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Development of E-Module on Bioinformatics Materials for SMA/MA

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Article Info

Abstract

This study aims to know the needs of learning teaching materials in the form of electronic modules (e-modules) made based on the results of observations and interviews with biology teachers at MA Unggulan Singa Putih Munfaridin Prigen District - Pasuruan. The type of research used is descriptive qualitative with the Research and Development (R&D) method, while the development model uses the ADDIE approach which consists of 5 (five) steps, including: (1) analyze, (2) design, (3) development, (4) implementation and (5) evaluation. The techniques in this study used three types, namely observation, interviews, and instrument/questionnaire assessments. The data collection instruments consisted of preliminary study instruments that conducted observations and interviews with biology teachers of MA Unggulan Singa Putih, material expert validation instruments, media experts, teacher responses, and student responses. Based on the results of observations and interviews at school, it shows that schools need teaching materials by utilizing technology and involving local wisdom. Based on the results of the study, it shows that (1) the e-module was developed using the canva application and published using flip PDF Corporate Edition; (2) the results of the feasibility test based on the average percentage of validation by material experts of 90.5%, media experts of 91.5%, and linguists of 89.2%; (3) the results of the practicality test obtained an average percentage of 93.3%; (4) the results of the feasibility and reliability test of the student response instrument were declared valid and suitable for use as an instrument to determine student responses. The results of the validity of the student response test instrument from 24 statement items showed that 23 were declared "valid" and 1 statement was "invalid", which indicates that overall the instrument or questionnaire for the practicality test is valid to be used as a bioinformatics e-module instrument. The reliability results of the student response test instrument obtained a Crobanch's Alpha value of 0.961 indicating that the bioinformatics e-module is "reliable" to be used as bioinformatics teaching material.

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1. Introduction

21st century education is considered in creating education that can produce products in the form of critical thinking resources, with the aim of building the foundation of a social and economic order that is aware of science as a 21st century society (Ramadhani & Yudiono, 2020) [30]. Education in this century is expected to achieve equality that is able to master any skills, such as critical thinking, creativity, collaboration, and communication in learning (Kemendikbud, 2017) [21]. In the Decree of the Ministry of Education, Culture, Research and Technology No. 262/M/2022 on the amendment of the Decree of the Ministry of Education, Culture, Research and Technology No. 56/M/2022 on the Guidelines for Implementing the Learning Recovery

Framework Curriculum, it is also mentioned about the independent curriculum that focuses on students by prioritizing their overall growth and developing the hard skills and character of learners (Makarim, 2022) [25].

Science or Biology subject areas provide a comprehensive learning foundation in understanding scientific concepts, scientific work methods, and systematic studies of living things and all aspects of their lives (Yahdiyani *et al*., 2022) [39]. Biology learning trains students to develop deductive, analytical, critical thinking, inductive abilities, and skills in solving problems that occur in the surrounding environment, besides that students are trained to develop competencies, as well as understanding skills (Athiyah, 2018) [5]. According to Hidayah (2022) said that learning theory with tools such as LKS (Student Worksheet) and textbooks still does not provide maximum results. The learning process will be more optimal if there is a practical process, where it becomes a parameter for students in improving psychomotor abilities. Practical activities also need to be equipped with learning tools such as learning materials tailored to student needs (Hidayah, 2022; Najamuddin *et al*., 2021) [16, 27].

Bioinformatics is a multidisciplinary scientific study that is a combination of molecular biology, mathematics, and informatics, and is also interpreted as a computational science to analyze and describe molecular biological data (Ningrum *et al*., 2017; Wibisono & Putri, 2021; Witarto & Sajidan, 2010) [28, 36, 38]. The development of information technology has contributed significantly to driving the exponential growth of innovation, especially in the pharmaceutical and medical fields. In the era of experiments, many began to utilize computer devices, commonly referred to as in silico, as an alternative to accelerate and support the testing process that was previously carried out *in vivo* or through an *in vitro* approach (Knapen *et al*., 2015) [22]. Technological advances help the health sector, especially pharmacy, in finding new drug candidates by appointing local herbal plants as one of the research materials in silico (Dewi, Yuli K, 2020) [10].

