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Developing Problem-Based Learning Module For Biotechnology Concepts

Ahmad Yani[1)], **Sahriah**[1)], **Romi Adiansyah**[2)]
[1)]STKIP Puangrimaggalatung Sengkang Jl.Sultan Hasanuddin No. 27 Sengkang
[2)]STKIP Muhammadiyah Bone, Bone
E-mail: ahyan_yani@yahoo.com, sahriah_rahim@ymail.com, romiadiansyahsoc@yahoo.com

Abstract: This study attempted to develop and know the effectiveness of PBL module for biotechnology concepts intended for high school students. Brog and Gall model was referred as the framework to develop the product. It comprises some stages, namely, analyzing potential and problems, collecting information, developing the module's initial design, validating the design, revising the design, and trying out the product. The appointed experts in product development and learning as well as high school biology teachers in Biology Teachers' Association (MGMP) validated the product. The validation showed that the product is practical and valid to be used. The module is also effective for learning, as evidenced by the PBL activities reaching "high" category and by the improvement of the students' cognitive domain represented in the improvement of the initial average score.

Key Words: problem-based learning module, cognitive learning outcomes, biotechnology concepts

Abstrak: Penelitian ini bertujuan untuk mengembangkan dan mengetahui efektivitas modul pembelajaran berbasis masalah untuk SMA pada konsep Bioteknologi. Model pengembangan merujuk dari Brog dan Gall. Tahapan pengembangan terdiri atas analisis potensi dan masalah, pengumpulan informasi, penyusunan desain awal modul, validasi desain, revisi desain, dan ujicoba produk. Validasi produk dilakukan oleh Pakar Pengembangan, Pembelajaran dan guru Biologi SMA melalui kegiatan Musyarawah Guru Mata Pelajaran (MGMP) Biologi. Hasil penilaian pakar menunjukkan bahwa modul yang dikembangkan valid dan praktis untuk digunakan. Modul ini juga efektif digunakan dalam pembelajaran, aktivitas PBL mencapai kategori "tinggi", serta meningkatkan hasil belajar kognitif peserta didik.

Kata kunci: modul pembelajaran berbasis masalah, hasil belajar kognitif, konsep bioteknologi

21st century learning design does not place emphasis on the cognitive domain only. Rather, it synergizes all three salient domains: cognitive, affective and psychomotor. Referring to the results of PISA and TIMSS assessment in 2013, Indonesian students are ranked second from below in order of ability. One of versatile factors contributing to such a situation suggests that the students are low in critical thinking and literacy, particularly related to science. In response to that, Indonesian government has put curriculum 2013 into effect, promoting scientific approach as its foundation.

The scientific approach is designed to enable the students to actively formulate concepts or principles through several stages of observation, namely, formulating problems, proposing hypotheses, collecting data with various techniques, analysing the data, drawing conclusions and communicating the concepts, laws or principles found (Daryanto, 2014).

The availability of various learning resources such as textbooks, teaching materials and modules is of great importance to make learning more meaningful. The module can be defined as written learning materials designed and presented particularly for independent learning. Moreover, it is also systematically presented, comprising a set of well-planned learning experiences designed to help the students achieve the learning goals (Daryanto, 2013).

Biology learning in high schools can be closely linked to the study of ecosystem, environment and biotechnology, for instance, all of which comprise authentic learning materials. Learning about biotechnology, for instance, is closely related to learning about everyday human life, providing high social values fa-

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miliar and contextual for the students. This is so, for there are many problems requiring effective solutions can be identified by learning biotechnology. Therefore, learning materials pertinent to biotechnology should be relevantly taught to achieve its actual purpose. Moreover, the effective learning can be achieved if the learning design is contextual and pay attention to the needs and characteristics of the students. Biotechnology module designed on the basis of problem-based learning, therefore, is expected to ready the students individually and activate their background knowledge before group learning takes place in the classroom. The combination of independent learning and group learning is an effort to foster the students' ability to think critically by solving problems they encounter and providing solutions for those problems.

