

# Entrepreneurship-Based Biotechnology E-Module Development to Improve Critical and Creative Thinking Skills

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## Entrepreneurship-Based Biotechnology E-Module Development to Improve Critical and Creative Thinking Skills

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**Abstract.** Courageous learning triggers learning loss, which is characterized by a decrease in the ability to think critically and creatively. The solution used with innovation in learning media is the e-model of entrepreneurship. This study aims to test the feasibility of entrepreneurship-based biotechnology e-modules and improve students' critical and creative thinking skills after using this e-module. This research and development (R&D), which applies the 4D model (Define, Design, Develop, and Dissemination). The study consisted of 31 class IXA students of junior high school. The research instrument consisted of expert validation questionnaires, pretest-posttest questions, and student response questionnaires. The analysis of the validation questionnaire for material and media experts produced an average score quite high with the appropriate criteria for use in classroom learning. The results of the t-test for students' critical and creative thinking skills yield a significant value of 0.0 which is smaller than 0.05, which means that there is a significant difference between students' critical and creative thinking skills in the pretest and post-test. Analysis of the N-gain value of students' critical and creative thinking abilities shows an average result of 0.46. This result is included in the category of moderate improvement, which means that the increase in students' critical and creative thinking skills is in the medium category. This e-module also has a very good response from all students. Based on the results of these analyses, the entrepreneurship-based biotechnology e-module is declared feasible for use in learning and can improve students' critical and creative thinking abilities.

**Keywords:** Critical thinking, Creative thinking, Biotechnology, E-modul, Entrepreneurship

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### INTRODUCTION

The Covid-19 pandemic that has hit Indonesia and various parts of the world since early 2020 has led to a crisis in education. This condition also forces the Indonesian government to carry out remote or online learning. However, this policy also raises several problems, one being learning loss. Indicators of learning loss during the current pandemic include decreased learning motivation, students' less critical and creative thinking abilities, and gaps in students. In achieving national education goals, students' ability to think creatively (creative thinking) and critically must be prioritized as the main target in the learning process. This is because young students are full of imagination and creativity, and the strength of their life is innovation (Zhou & Zhou, 2021). Creative thinking for students can be interpreted as the ability to create new things in learning, both in the form of the ability to develop information obtained from teachers in the teaching and learning process, such as in making new combinations in learning (Álvarez-Huerta et al., 2022), and the ability to think critically (critical thinking) which students also

need to support creativity. This critical thinking ability is defined as an ability that utilizes cognitive skills that are useful for improving learning outcomes, such as solving problems carefully, arguing, and analyzing thoughts (Tanti et al., 2020). The ability to think critically and creatively is very important in supporting online learning efforts that are currently taking place. However, improving students' critical and creative thinking skills during pandemic is difficult. Teachers must guide students to improve critical and creative thinking skills, either directly or indirectly.

The proposed solution to overcome the problem of learning loss and increase students' ability to think critically and creatively is to use good learning media. Good learning media will usually provide convenience, foster interest in learning, make it easier for students to learn independently, and make the learning process more effective (Isnaeni et al., 2021). One of the media that meets these criteria and is developed rapidly during the pandemic is electronic modules (e-modules). E-module is an ICT (Information and Communication Technology)-based learning medium that displays text, images,

graphics, audio, animation, and video in the learning process (Suwatra et al., 2018). The advantage of e-modules compared to other printed modules is that they are interactive. E-modules can be read via laptops, computers, and mobile phones. E-modules can also provide many facilities such as text, graphics, images, photos, audio, video and animation in an integrated way (Syahrani et al., 2016).

6 Previous research showed that problem-based interactive physics e-modules could improve students' critical thinking skills (Sujanem & Suwindra, 2023). Other research aimed to develop e-modules using the Moodle application to provide an attractive appearance and CBT-based learning features that support online and offline learning and feature access rights so that they can only be accessed by students and teachers (Siti et al., 2020). Yermadesi et al (2023) also conducted research 6 on the effectiveness of an e-module, where the results of her research showed that digital science modules based on a scientific approach could improve student learning outcomes.

10 Another technique for developing one's critical and creative thinking skills is the concept of entrepreneurship. Entrepreneurship is an individual's ability to apply new creative ideas or innovations to solve a problem while making a profit (Adeel et al., 2023; Wardana et al., 2020). An entrepreneurial mindset can make students more critical in dealing with a problem and creatively use the problem to become a valuable opportunity (Johnstad et al., 2023). Entrepreneurship-based learning can implement learning activities in experiments, learning by doing, teamwork, and work projects, where creativity and problem-solving are the main goals (Hartikainen et al., 2023).

