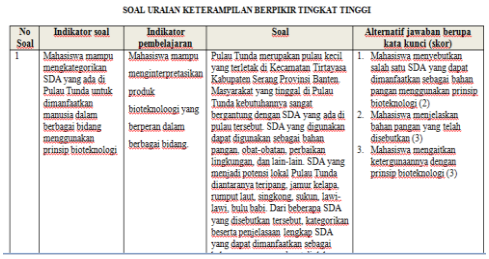
Setelah kegiatan diskusi, mahasiswa diharapkan mampu:

1. menginterpretasikan produk bioteknologi yang berperan dalam berbagai bidang
2. menganalisis permasalahan SDA yang dapat dimanfaatkan menggunakan prinsip bioteknologi
3. menilai produk bioteknologi dalam berbagai bidang
4. meregulasi diri dalam melakukan kerja kelompok dalam membuat produk bioteknologi menggunakan PjBL
5. berfikir lancar dalam melakukan kerja kelompok dalam membuat produk bioteknologi menggunakan PjBL
6. menilai produk bioteknologi yang dihasilkan memiliki kelebihan ataupun kekurangan

TAHAPAN 1 PjBL : PENENTUAN PERTANYAAN MENDASAR

Figure 2. Example of the LKM based PjBL to Increase Higher-Order Thinking Skills

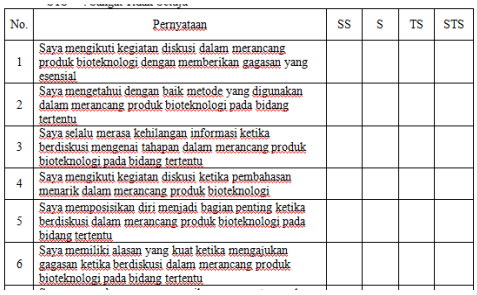
To find out the students' higher-orderthinking ability, an evaluation instrument was designed that refers to the aspect/indicator of critical thinking ability and creative ability. The evaluation instruments consist of a questionnaire (affective) questionnaire, a rubric of biotechnology product assessment (psychomotor) and an instrument of description test (cognitive). Indicators of critical thinking skills measured in the evaluation include the ability to interpret, analyze, evaluate and infer (inference). Meanwhile, the ability to think creatively includes several indicators: namely Fluency conveys many ideas/solutions; Flexibility conveys ideas from several different categories; Original (originality) conveysthe unusual ideasor rarely submitted by others; Detailedin conveying ideas (elaboration). This creative thinking ability is reflected in the assessment of biotechnology products which produced by the students.



SOAL URAIAN KETERAMPILAN BERPIKIR TINGKAT TINGGI

No Soal	Indikator soal	Indikator pembelajaran	Soal	Alternatif jawaban berupa kata kunci (skor)
1	Mahasiswa mampu mengkategorikan SDA yang ada di Pulau Tunda untuk dimanfaatkan manusia dalam berbagai bidang menggunakan prinsip bioteknologi	Mahasiswa mampu menginterpretasikan produk bioteknoloogi yang berperan dalam berbagai bidang.	Pulau Tunda merupakan pulau kecil yang terletak di Kecamatan Tirtayasa Kabupaten Serang Provinsi Banten. Masyarakat yang tinggal di Pulau Tunda kebutuhannya sangat bergantung dengan SDA yang ada di pulau tersebut. SDA yang digunakan dapat digunakan sebagai bahan pangan, obat-obatan, perbaikan lingkungan, dan lain-lain. SDA yang menjadi potensi lokal Pulau Tunda diantaranya teripang, jamur kelapa, rumput laut, singkong, sukun, lawi-lawi, bulu babi. Dari beberapa SDA yang disebutkan tersebut, kategorikan beserta penjelasan lengkap SDA yang dapat dimanfaatkan sebagai	1. Mahasiswa menyebutkan salah satu SDA yang dapat dimanfaatkan sebagai bahan pangan menggunakan prinsip bioteknologi (2) 2. Mahasiswa menjelaskan bahan pangan yang telah disebutkan (3) 3. Mahasiswa mengaitkan kegunaannya dengan prinsip bioteknologi (3)