Prior to the present research, the researcher conducted an observation on biology books in SMA Negeri 2 Sengkang (state high school). There were 18 biology books from 5 publishers for 12 grade students observed and the results showed that only 22.22% of them fit the standards of graduate competence stipulated in the curriculum 2006, facilitating the students to improve their critical thinking skills. The students' interest to read the book reached 46.51% only, as evidenced by data accessed from the library. An initial survey conducted by the researcher, moreover, showed that science and language teachers in the school have used a module in the teaching and learning process by 57.56%. Moreover, 61.71% of the students stated that they like the module as it is effective and interesting so that it helps them learn the materials better.

Furthermore, it was also found that only 28.57% of biology teachers in Sengkang has ever made and utilized biology module for the teaching and learning in the last 2 years. This situation shows that it is of great importance to develop a relevant module comprising suitable learning materials for the needs of the students. To achieve such a purpose, problem-based learning (henceforward PBL) is a learning strategy that can facilitate the students to improve their critical thinking skills and enable them to detect and solve authentic problems they encounter. This strategy also closely corresponds with scientific approach stipulated in curriculum 2013 (Depdikbud, 2013).

There have been several studies conducted pertaining to the notion of PBL and the development of module (Citrawathi, 2006; Setyorini, 2009; Suratsih *et.al.,*2009; Izaak, 2010; Patkur, 2013). The results of those studies reveal that the development of the module effectively improve and activate the students' background knowledge and it also receives positive feedbacks from the students, all of which confirm the validity of such development.

The positive results of the previous research and development (R&D) studies above show that the development of module is necessary to arrive at effective learning. It follows that there have never been any effective and valid biology modules available in SMAN 2 Sengkang which respond the students' needs with scientific approach. The fact that there is a discrepancy between the expectations of the education system and the current reality in SMAN 2 Sengkang motivates the researcher to develop the suitable module. This is so, for the available biology modules do not provide ample opportunities for students to develop their critical thinking skills and to solve authentic problems they face. The modules also do not expose the students to scientific learning which particularly suits the expectations of the curriculum. Therefore, the present R&D study is aimed at developing a biotechnology module implementing problem-based learning which is designed to train the students to enhance their critical thinking skills with the scientific approach. It suggests that they are supposed to discover problems and offer solutions so that the objectives of effective and efficient learning can be achieved

METHOD

This study is referred as research and development model in which the R&D model proposed by Borg & Gall (1989) was mainly employed. This model comprises 10 stages; analyzing the curriculum, gathering information, making the module design, validating the design, making revision based on the experts' validation, trying out the module, making revision based on the try-out, revising the product, trying it out and disseminating the product.

The module in the present study is a printed material developed based on the observed problems, gaining insights from curriculum 2006 as well as curriculum 2013. The module was also developed by considering the results of observation and interviews with some teachers and students in Tempe district; the analysis of available modules also resulted as considerable factors in conducting this study. The results of the above stages served as the main framework referred to develop the module which is characterized by scientific approach and PBL. The elements of PBL manifested in learning materials in the module such as self-reflective exercises for self-study and crosswords intended to train the students' metacogni-

tion. Moreover, the module also included aspects associated with affective domain through caricatures and wise sayings. This module, however, was limited to the development of learning materials related to biotechnology which is a part of biology learning for 12th grade science students.

The module was validated by 2 experts and the teachers attending MGMP. The results of the validation served as a guideline to revise the module. The revised product, moreover, was tried out to evaluate its efficacy and effectiveness. The efficacy of the product was rated on the basis of some indicators: whether the module interests the students, increases their learning motivation, challenges their critical thinking skills, provides them with innovative learning activities, maximizes their group learning, and helps them understand the learning materials. Furthermore, the effectiveness of the product was seen from to what extent the learning activities realize PBL model through some indicators; the students are able to discover problems, define them, investigate them to find alternative solutions, evaluate their investigation, prepare the report, and communicate their findings. The completion of all learning activities was analyzed to know if they have improved the students' competence in all three domains, namely, cognitive, affective and psychomotor, particularly related to their understanding on biotechnology concept.

The results of this study were analyzed by using quantitative descriptive technique in the form of validation sheet, interview, the students' response, and the learning outcomes. Descriptive qualitative technique was also employed in the form of the feedback gained from the validators and teachers. The initial stage of the development model proposed by Borg & Gall (1989) manifested in analyzing the curriculum 2006 applied in SMAN 2 Sengkang, the available modules and teaching materials, the implementation of those products and factors supporting or hindering the development of the product.