This entrepreneurial spirit is very much needed in the online learning process. Students will encounter various problems during independent study at home. Entrepreneurship spirit can make students more independent in solving learning problems they face while studying at home. This is because entrepreneurship-based learning is flexible, and can follow the needs of students, the conditions of the learning environment, and curriculum design (Walmsley & Wraae, 2022). One of the science learning materials that can train this entrepreneurial spirit is biotechnology material. Biotechnology products produced by students in learning will generate selling points to build an entrepreneurial spirit and improve students'

critical and creative thinking skills.

The results of preliminary observations conducted at SMP Negeri 7 Tegal showed that both teachers and students stated that entrepreneurship-based biotechnology e-modules needed to be developed. Students said biotechnology material was very difficult to understand, and students wanted biotechnology learning media that was easy to understand with an attractive appearance. The teacher also revealed the need to develop this e-module because entrepreneurship is important in learning biotechnology material. Besides, e-modules would make the learning process becomes more practical because they can be studied anytime and anywhere. The teachers think that entrepreneurship in biotechnology material can help students improve their critical and creative thinking skills. The information shows the importance of developing entrepreneurship-based biotechnology e-modules to improve students' critical and creative thinking skills. The objectives of this study are 1) to test the feasibility of entrepreneurship-based biotechnology e-modules and 2) to improve students' critical and creative thinking skills through the use of entrepreneurship-based biotechnology e-modules.

## METHODS

This study was a research and development (R&D) type that applied 4D techniques (Define, Design, Develop, and Dissemination). The research subjects to test the feasibility of entrepreneurship-based biotechnology e-modules were one material expert, one media expert, and ten students for small-scale trials. In this study, the improvement of students' critical and creative thinking skills on a large-scale trial using 31 class IXA students at SMP Negeri 7 Tegal were tested. The instrument used was an expert validation questionnaire, a student response questionnaire about the pretest-posttest of students' critical and creative thinking abilities. The expert validation and student response questionnaires used a Likert scale with four categories of answer choices (very good/agree, good/agree, not good/agree, and not good/agree). This questionnaire was given to students in large-scale and small-scale trials. The test questions for students' critical and creative thinking skills consisted of multiple-choice questions and descriptions.

The research stage that was carried out first was defining. This stage was carried out through a

literature review and giving a needs questionnaire to teachers and students to analyze the problems or a product to be developed. The next stage was planning everything needed for research, for example, selecting e-module and media formats, preparing learning tools, and planning research activities. The next stage consisted of development. At this stage, the product had started to be made, then assessed by experts and tested on students. The last stage was deployment, which consisted of revision, packaging, and deployment. However, this article only discusses up-to-trial activities to determine the increase in students' critical and creative thinking skills.

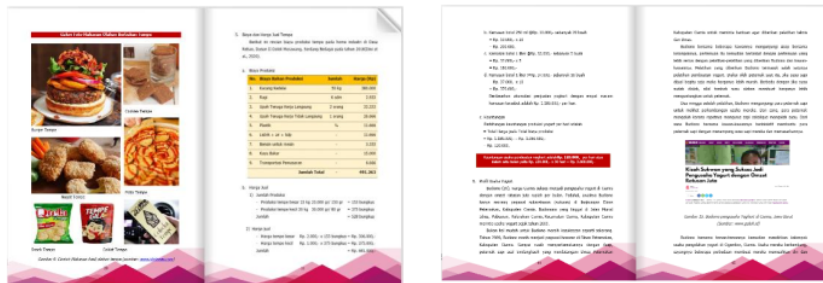
The development of entrepreneurship-based e-modules was through an expert validation process, namely expert validation and materials, to ensure the feasibility and alignment of entrepreneurship-based e-modules. The validation results from experts were used for small-scale tests. The small-scale test was carried out with ten students and then produced questionnaire data used to revise the product referred to as revision 1 product. The entrepreneurship-based e-module from revision one was then given to science teacher colleagues to be corrected and examined. The results of this revision were referred to as revision II, which was then implemented for large-scale tests. The large-scale test was carried out by class IXA of

SMP 7 Tegal. The results of the large-scale test were referred to as revision III. Revision III was corrected and became the entrepreneurship-based E-module's final product. Data analysis from validation and student response questionnaires used percentage description and category techniques. Data analysis on students' critical and creative thinking abilities was carried out through a t-test and then continued with an analysis of the pretest-posttest N-gain value. The N-gain value category consists of three: high, medium, and low.