Based on the results of a preliminary study conducted through interviews and observations with biology teachers, several problems were identified in teaching biotechnology at MA Unggulan Singa Putih Munfaridin, Prigen District, Pasuruan Regency. The findings show that (1) there is a lack of learning media, teaching materials, and learning resources for bioinformatics instruction; (2) teachers need alternative solutions to overcome these limitations; (3) bioinformatics material needs to be introduced to students in the form of learning content designed in line with current technological developments; and (4) bioinformatics is one example of modern biotechnology that can be introduced to students. Bioinformatics is considered a key topic in modern biotechnology because it does not require high costs, sophisticated equipment, or highly specialized experts to be applied in learning activities. In addition, bioinformatics can be used as teaching material at the senior high school (SMA/MA) level to bridge abstract theory with real data, develop 21st-century skills through a STEM (Science, Technology, Engineering, and Mathematics) approach, and increase relevance to health and pandemic-related issues (Bayat, 2002; Hafsan, 2021) [7, 14].

2. Method

The research method used is descriptive qualitative, where this research has the main characteristics of a natural, real background, with methods such as observa st tion, interviews, and reviewing documents (Subandi, 2011) [33]. This research applies the Research and Development (R&D) method, while the development model applied is the ADDIE development model which consists of 5 steps, including: (1) analyze, (2) design, (3) development, (4) implementation, and (5) evaluation.

Subjects in this study are sources who are samples to obtain information about learning biology, especially the chapter on modern biotechnology in the classroom. Subjects/respondents in this study were biology subject teachers, and two grade X students. While the object of the research is the development of teaching materials in the form of bioinformatics electronic modules obtained from informants related to the phenomenon and background of problems during learning at MA Unggulan Singa Putih Munfaridin Kec. Prigen-Pasuruan. This research develops Bioinformatics learning e-modules based on in silico and molecular docking on herbal plant compounds that have potential as drug candidates. The ADDIE model instructional design has effective goals that focus on authentic task activities, complex knowledge, and natural problems (Hidayat & Nizar, 2021) [17].

Data collection techniques in this study include in-depth interviews, observation, documentation, and distribution of instruments or questionnaires. Interviews were conducted with biology teachers of students with initials with the aim of obtaining information related to the difficulties faced during classroom learning activities. The results of the interview and observation process were used as a preliminary study to determine the right teaching materials at MA Unggulan Singa Putih. Documentation is applied to obtain data in the form of photos, images, videos, recording important notes related to research, while instruments or questionnaires are used with the aim of knowing the practicality and feasibility of bioinformatics e-module learning media which will be shown to expert validators of material, media, language, teachers and students.

The validation instruments or questionnaires in this study include material expert validation instruments, media expert validation, and linguist validation for the purpose of obtaining an assessment of the feasibility of the designed electronic module teaching materials. Validation of material experts, media experts, and linguists is carried out to adjust the learning outcome (CP) material in the phase E element of the Merdeka Curriculum related to students' biological understanding and process skills. The electronic module assessment was carried out by lecturers with the criteria of graduating from S2 or S3 and graduating from S2 Indonesian Language and Literature for language expert validators. As for the purpose of assessing the practicality of the bioinformatics electronic module, it was carried out on biology subject teachers and grade X students at MA Unggulan Singa Putih.

Data from the assessment of bioinformatics electronic module instruments or questionnaires were obtained from material experts, media experts, linguists, practicality assessments from teacher responses, and students. The following criteria for expert instrument validation and practicality are presented in Table 1:

Table 1: Criteria for Expert Instrument Validation and Practicality

Score	Assessment Criteria
1	Very less feasible / practical
2	Less feasible / practical
3	Fairly feasible / practical
4	Feasible / practical
5	Very feasible / practical

Source: (Hikmah *et al.*, 2020; Sugiyono, 2017) [18, 34]

The assessment of material, media, language experts, as well as responses from teachers and students were calculated by applying the following formula:

$$Score = \frac{amount\ obtained}{Score\ Total} \times 100\%$$

After obtaining the score, the next step is to calculate the mean value to determine the final score which is adjusted to the score interpretation guidelines as shown in Table 2.