The qualitative descriptive analysis manifested in the presentation of the quality of the module based on the suggestions given by the experts and the biology teachers related to the PBL model and biotechnology concepts. The module can be applied for use if it hits the minimum category "valid" ($2.5 \leq M \leq 3.5$). The efficacy of the module in the learning process comprised some indicators such as the students' response to the module gained by analyzing their responses and observing the learning process. This efficacy was seen from the accomplishment of all indicators in which the students' response should reach the 70-80 category (high). The effectiveness of the module was considered on the basis of analysis of the students' learning outcomes in the three domains which should reach 75, the minimum passing grade for biology learning in SMAN 2 Sengkang. The analysis of indicators related to PBL model was set to meet the minimum standard at 70%-84% (high). To measure the validity of the percentage, efficacy and effectiveness of each indicator, the average score was employed. The average score was resulted from the total score divided by the number of respondents answering the questionnaire administered.

RESULTS

The development of problem-based learning module on biotechnology covers 6 stages as follows.

Analysis and Identification of Potential Problems

Analyzing Curriculum

The results of the analysis of Standard of Content in Curriculum 2006 for biology subject are as follow. 1) Biology learning emphasizes the provision of direct experiences to develop students' competence. 2) The learning process is deemed to be vital. 3) Learning materials for biology are designed to enable students to develop their analytical, inductive and deductive reasoning in order to solve authentic problems. 4) The scope of biology learning for 12th grade comprises the process taking place in plants, metabolism, heredity, evolution, biotechnology and its implications on science, environment, technology and society. 5) The concept of biotechnology entails one standard of competence, namely, SK 5: to understand the basic principles of technology and its implications on *salingtemas*. It furthermore consists of two standards of competence, namely, KD. 5., which reads to explain the meaning, principle, foundation and types of biotechnology, and KD. 5.2, which reads to explain and analyze the roles of biotechnology as well as the implications of biotechnological products on *salingtemas*. 6) There are some indicators to be achieved in SK. 5: the students are able to explain the notion of biotechnology, differentiate between traditional and modern biotechnology, explain the principles of genetic engineering and its outcomes, make products of traditional biotechnology and explain how to extract DNA. 7) Biotechnology learning for 12th grade science students takes place in the second semester

and 8 meetings (20 x 45 min) are allotted for this topic.

The Results of Analysis

The examination of KTSP in SMA Negeri 2 Sengkang was conducted as a first step in R & D study to understand and detect possible obstacles that potentially hinder all attempts to achieve the objectives of effective and efficient learning. The results are presented in Table 1.

Potential and Problems

The number teachers holding a Bachelor degree in SMA Negeri 2 Sengkang reaches 100% and a Mas-

Tabel 1. The Results of Analysis of Curriculum 2006 (KTSP) in SMAN 2 Sengkang

Functions and Factors	Criteria for Readiness	Real Conditions
1	2	3
A. Functions of teaching and learning process		
1. Internal factors		
a. Use of teaching methods b. Learning media c. Development of media d. Evaluation	a. Teachers are able to use various methods. b. Teachers are able to prepare learning media. c. Teachers are able to develop the media. d. Teachers are able to develop instruments for evaluation.	a. 97% of the teachers are able to apply various methods. b. 95% of the teachers are able to prepare the media as expected by the curriculum. c. The teachers still use the available media. d. 95% of the teachers are able to develop the instruments.
2. External factors		
a. Parental support	a. Financing participation	a. Limited funding from the committee
B. Functions of Supporting Personnel		
1. Internal factors		
a. Educational background b. Ratio of teachers and students	a. High school teachers at least hold a Bachelor's degree b. There should be an adequate number of teachers for each subject	a. All high school teachers hold a Bachelor's degree b. Such a proportional ratio is not available yet
2. External factors		
a. Teachers procurement and distribution	a. The number of teachers appointed for each subject is adequate already	a. Teacher placement is still inadequate or inaccurate
A. Supporting factors of facilities/infrastructures		
1. Internal factors		
a. Facilities condition b. Infrastructure condition	a. The facilities are conducive to learning b. The infrastructures are conducive to learning	a. Some facilities are not conducive to leaning b. Some infrastructures are not conducive to learning
2. External factors		
a. Support	a. Fulfilment of the needs of facilities and infrastructures	a. The number of facilities and infrastructures to support the learning is insufficient
B. Supporting functions of training		
1. Internal factors		
a. Development of syllabus and assessment system	a. Implementation of optimal learning process which corresponds with the syllabus and assessment system	a. The teachers' ability to formulate well-designed assessment system
2. External factors		
a. Upgrading, Workshop b. The curriculum is still not thoroughly implemented	a. The school is facilitated to held workshops. b. Availability of complete curriculum guidelines	a. Limited budget b. Tentative curriculum guidelines