**RESULTS AND DISCUSSION**

**Entrepreneurship-based Biotechnology e-module feasibility**

The feasibility level of developing entrepreneurship-based biotechnology e-modules was measured by expert validation, including lecturers of media experts and subject matter expert lecturers, supplemented by student response data on small-scale trials. For media experts, feasibility consists of module size, module design, and module content design aspects. In contrast, material feasibility experts consist of aspects of content feasibility, presentation feasibility, language feasibility and contextual assessment feasibility (Fig.1).



**Figure 1.** Some of the module's contents include successful entrepreneur content, examples of processed biotechnology products, and capital estimation.

The developed biotechnology e-module could help students train their entrepreneurship, critical, and creative thinking skills. This e-module was also expected to help students understand the concept of biotechnology and its role in human life as an achievement of KD 3.7. Students were also expected to be able to create and develop innovations in one of the conventional biotechnology products as KD 4.7 achievements.

The characteristics of biotechnology e-modules developed in digital form had the advantage of being easy to use by students and could be accessed directly via smartphones and laptops online. Another characteristic was the appearance of the e-module, which contained images that attracted students' interests. The images displayed in the e-module were relevant to biotechnology material. The food



biotechnology products presented in the e-module could be found easily in everyday life, so they could motivate and inspire students to innovate in making processed products from biotechnology materials. E-modules helped students to have contextual learning experiences to increase students creativity and critical thinking skills with teacher as mentor for students activity and the right method such as STEM and socio critical problem based on entrepreneurship (Kurti, 2022; Purwanto et al., 2022; Yaki, 2022).

The e-module also provided tutorials on making processed products from biotechnology materials as inspiration for students. Examples of content for making processed products from tempeh and sticky tape. Processed products presented were equipped with estimated capital estimates and product selling prices relevant to entrepreneurship content. Entrepreneurship content presented in the e-module could increase student self-contained with relevant and comprehensive material (Atmojo et al., 2022).

Articles on successful entrepreneurs in business development for processed biotechnology products inspired and motivated students to develop an entrepreneurial spirit from an early age. Entrepreneurship in students was trained using LKPD (students' worksheets), which can explore students' ideas and creativity to make innovative products processed by conventional biotechnology. The use of conventional biotechnology in LKPD was chosen because it was easy for students to make and apply. LKPD was made online so that students can easily access LKPD.

The e-module was equipped with videos that could be directly accessed via the e-module without making it easier for users to study and read the content presented. An example of the video was a bread-making tutorial. A user-friendly display that could be flipped like a physical book makes e-modules attractive and flexible and easily accessible via smartphone or laptop online. The display of e-modules that were user-friendly and easy to access could increase student learning interactivity and motivation (Asi et al., 2021; Irwansyah et al., 2017; Yulianci et al., 2021).

From the assessment of experts, learning media applied in the classrooms has several advantages. The advantages of the entrepreneurship-based biotechnology e-module application were learning media that were flexible and accessible anytime and anywhere so that they could be used as an alternative to

Android-based online learning . In line with the research of (Handaru & Pujiriyanto, 2020; Sofyan, Hendra et al., 2019; Zulfiani et al., 2021) that the Android e-module is very practical, so that it can be recommended for learning. The biotechnology module is entrepreneurial-oriented to increase student entrepreneurial interest (Astiana et al., 2022; Harichandran et al., 2018). However, the drawback was that this module was still in printed form, not an e-module (soft files) that can be accessed via Android or a computer.

The feasibility level of developing entrepreneurship-based biotechnology e-modules was measured by expert validation, including lecturers of media experts and subject matter expert lecturers, supplemented by student response data on small-scale trials. For media experts, feasibility consisted of module size, module design, and module content design. In contrast, material feasibility experts comprised aspects of content feasibility, presentation feasibility, language feasibility, and contextual assessment feasibility. Learning using entrepreneurship-based biotechnology e-modules that have been declared valid could be used in trials or implementation in classroom learning. The results of the material validation study and learning media using entrepreneurship-based Biotechnology e-modules can be described in Table 1.

**Table 1.** Results of Material Validation Test Analysis

Evaluation	Validation Results (%)	Criteria
Material Expert	89	Valid
Media Expert	94	Valid

Based on Table 1, Entrepreneurship-based biotechnology e-module learning media is said to be valid with an assessment score by the validator can be obtained with a score of 89% with very valid criteria. UNNES Science lecturers carried out media validation. Learning media can be operated easily by teachers and students, suitability in the use of letters and colors adapted to the material, balanced display between content, navigation, brightness that is not flashy, and level of detail appropriate to the material. In the module design aspect, there is access for students to see the following page quickly.