Table 2: The Score Interpretation Guidelines

Score	Assessment Criteria
0% - 20%	Very less feasible / practical
21% - 40%	Less feasible / practical
41% - 60%	Fairly feasible / practical
61% - 80%	Feasible / practical
81% - 100%	Very feasible / practical

The validity test is a test that aims to measure whether the data under study is valid or invalid, with the criteria that if r-count is greater than r-table, it is categorized as valid, but if on the contrary it is categorized as invalid. While the reliability test is carried out to find out how far the questionnaire or instrument used in the study. Using the SPSS 22.0 for windows program, the variable is declared reliable with the Cronbach's Alpha value criterion of more than 0.6, it is categorized as reliable, otherwise it is categorized as unreliable.

3. Results and Discussion
3.1. Preliminary Results of Electronic Module Development
A. Analyze
Needs Analysis
In the analysis research stage, the methods applied by researchers are interviews and observation (observation) at MA Unggulan Singa Putih, Prigen, Pasuruan. Observation carried out in class X and the interview stage, on the Biology teacher named Ni'matul Ula, S.Pd and two class X students namely SAI and AH. Activities at this stage, is an initial assessment to gather information that will be applied as a reference to the development of e-module teaching material. The following is a summary of the results of observations and interviews conducted:
1. The lack of the latest media and teaching materials in class X MA Unggulan Singa Putih, Prigen, Pasuruan.
2. MA Unggulan Singa Putih is a modern boarding school, where students are accustomed to learning independently, innovatively, following technological advances and prioritizing local wisdom as practical material. The school really needs interesting and informative learning resources related to the development of science.
3. Bioinformatics material needs to be introduced to students in the form of modern teaching materials that are adapted to the times;
4. Bioinformatics is a variation of learning to determine the initial detection of a compound's potential as a drug candidate.

Curriculum Aanlysis
The purpose of analyzing the curriculum is to collect information related to the material to be implemented into e-module teaching materials. MA Unggulan Singa Putih School has implemented the latest curriculum, namely the Merdeka Curriculum, where learning is project-based or practical for the development of soft skills and student characteristics in line with Pancasila Students (Hakim, 2020) [15].

Learner Analysis
The results of the learner analysis were obtained from classroom observations, teacher and student interviews. According to the results of interviews with biology subject teachers and two students, it can be concluded that student character is formed from the habits of students who learn independently. Students who study at school are students who are also boarding school students, where by the caregivers Romo Kyai and Mrs. Nyai, the ustadz / ustadzah in the pesantren and teachers at school who always train with independence, skills, creativity, and follow learning according to existing technological developments. Limited learning media makes the learning process hampered from teacher to student and vice versa, and the character of students who like coherent learning, practice with a conventional touch as well as modern and learning styles of some students between kinesthetic, audio, and visual learning styles.

B. Design
Electronic Module Design
The initial activity in developing teaching materials is to design a draft bioinformatics electronic module as cover page, editorial, sekapur sirih, table of content, Electronic Module Instruction, bibliography, glossary, and compiler profile.

Bioinformatics Electronic Module Flowchart
The activity of compiling a flowchart has an important purpose in the design stage which will be developed into an electronic module product (e-module), one of which is to visualize the sequence of steps or processes coherently, clearly, and in detail, especially in activities that are complex and structured.

Bioinformatics Electronic Module Storyboard
The creation of the storyboard itself has an important purpose, namely visualizing the electronic module design product, explaining the flow of pictorial narration, point of view placement, continuity between elements in a coherent manner of learning material, devices, and important

information into a storyline.

C. Development
Material Collection
Material collection activities are important activities as the basic material for developing teaching material products that are tailored to the needs. Some of the activities carried out include making lesson plans, making test steps, conducting in silico and molecular docking tests, the results of which are used for electronic module content.

Creation of Bioinformatics E-Module
The bioinformatics electronic module is created using a web application, namely Canva, and utilizes advanced features in it such as creating barcodes or shortlinks that will be installed on the content of the bioinformatics electronic module. Barcodes or shortlinks that will be installed on module content are also one of the main advantages of electronic-based. It aims to reach all needs such as video content, images, learning materials and quiz content connected to a webserver or different applications that are not installed in the bioinformatics e-module content.

Publishing
The publishing process includes uploading e-modules in PDF format that can be accessed online via a link on a laptop, smartphone, or computer, as well as in exe format for offline use on a computer/laptop. The software utilized in this process is Flip PDF Corporate Edition. When publishing, the addition of videos, quizzes, LKPD, and some material content that can be accessed through barcodes and links contained in the e-module is carried out.