ter's degree 9.26%. The learning process is optimized and adequate teaching materials and media are available. However, the observed problems include the teaching and learning activities which seem to be improvised, the learning media which seem to be a mere formality, and the existing teaching materials which have not met the criteria. The above circumstances, therefor, call for serious attention in order to alleviate the problems and it motivates the researcher to develop a suitable teaching package.

Collecting Information

All information needed had been collected. In the preliminary study, observations and interviews had also been conducted. The results are presented as follows. a) The correspondence between the biology books and the SKL sequence as well as the demands of curriculum 2006 to facilitate the students' needs for critical thinking reaches only 22.22%. b) The number of library visitors and biology book borrowings in the school library reaches 46.51%. c) The number of high school teachers who have ever used a module in their teaching in Tempe district accounts for 28.57%. d) The number of language and science teachers in SMAN 2 Sengkang using a module in their teaching reaches only 57.64%. e) With regard to the module, 61.71% of the students stated that they like the module while 1.14% of them dislike it.

The Module's Initial Design

The preparation for the module's initial design considered the students' needs to develop their critical thinking skills and problem-solving abilities. As a result, problem-based learning was decided to be a learning model that best suits the purpose of biology learning and is appropriate to the learning stage of 12th grade students. The module's initial design went through several stages 1) formulate the learning objectives based on the curriculum, 2) investigate the students' needs, 3) prepare learning activities entailing handbook, crosswords, and exercises for self-study to enhance the students' critical thinking skills, 4) prepare pre-tests/ post-tests to measure the students' potential, 5) include aspects associated with affective domain through caricatures and wise sayings 6) prepare details of biotechnology learning materials corresponding with the learning objectives stipulated in KD. 5.1 which read "to explain the meaning, principles, foundations, and types of biotechnology" (Module1) and in KD. 5.2 which read "to explain and anlyze the roles of biotechnology and the implications of biotechnological products on *salingtemas*"(Module 2), 7) prepare teacher's notes or summaries based the objectives serving as a reinforcement of biotechnology concepts, 8) provide a glossary of biotechnology terminologies to help the students understand them better and achieve the objectives, 9) complete the module with "*infobiotek*", supporting information related to any recent development on biotechnology, 10) create interesting cover and supporting information to the teachers and students with good design and ease of use.

Validation of the Module's Initial Design

The results of qualitative analysis on the appointed experts' comments and suggestions are shown in Table 2 and quantitative analysis in Table 3.

The results of evaluation of the quality of the module's initial design based on biology teachers' suggestions in MGPMP forum are presented in Table 4.

Quantitative evaluation of the biotechnology module's design is shown in Table 5.

Revision of the Module's Design

In accordance with the suggestions and comments gained from the appointed experts and biology teachers in MGMP, the researcher revised the mod-

Table 2. Qualitative Evaluation of PBL Module of Biotechnology Concepts

No.	Aspects	Experts in Learning	Experts in Biotechnology
		General comments and suggestions	
1.	Instructions	The instructions should be more succinct	The instructions need revising as they are not really clear
2.	Content	The learning materials should be grouped according to each meeting	Some concepts need revising carefully
3.	Language	Good	The language structures are good already but there are still some typing errors
4.	Layout	Some improvements are recommended	-