After being validated by media experts, the next step was validating the learning material by

UNNES Science lecturers. The material in learning media was assessed based on the feasibility of content, presentation feasibility, language feasibility, and contextual assessment feasibility. The validation stage by material experts obtained an average score of 94% with excellent criteria. In all aspects of the assessment, components get excellent standards. Material experts suggested that learning media could be implemented in classroom learning. Adding motivation to entrepreneurship-based biotechnology to support students' critical and creative thinking skills is necessary.

From the experts' assessment, learning media that are applied in learning have several advantages. The advantages of entrepreneurship-based biotechnology e-module applications are learning media that are flexible and easily accessible anytime and anywhere so that they can be used as an alternative to Android-based online learning. In line with the research of (Zulfiani et al., 2021) that the Android e-module is very practical so it can be recommended for education. hudaya 2021 that the biotechnology module is entrepreneurial-oriented to increase student entrepreneurial interest. However, the drawback is that this module is still in printed form, not an e-module that can be accessed via Android or a computer.

In the next stage, namely the feasibility test of students. At this stage, it was carried out by giving response questionnaire sheets to students. Small-scale student response questionnaire data were obtained from 10 students. The results of the student response questionnaire are shown in Table 2.

**Table 2.** Results of Analysis of Student Responses to Media

Learners	Scor (%)	Criteria
10 D	84	Very good

Based on the analysis of student responses in Table 2, it was found that 84% had very good criteria. So based on the results of the study of student responses, the biotechnology-based e-module learning media is very good for using to support the science learning process in biotechnology material, especially in improving critical and creative thinking skills.

Students revealed that the appearance of the e-module made was exciting, making learning exciting. Students strongly agree that biotechnology material learning media can be

used in distance learning. In line with research by Mardiyah et al. ,(2022) e-modules can be used for independent study outside school hours, and distance learning can also be carried out. In line with research by Isnaeni et al (2021) showed that the biotechnology module was proven effective.

Entrepreneurship-based biotechnology e-modules that experts declared feasible and received good responses from students in small-scale trials were then implemented in the learning process in class IXA of SMP Negeri 7 Tegal. The implementation phase aimed to improve students' critical and creative thinking skills. This increase was measured through providing students with critical and creative thinking ability test questions in multiple choice and essays. The results of data analysis of students' critical and creative thinking skills in the pretest and posttest of students can be seen in Table 3.

**Table 3.** Results of N Gain Analysis of Pretest and

	Posttest Students' Critical and Creative Thinking Ability				
	N	Min.	Max.	Average	Category
Pretest	31	20.00	80.00	57.74	Not good
Posttest	31	58.00	100.00	80.58	Pretty good
N-gain score	31	-0.40	1.00	0.46	Currently

Based on research data on students' critical and creative thinking abilities in Table 3, the pretest activity obtained an average of 57.74. Meanwhile, in the posttest activities, the average score of students' critical and creative thinking skills tested was 80.58. Data on the average pretest and posttest scores of these students' critical and creative thinking skills showed an increase. The results of the T-test in Table 3 proved this, where the significance value of the T-test was 0.00, which was smaller than 0.05. This test's results showed a significant difference between the average pretest and posttest scores of students' critical and creative thinking abilities. The results of this t-test align with previous research, which showed that the biotechnology module was proven effective in increasing students' creative thinking skills (Hasanah et al., 2023). In line with research by Handajani et al (2022) that entrepreneurial biotechnology-based learning can improve students' life skills. In line with research by Verawati et al (2021) biotechnology and entrepreneurship improve students' critical thinking. In line with research by Bureth et al (2014) The importance of

biotechnology entrepreneurship science. In line with research by Dewi & Mashami, (2019) entrepreneurship is effective in increasing students' creative thinking skills. In line with research by Atmojo et al., (2022) creative thinking skills in the aspects of flexibility, fluency, originality, and elaboration can be increased effectively through entrepreneurship activities.

The results of the t-test, which showed a significant difference between the average pretest and posttest scores of students' critical and creative thinking abilities, became the basis for conducting the N-gain test. The test was conducted to determine the level of improvement in students' critical and creative thinking skills. The N-Gain description in Table 4.5 shows that the category of increasing critical and creative thinking skills in this study is moderate. This is in line with findings from previous studies, which explain that the application of entrepreneurship learning significantly affects students' critical thinking abilities (Khotimah et al., 2016). In line with research by Isnaeni et al. (2021) Science learning has a vital role in training critical thinking skills, analytical skills, scientific attitudes, and environmental care attitudes.