Electronic Module Product Trial
The next activity is to validate electronic module products by linguists, media, and material experts to test the feasibility of bioinformatics e-modules. The validation results obtained a feasible predicate in terms of material, media, and language. After that, student and teacher response tests were also carried out to obtain practicality validation.

D. Implementation
Bioinformatics electronic module (e-module) products that have been declared feasible by validators, then tested on 1 biology teacher and 10 students in small group tests at MA Unggulan Singa Putih, kec. Prigen, kab. Pasuruan. Teacher response trials and student responses were carried out online who had studied Modern Biotechnology material online through google forms and other online applications. Electronic module products (e-module) and teacher response validation sheets are sent via WhatsApp, as well as with students. The results of teacher and student responses will be entered into the webserver dashboard linked to the researcher's gmail, so that researchers can find out the results of the response directly when validation has been carried out on the product.

E. Evaluation
The evaluation stage is to revise the bioinformatics e-module product based on suggestions and comments from linguists, media, and material experts. After the revision based on the experts, the next revision was carried out referring to the responses of teachers and students at the implementation stage.

3.2. Bioinformatics Electronic Module Feasibility Validation Results
Material expert validation results
Validation activities are carried out by several assessors (validators) based on expertise, namely language, media, and material experts. Material expert validators are Fuad Jaya Miharja S. Pd. M. Pd. as material expert 1 and Ahmad Fauzi S. Pd. M. Pd. as a material expert 2 who is a lecturer in Biology Education, Faculty of Teacher Training and Education, University of Muhammadiyah Malang. The material validation process aims to obtain an assessment of the feasibility of the bioinformatics e-module product developed as teaching material at MA Unggulan Singa Putih. The following is the validation result data presented in Table 4:

Table 3: Material Expert Validation Results 1 and 2

Assessment Results	Expert Material 1	Expert Material 2
Total Assessment Score	104	95
Maximum Score Total	110	110
E Module Quality Percentage Bioinformatics	94,5%	86,4%
Category	very worthy	very worthy

The percentage results of the assessment (validator) of material expert 1 and material expert 2 based on the feasibility aspect of graphing can be reflected in Figure 5 of the following diagram:
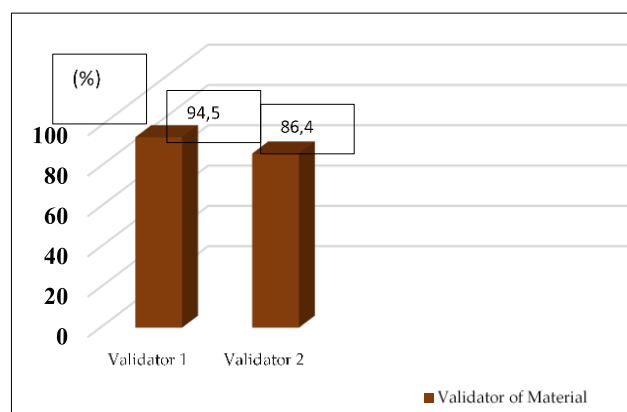

Fig 5: Diagram Percentage Diagram of Material Expert Validation Results

Based on Table 4 and Figure 5, the results of the assessment of material experts (validators) 1, obtained a percentage of the quality of bioinformatics e-modules of 94.5% with the category "very feasible". Validator 1 gave suggestions, namely that the author provide reinforcement of the context of bioinformatics material in everyday life and the question that must be answered is, "what are the benefits or why do students need to learn or understand bioinformatics?". In addition, validator 1 gave an impression to researchers, in order to improve some parts or parts such as images, and fonts should not use bold. Meanwhile, the assessment of material expert validator 2 has a percentage of 86.4% with the category "very feasible". In the feasibility assessment by validator 2, notes were given about the e-module, namely about the appearance of the bioinformatics electronic module which is very attractive and based on current technology. In addition, although in general it is very good, it still needs

revision according to the notes given so as not to cause misconceptions in some word definitions, for example the definition of molecular docking which needs to be revised and dug back deeper understanding from reliable references, and the definition of biotechnology and modern biotechnology does not need to be defined twice in the glossary.