Tabel 3. Quantitative Evaluation of PBL Module of Biotechnology Concepts

No.	Aspects	Experts in Learning Average	Category	Experts in Biotechnology Average	Category.
1.	A. Instructions	3,8	SV	3,6	SV
2.	B. Content	3,4	V	3,3	V
3.	C. Language	3,8	SV	3,3	V
4.	D. Layout	3,4	V	2,7	V
	Average	3,6	SV	3,2	V
	Standard Deviation	0,23		0,38	
	Ideal Score	4,0		4,0	

Notes:

Highly Valid	3,5 = M = 4,0	HV
Valid	2,5 = M = 3,5	V
Moderate	1,5 = M = 2,5	M
Invalid	M < 1,5	I

Table 4. Biology Teachers' comments on PBL Module

NO.	Codes of the teachers	Comments
		A. Instructions
1	2	3
1.	Sri....	a. The punctuation marks should be carefully written
		B. Content
2	Sha....	a. The questions for crosswords would be better if provided in one word
3	Ridha....	a. It is suitable for high school students
4	Sri....	a. Some questions mentioned in the instructions are not found in the module b. The affective domain is not adequately accommodated c. Some items are not operationally defined d. Some learning objectives are not found in the summary section
5	Ahm...	a. The affective domain is not included b. Some items are not operationally defined c. Some learning objectives are not found in the summary section
6	Her....	a. Some pictures used are not clear and relevant
8	Imr....	a. It would be better if the learning objectives are stated in each meeting b. The learning materials should be more proportionally graded for each meeting to help the students understand them better
		C. Language
9	Sri....	a. The language is clear and good
	Yas....	a. The language is too sophisticated for the students' level
		D. Layout
10	Shah....	a. The cover is less interesting. It would look better if the picture of Dangke is wrapped. b. It is quite interesting. There should be more caricatures included.
11	Ahm...	a. A full-color layout would look better
12	Yas....	a. The picture used for the cover should correspond with the learning materials
13	Dar....	a. It is less interesting. It should vary and be more colorful
14.	Sri....	b. It should be more colorful and represent the process

Table 5. Biology Teacher's Evaluation of The Module

No.	Aspects	Indicator	Score	Avrage	Stdev	Ideal Score	Categ ory.
1	A. Instruction	5	25	3,47	0,05	4,0	V
2	B. Content	22	20	3,39	0,71	4,0	V
3	C. Language	6	214	3,24	0,80	4,0	V
4	D. Layout	7	229	2,97	0,83	4,0	V
	Total	40	1388	3,27	0,37	4,0	V

Notes:
Highly Valid 3,5 = M = 4,0 HV
Valid 2,5 = M = 3,5 V
Moderate 1,5 = M = 2,5 M
Invalid M < 1,5 I

ule's initial design in several aspects: 1) pertaining to the instruction, it is presented more succinctly and all typing errors are revised carefully, 2) pertaining to the content, the revision entails improving inaccurate concepts, compiling detailed descriptions of the learning materials for each meeting, stating the learning objectives for each meeting, and including the affective domain, 3) with regard to the language aspect, it only entails the simplification of the language according to the needs of the students, and 4) pertaining to the layout, improvements entail changing the picture for the cover and adding more caricatures and colors.

Small-scale Try Out

The students' responses to the module are presented in Table 6.

The Students' Activities

Pertaining to the application of the biotechnology module, the students engaged with learning activities suitably corresponding to PBL model. Table 7 shows the level of students' engagement elicited from the observations (8 times).

The Students' Learning Outcomes

The results of the pre-test and post-test administered are used to determine the learning progress of the students. The pre-test is intended to measure the students' initial knowledge and the post-test to know whether the students using the PBL module have achieved the learning objectives for biotechnol-ogy concepts. The post-test is also useful to deter-mine the score of the students' cognitive domain. The results of both tests are presented in Table 8.