Figure 3.The Example of High Thinking Ability's Descriptive Test



No.	Pernyataan	SS	S	TS	STS
1	Saya mengikuti kegiatan diskusi dalam merancang produk bioteknologi dengan memberikan gagasan yang esensial				
2	Saya mengetahui dengan baik metode yang digunakan dalam merancang produk bioteknologi pada bidang tertentu				
3	Saya selalu merasa kehilangan informasi ketika berdiskusi mengenai tahapan dalam merancang produk bioteknologi pada bidang tertentu				
4	Saya mengikuti kegiatan diskusi ketika pembahasan menarik dalam merancang produk bioteknologi				
5	Saya memposisikan diri menjadi bagian penting ketika berdiskusi dalam merancang produk bioteknologi pada bidang tertentu				
6	Saya memiliki alasan yang kuat ketika mengajukan gagasan ketika berdiskusi dalam merancang produk bioteknologi pada bidang tertentu				

Figure 4.The Example of Higher-Order Thinking Ability's Attitude Questionnaire

No	Indikator	Kriteria penilaian	Produk bioteknologi yang dinilai		
			1	2	3
1	Mahasiswa mampu menghasilkan produk bioteknologi yang dimunculkan dari ide orisinil	a. Produk dari peran bioteknologi yang dirancang sesuai dengan bidang yag dipilih			
		b. Produk yang dirancang berasal dari kombinasi berbagai konsep dalam bioteknologi			
		c. Produk yang dirancang memiliki keunikan atau berbeda dengan produk lain karena berasal dari potensi lokal suatu daerah.			

Figure 5.The Example of a Product Rating Rubric for Higher-Order Thinking Skills

2. The Results of Learning Equipment Validation

Before it can be used in learning, RPS equipment, LKM and evaluation instruments designed were assessed and validated by the experts. RPS and LKMwere assessed based on aspects and indicators of component completeness, content properness, presentation, and language. The evaluation instruments were assessed based on the aspects and indicators of component completeness, presentation, and language. The assessment criteria usesLikert scale, ie score 1 (very less), score 2 (less), score 3 (enough), score 4 (good), and score 5 (very good). The scores obtained then were calculated its percentage of each indicator assessed.

The validation results of learning equipment showed that the three instruments of RPS, LKM, and evaluation instruments are valid and feasible to be used in biotechnology learning. The average value for the entire equipment is 85.7%, which is included in very eligible criteria. Figures 6, 7, and 8 showed the acquisition value per aspect of the assessment for the RPS, LKM, and instrument of evaluation test.

In the RPS, the highest aspectsare in the presentation aspect and the language which is one of the indicator of each is the interconnection between the clear components and the language used does not cause double meaning. For LKM, the highest aspect is on the feasibility of the content in which the indicator is related to the material presented, the workings, and discussion questions, while for the instrument of evaluation test's high-ability thinking skill is good for almost all aspects ie cognitive, affective or psychomotoric assessment.

In general, the experts judge that the learning equipments made by the researchers have met the feasibility aspects of the equipment oriented on the development of high-order thinking skill and the utilization of the potential of biological resources of Tunda island. Nevertheless, there are some criticisms and suggestions submitted by the experts related to the design of the existing learning equipments. In general, the weaknesses that arise are on the language aspects, including the consistency of the terms used, and the

errors of writing that have not been perfected spelling. The suggestion given by the experts becomes the basis for the improvement/revision of the learning equipments, so that it can be used for the next stage of the limited test and field test.

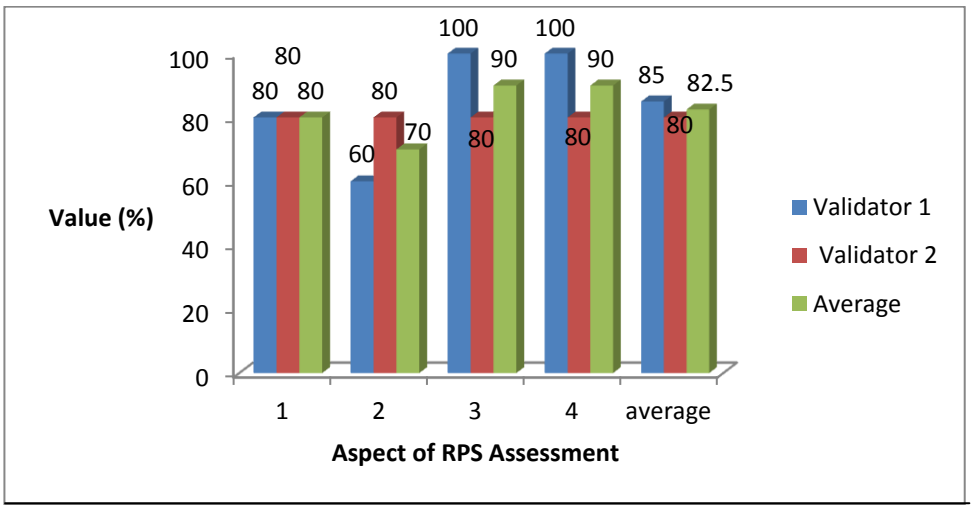


Figure 6.The Validation (Judgment) of RPS by The Experts. Aspect of Assessment: (1) Component Completeness, (2) Content Properness, (3) Presentation, (4) Language