These results become the foundation for revealing that the use of entrepreneurship-based biotechnology e-modules improves students' critical and creative thinking skills. Increasing students' critical and creative thinking skills occurred because students used biotechnology-based e-modules for entrepreneurship. This electronic module provided a variety of contextual materials and displayed attractive images so that students become interested and motivated to learn. The material discussed in this e-module was very close to students' daily lives. One of the materials was tempeh biotechnology material, where this type of food is a meal that students eat almost every day. The images displayed were also very good quality with bright colors, causing the developed e-module to attract students' interest in learning. Students' interest in learning was undoubtedly related to students thinking abilities such as critical and creative thinking abilities. This statement is proven in the previous research, which states that students' learning interest has a positive and very close relationship to students' critical thinking skills (Kencanawaty, 2016). The same statement was expressed by Tambunan, (2016) who says that learning interest influences students' creative thinking abilities, where the higher the interest, the better the creative thinking abilities.

Another reason the entrepreneurship biotechnology e-module can improve critical and creative thinking skills is that this e-module also provided LKPD (Student Worksheets) at the end of each chapter of e-module learning materials. This LKPD invited participants to be able to think critically and creatively in solving a problem and making simple biotechnology products. This LKPD also provided space for students to develop their creativity in making biotechnology products, where students developed superior products into better biotechnology products according to the version of each student. These results align with previous research, which revealed that applying Bioentrepreneurship-based worksheets can improve students' creative thinking skills (Nufaizah, 2019). Sinaga & Anas (2022) also revealed that using biotechnology worksheets in learning can improve students' critical thinking skills. This was explained in other studies that worksheets that invite students to create a product can train critical thinking skills and other higher-order thinking skills (Dewi, 2019).

One of the reasons that make students' creative and critical thinking skills better than before the research was the link feature connected directly to YouTube in the developed e-module. This adds added references or information for students. When making simple biotechnology products by themselves, students could develop their creativity through the various information they had obtained. The diversity of information students obtained in the entrepreneurship-based biotechnology e-module certainly helped improve students' critical and creative thinking skills. Previous study also shows that developing flipbook maker-based e-modules could improve students' critical thinking skills (Latifah et al., 2020). Other research also state that flip pdf-based e-modules can improve students' creative thinking abilities (Hasanah et al., 2023). The same statement was expressed by (Lackeus, (2017) Entrepreneurship instills motivation, confidence and a feeling of relevance among students. The same statement was expressed by Patzelt et al., (2014) biotechnology and entrepreneurship have great opportunities for the entrepreneurial world. other than that according by Stamboulis & Barlas, (2014) young people learn organizational skills, including time management, leadership development, and interpersonal skills.

The implementation stage of the entrepreneurship-based biotechnology e-module



consisted of testing students' critical and creative thinking abilities, as well as an analysis of students' responses to the developed and implemented e-modules. On a large scale, student response questionnaires to the developed learning media were given to 31 students. Students could open up and study together, learning and understanding media applications. Students used this e-module during the process of learning biotechnology material. After that, students were given a response questionnaire to provide an assessment of the learning media. The results of the response questionnaire or student responses can be seen in Table 4.

**Table 4.** Results of the Analysis of Student Responses to the e-module

Student	PresentaseSkor (%)	Criteria
31 PD	84	Very good

From the student response questionnaire data, Table 4 shows average rating score is 84% with very good criteria. Based on the questionnaire data, students' responses showed that learning media for biotechnology materials helped the science learning process. Students think that learning media on biotechnology material is easy to understand, making it easier for them to understand the concept of biotechnology material. The use of learning media makes it easier for teachers and students to learn. This is in line with Ratna Suminar's research (2017) that e-modules can make it easier for students and teachers to learn so that the time spent studying biotechnology can be understood. This research is also good in developing biotechnology in the field of entrepreneurship Yusuf & Ahda, (2020).

The research and development showed that it supports students' critical and creative thinking skills. In addition, the developed entrepreneurship-based biotechnology e-module received a very positive response from all students. So it is highly recommended to be used in learning science at school.

The novelty of this research is in the form of utilizing biotechnology which is taken from the concept and then applied to an e-module combined with the use of an entrepreneurship basis which, of course, will become a real practice for students. The benefits obtained are that simple things related to food have provided high selling power and experience for science education. The result is that apart from enjoying it, it can also be read, studied and understood.

## CONCLUSION

Based on the analysis and discussion of research results, the conclusion that can be drawn from this study is that entrepreneurship-based e-biotechnology e-modules are claimed to be very suitable to use in science learning, especially at the high school level. This is based on the average rating score of the experts, which shows the results are in the form of feasible criteria. The developed e-module can also improve students' critical and creative thinking skills. This is indicated by the average N-gain value, which is in the moderate category. This e-module also received a positive response from students in small-scale and large-scale trials

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