Tabel 6. Results of Analyses of Students' Response

No.	Indicators	Average	Stdev	Ideal Score	Category
1.	The students feel comfortable and interested	89,7	1,398	100	VH
2.	The students are highly motivated	89,9	3,350	100	VH
3.	The students are challenged to think critically to solve the problems	91,1	1,749	100	VH
4.	The students discover new and innovative learning activities	88,9	1,923	100	VH
5.	The teachers actively monitor and facilitate the students' learning	89,6	2,209	100	VH
6.	The students are satisfied with the products of group work	88,2	2,296	100	VH
7.	The PBL module helps the students to better understand the topic	86,2	1,070	100	VH
	Total average	89,1	1,161		VH

Notes:
85-100 Very High (VH)
70- 84 High (H)
50- 69 Moderate (M)
40- 54 Low (L)
20-39 Poor (P)

Table 7. The Students' Activities

No.	The students' activities	Average Meeting 1-8	Stdev	Ideal Score	Category
1.	Finding problems	88,9	6,00	100	VH
2.	Analyzing the problems	84,3	4,83	100	H
3.	Opting for alternative solutions	86,4	5,01	100	VH
4.	Gathering information	93,2	2,13	100	VH
5.	Processing the information	84,6	7,47	100	H
6.	Reporting the solutions	77,9	15,33	100	H
7.	Displaying the products of group work	58,93	21,16	100	M
	Total average	82,04	5,66	100	H

Notes:
85 - 100 Very High (VH)
70 - 84 High (H)
55 - 69 Moderate (M)
40 - 54 Low (L)
20 - 39 Poor (P)

Table 8. The Results of Analyses of Students' Cognitive Domain *(Pretest and Postest)*

	Category	*Pretest*	*Postest*
1.	The number of the test takers	33 people	33 people
2.	The number of successful test takers	0 people	32 people
3.	Above the average	19 people	13 people
4.	Below the average	14 people	20 people
5.	Completeness	0 %	96,97%
6.	Total	1210	2893
7.	The smallest	16,67	76,67
8.	The biggest	56,67	96,67
9.	Average	36,67	90,40
10.	Standard Deviation	8,780	4,469

DISCUSSION

In this discussion section, the researcher elucidates the stages conducted to develop the module and provide descriptions pertaining to its efficacy and effectiveness in the teaching and learning process.

The Stage of Analyzing Potential Problems

Curriculum Analysis

To develop the teachers' competence, they verily should make an attempt to proportionally facilitate the students' learning by exposing them to direct and authentic learning experiences. In the implementation of process skills, the teachers are supposed to employ scientific learning in their class so that the students are encouraged to obtain factual information and solve authentic problems they encounter in their daily lives.

Biology subject is developed through the ability of analytical, inductive, and deductive thinking to solve problems related to natural phenomenon. To achieve the objectives of biology learning in shaping a scientific attitude, it is necessary to provide techniques, strategies, methods and appropriate learning model, one of which is problem based learning. Biotechnology is one of the scope of biology that should be mastered by the students to be applied in everyday life in order to preserve the environment and be able to solve environmental prob-lems with appropriate learning model To arrive at the mastery of the concept, it takes sufficient time based on the results of analysis of SK/KD and their indicators of achievement.

The Results of Curriculum 2006 (KTSP) Analysis in SMAN 2 Sengkang

The ideal application of KTSP needs to consider the condition of the schools that will implement the curriculum. The investigation of the curriculum 2006 applied in SMAN 2 Sengkang presented in Table 1 shows that the teachers still need to improve their ability in preparing the teaching materials closely corresponding with curriculum demands. Moreover, all stakeholders have to make efforts to develop such teaching materials and the selection of methods and learning models should be carefully chosen to meet the students' needs. Therefore, the school and government should prepare adequate and suitable learning resources (mod-

ule/handbooks) corresponding with the curriculum, more specifically the 2013 curriculum promoting scientific learning.

The Stage of Identifying Potential Problems

The number teachers holding a Bachelor degree in SMA Negeri 2 Sengkang reaches 100% and a Master's degree 9.26%. The learning process is optimized and adequate teaching materials and media are available. However, the observed problems include the teaching and learning activities which seem to be impro-vised, the learning media which seem to be a mere formality, and the existing teaching materials which have not met the criteria. The above circumstances, therefor, call for serious attention in order to alleviate the problems and it motivates the researcher to develop a suitable teaching package.