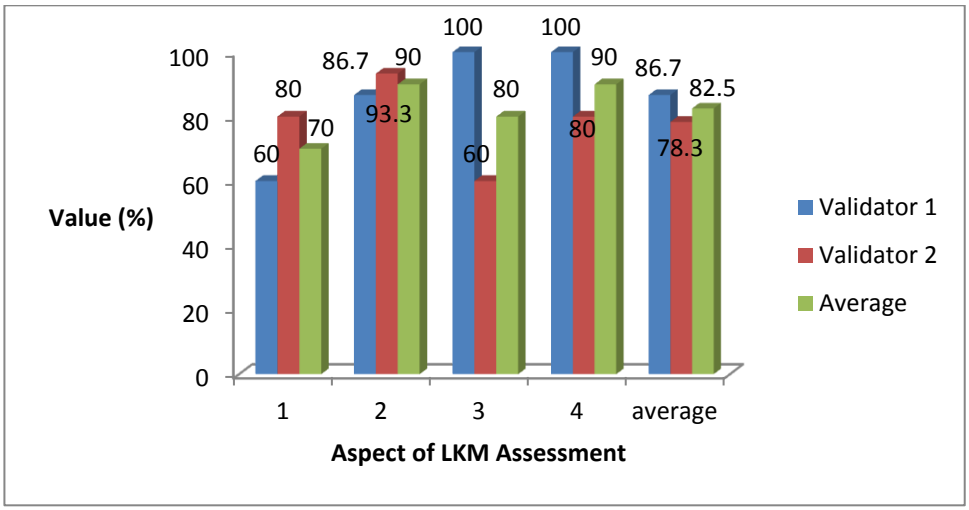


Figure 7.The Validation (Judgment) of LKM by The Experts. Aspect of Assessment: (1) Component Completeness, (2) Content Properness, (3) Presentation, (4) Language

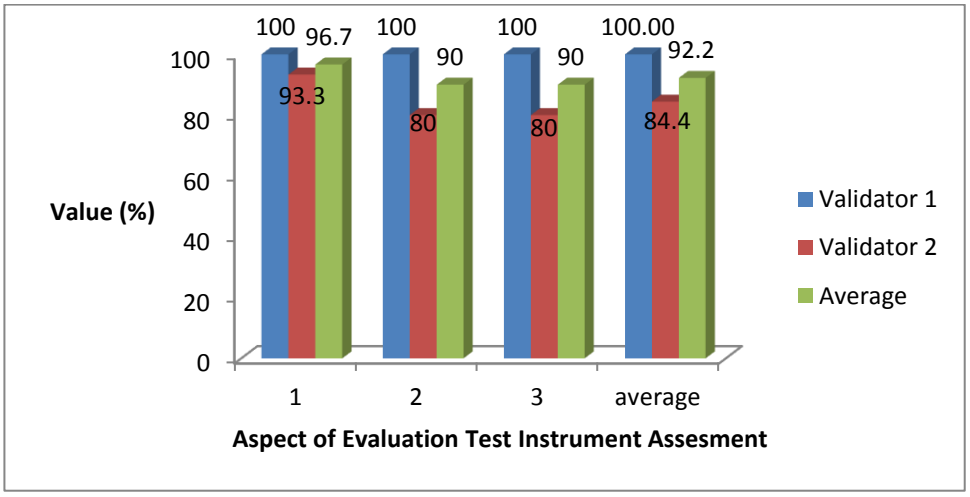


Figure 8.The Validation (Judgment) ofEvaluation Test Instrument by The Experts. Aspect of Assessment: (1)Content Properness, (2) Presentation, (3) Language

CONCLUSION

This development research results the product in form ofthe learning equipments, consisting of semester learning plans (RPS), the student worksheets (LKM), and the evaluation instruments in the cognitive, affective, and psychomotor domains. The learning equipments were designed with the orientation of the developing high-order thinking skill and the utilization of Tunda island's biological resources in the manufacture

of biotechnology products. The results of validation test by the experts showed that all the learning equipments designedhave an average value of 85.38%, which is included in the criteria is very feasible. This means that after the revision, the learning equipments produced can be tested in a limited and field tests and used in biotechnology course.

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