Media Expert Validation

Media expert validation was carried out by 2 validators, namely Dr. Nurwidodo, M.Kes as media expert 1 and Tutut Indria Permana, S.Pd, M.Pd media expert 2 who is a lecturer in Biology Education, University of Muhammadiyah Malang. The material validation process aims to obtain an assessment of the feasibility of the bioinformatics e-module product developed as teaching material at MA Unggulan Singa Putih. The following is the data on the validation results of media expert 1 and media expert 2 in Table 5 below:

Table 5: Media Expert Validation 1 and 2

Assessment Results	Media Expert 1	Media Expert 2
Total Assessment Score	58	61
Total Maximum Score	65	65
Bioinformatics E-Module Quality Percentage	89,2%	93,8%
Categories	Very Feasible	Very Feasible

The percentage results of the assessment (validators) of media experts 1 and media experts 2 based on the feasibility aspect of graphing are presented in the form of Figure 6 of the following diagram
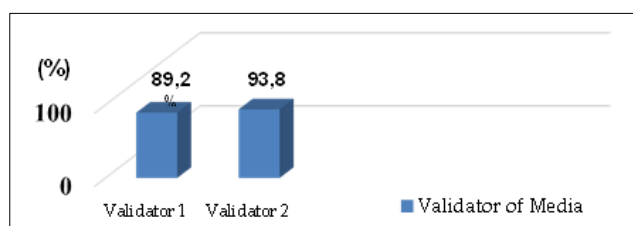

Fig 6: Percentage Diagram of Media Expert Validation Results

Based on Table 5 and Figure 6, the assessment results obtained from the media expert validator 1, namely the total assessment score of 58 out of a maximum score of 65, the percentage obtained is 89.2% with the category "very feasible". Media expert validator 1 gave notes in the form of suggestions for developing bioinformatics e-modules, namely the use of modules that are effective and efficient for high school students, but some parts need to be improved such as letters need to use fonts that can be changed to italic for needs when writing scientific or English words, should not use bold fonts, and the navigation section should only be made on a sheet. The impression given by validator 1, namely that overall the e-module is good and efficient, only needs to replace the parts that have been written in the notes. Meanwhile, the assessment results obtained from the media expert validator 2 are the total assessment score of 61 out of a maximum score of 65, the percentage obtained is 93.8% with the category "very feasible". In addition, validator 2 gave advice, that the e-module as a whole was good, but there were some parts that seemed more suitable for independent

learning for group activities that were still not visible, illustrations still did not show "bioinformatics", details and design composition were too crowded if used for high school students. The validator gave suggestions for the author to improve the parts that need to be revised and add collaborative activities to fulfill assessment criterion number one.

Linguist Validation

Language expert validation was carried out by 1 validator, namely Yusril Ihza Fauzul Azhim, S.S, M.A, who is a lecturer, director, and writer at Surabaya State University. The material validation process aims to obtain an assessment of the quality of the language applied to a learning media, writing, or scientific work of bioinformatics e-module products developed as teaching materials at MA Unggulan Singa Putih. Data from linguist validation results are presented in Table 6 below:

Table 6: Linguist Validation Results

Assessment Results	Linguist
Total Assessment Score	58
Total Maximum Score	65
Bioinformatics E-Module Quality Percentage	89,2%
Categories	Very Feasible

The results of the percentage of assessment (validators) of linguists based on aspects of presentation feasibility and linguistic feasibility can be presented in the form of a diagram in Figure 7 below:
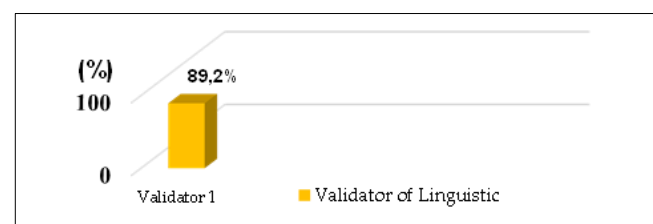

Fig 7: Percentage Diagram of Linguist

According to Table 6 and Figure 7, the results of linguist validation showed that the number of linguist assessment scores was 58 out of a maximum score of 65, while the percentage of bioinformatics e-module language quality was 89.2% with the category "very feasible". The linguist validator gave quite complete notes in the notes table contained in the attachment, besides that the validator gave the impression that the e-module was packaged systematically, creatively and innovatively. In the presentation of material, both from the definition of terms, core material, concepts, learner projects, assessments, and literature, it includes Learning Outcomes and Flow of Learning Objectives in a systematic, structured and measurable manner. Even in the concepts and tasks for students, this E-Module presents visuals and content that are elegant, easy to understand, critical, and innovative and creative according to the needs of teachers and students based on the intended level. In addition, the validator also gave advice that the author should be more careful on issues of grammar, spelling, and punctuation, because this will affect the understanding of e-module readers. The rest is suitable for publication and implementation.