The Stage of Collecting Information

Considering the analysis of the potential problems above, it calls for steps to overcome the problems, especially related to learning resources that have not adequately facilitated the needs of the students. Pertinent to the application of appropriate methods or learning models, the preliminary observation showed that biology learning carried out in SMAN 2 Sengkang has not fully corresponded with the curriculum, particularly in sequencing the learning materials, as regulated in SK/KD in Standard of Content, curriculum 2006. This situation influenced the students' interest to visit the library and borrow the biology books. Furthermore, the teachers also make no efforts to prepare adequate and suitable teaching materials. The teaching methods and learning models also less vary as they are dominated by the conventional ones. In addition, pertinent to the use of a module by the teacher previously, the respondents stated that they find it interesting and helpful though the rate is relatively low.

The Stage of Developing the Module's Initial Design

The module's initial design underwent several steps as follows: a) analysing curriculum, potential and problems, b) gathering information c) analyzing SK/KD, d) deciding learning materials included, e) determining the learning objectives, f) determining the indicators, g) determining learning strategies, methods and models, i) developing description and summary of the materials, k) developing instruments for test and self-assessment, l) developing crosswords, m) making a glossary, (n) developing exercises, o) developing instructions to use the module and the first and last part of the module, (p) finising product by reconsidering all aspects as instructions, content, language and layout.

Validaton Stage

The results of the evaluation of the module presented previously showed that the module has theoretically a good level of validity. However, it needs revising in some aspects, as suggested by the appointed experts and teachers. In line with the previous attempts made to develop such modules, the validated module can be employed after necessary revisions are made (Kumalasari, 2011).

Revising the Design

The revisions made included improving the clarity of the instructions, grouping the materials in accordance with the meeting, stating the learning objectives, improving the quality of the items and the module's appearance, and adding affective domain with more caricatures and wise sayings.

Try-out Stage

The tryout was conducted in Tahap SMAN 2 in which the study took place to alleviate the identified problems. In accordance with the concept and description of the materials, the try-out was administered to 33 science students of 12^{th} grade in 8 meetings corresponding with the results of analysis of SK/KD for biology subject in the even semester. This stage was attempted to measure the efficacy of the module and effectiveness of the module to achieve the intended learning objectives.

Evaluation of Practicality and Effectiveness of the Module

After improvement on PBL Modul in accordance with the obtained suggestions and critics, hence design improvement phase is continued by testing the product to test the practicability and effectiveness circumstantially in the field.

Practicality

The practicality of the module was represented in the results of analysis of the students' response to the module as well as their learning activities supported by the use of the PBL module. It attests the previous findings that the use of module in learning can generate positive response from the students due to its practicality (Suratsih 2009 & Patkur M, 2013). In addition, Rusman (2013) also states that a module can enhance the students' learning motivation.

Effectiveness

As presented in the foregoing quantitative description in Table 2, it hit the 'very high' or 'high' category indicating that the use of PBL module enhances the students' creativity. Moreover, in the analysis of students' activities presented previously in Table 2, the results correspond with the expectations of the decree of government No. 22 in 2006 pertinent to Standard of Content, curriculum 2006, for biology subject in high school (Depdiknas, 2006) and in line with curriculum 2013 as well.

In addition, the analysis of the learning outcomes encompassing cognitive, affective, and psychomotor domain shows that the development of PBL module for biotechnology concepts has a significant effect on the students' learning. It endorses a study by Patkur (2013) that a module can increase the effectiveness of learning. Most importantly, the achievement of students' learning reaches 96.97%, as evidenced by the results of the post-test in Table 7 showing that the PBL module is effective and efficient to be used for learning biology. It also corresponds with Sudjana & Rivai' statements (2008) that a module is one of effective and efficient learning resources to achieve the learning objectives by 80%.

CONCLUSIONS

As shown in the presentation of findings and discussion, the development of the PBL module for biotechnology concepts entails 6 stages 1) analysing and identifying problems, 2) gathering information, 3) developing the module's initial design, 4) validating the design, 5) revising the design, and 6) trying out the product. The proposed design is based on the analysis process comprising the analysis of the curriculum 2006 applied in SMAN 2 Sengkang, potential and problems in the schools, and the collection of information related to available learning resources, the teachers and the students through the observation.

The module has been validated by the appointed experts and evaluated by biology teachers. Their suggestions served as a basis to revise product. The try-out showed that the module is efficient and effective to be used for learning, as evidenced by "very high" category gained from the students' response and the indicators set to reveal the practicality. As evidenced by the "high" category pertinent to the students' activities, it showed that the module is practical for learning biotechnology concepts corresponding with the indicators set for PBL activities. The module also effectively improved the students' cognitive, affective and psychomotor domain.

REFERENCES

Arikunto, S. (2006). *Prosedur penelitian suatu pendekatan praktik.* Jakarta: Rineka Cipta.

Borg, W.R. & Gall, M .D. (1983). *Education research an introduction.* New York: Von Hoffman Press, Inc.

Citrawathi, D. (2006). Pengembangan pembelajaran biologi dengan menggunakan modul berorientasi siklus belajar dan pengaruhnya terhadap hasil belajar siswa di SMA. *Jurnal Pendidikan dan Pengajaran , 3*, 534–551.

Daryanto. (2013). *Menyusun modul bahan ajar untuk persiapan guru dalam mengajar.* Jogjakarta: Gramedia.

Departemen Pendidikan Nasional, Ditjen PMTK. (2006). *Sosialisasi KTSP 2006*. Jakarta: Depdiknas.

Departemen Pendidikan dan Kebudayaan, Ditjen PMTK. (2013). *Sosialisasi kurikulum 2013*. Jakarta: Depdikbud.

Ditjen PMTK. (2013). *Tantangan, kebijakan, dan program strategis peningkatan mutu pendidik dan tenaga kependidikan.* Paper presented at Rembug Nasional, Ditjen PMPTK, Depdiknas, Jakarta.

Wenno, I. H. (2010). Pengembangan modul IPA berbasis problem solving method berdasarkan karakteristik peserta didik dalam pembelajaran di SMP/MTs. *Jurnal Cakrawala Pendidikan, 2*(2). doi:10.21831/cp.v2i2.338.

Kumalasari, D. (2011*). Pengembangan modul biologi sistem reproduksi manusia model siklus belajar (learning cycle) 5E untuk meningkatkan hasil belajar siswa kelas XI SMA negeri 1 Malang* (Unpublished undergraduate's thesis). Universitas Negeri Malang, Malang.

Nurdin. (2007). *Model pembelajaran matematika yang menumbuhkan kemampuan metakognitif untuk menguasai bahan ajar* (Unpublished doctoral dissertation). Universitas Surabaya, Surabaya.

Paidi. (2008). Pengembangan perangkat pembelajaran dan pengaruhnya terhadap kemampuan metakognitif, pemecahan masalah, dan penguasaan konsep biologi. *Jurnal Pendidikan Biologi UM Malang*, *1*(1).

Patkur, M., & Wibowo, T. W. (2013). Pengembangan modul pembelajaran *autocad* untuk meningkatkan efektivitas pembelajaran peserta didik kelas X TPM di SMKN 1 Sidoarjo. *Jurnal Pendidikan Teknik Mesin, 1*(3), 89–96.

Rusman. (2013). *Metode-metode pembelajaran*. Jakarta: Rajagrafindo Persada.

Sanjaya, W. (2012). *Strategi pembelajaran berorientasi standar pendidikan*. Jakarta: Kencana Predana Media Group.

Santyasa, I. W. (2007). Model-model pembelajaran inovatif. Retrieved December 9, 2013, from http://www. free webs.com.

Sugiono. (2009). *Metode penelitian pendidikan pendekatan kuantitatif, kualitatif, dan R & D*. Bandung: Alfabeta.

Suratsih, Henuhili, V., Rahayu, T., & Hidayat, M. L. (2009). Pengembangan modul pembelajaran genetika berbasis fenomena lokal. *Cakrawala Pendidikan, 2*, 165–176.

Susilo, M. J. (2007). *Kurikulum tingkat satuan pendidikan (KTSP)*. Jogjakarta: Pustaka Pelajar.

Setyorini, O. (2009). *Pengembangan modul pembelajaran IPA terpadu model direct instruction melalui teknik QUEST untuk siswa SMP/MTs dengan tema benda optik* (Unpublished undergraduate's thesis). Universitas Negeri Malang, Malang.

Trianto. (2012). *Metode pembelajaran terpadu konsep, strategi, dan implementasinya dalam KTSP.* Bandung: Bumi Aksara.