3.3. Results of Practicality Validation of Bioinformatics Electronic Module
Results of Practicality Assessment of Biology Teacher and Learner Responses

After the bioinformatics e-module product was declared feasible by material, media, and language expert validators at the validation stage, the next product trial was carried out. The e-module product testing was carried out on 1 biology teacher, namely Mrs. Nikmatul Ula, S.Pd at MA Unggulan Singa Putih. The following are the results of the teacher response practicality assessment in Table 7:

Table 7: Results of Practicality Assessment of Biology Teacher

Assessment Results	Biology Teacher Response
Total Assessment Score	114
Total Maximum Score	120
Bioinformatics E-Module Quality Percentage	95%
Categories	Very Practical

According to Table 7, the results of the assessment of the practicality of the Biology teacher's response were obtained, while the percentage of the quality of the practicality of the bioinformatics e-module was 95% with the category "very practical". The biology teacher response trial provides a fairly complete record of the e-module product which can be seen in the table contained in the attachment, but some important notes in the form of suggestions from teachers to improve the quality of the e-module, namely the suitability of intellectual development is appropriate but what needs to be considered is ensuring students to operate the electronic-based media. In addition, there are some parts that are power text that should be given pictures to clarify and insert illustrations that represent the material. In this study, only small group research was carried out because class X students of MA Unggulan Singa Putih class of 2024/2025 only numbered 10 students. The following are the results of the student response trial in Table 8.

Table 8: Results of Practicality Assessment of Learner Responses

Respondents	Ʃ score	Ʃ Maximum Score	Practicality Quality Percentage (%)
Student Response 1	96		80
Student Response 2	118		98,3
Student Response 3	117		97,5
Student Response 4	119		99,2
Student Response 5	108	120	90
Student Response 6	119		99,2
Student Response 7	97		80,8
Student Response 8	103		85,8
Student Response 9	119		99,2
Student Response 10	101		84,2
average assessment	914,2		
average percentage assessment	91,42		

According to Table 8, the results of the learner response trial with the number of respondents 10 students obtained the percentage of student responses 1 to student responses 10 each in order are 80%, 98.3%, 97.5%, 99.2%, 90%, 99.2%, 80.8%, 85.8%, 99.2%, and 84.2%, while the mean score of the percentage of practicality quality is 91.42% with the category "very practical". The results of the percentage of teacher responses and the average student practicality scores

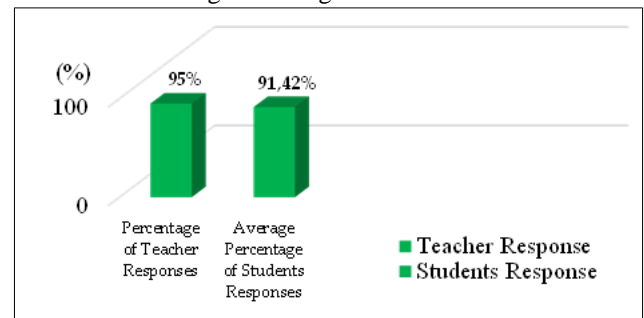are listed in the diagram in Figure 8:

Fig 8: Diagram of the Percentage of Practicality Assessment Results of Teachers and Learners

According to Figure 8. the results of practicality validation through teacher responses obtained a percentage value of 95% with the category "very practical", while the results of practicality validation of student responses obtained an average percentage of 91.42% and categorized as "very practical". According to the results of the biology teacher response trial and student responses to the bioinformatics e-module product at MA Unggulan Singa Putih using Flip PDF Corporate Edition and getting the predicate category "very practical". The overall assessment percentage results can be presented in the diagram in Figure 9 below:
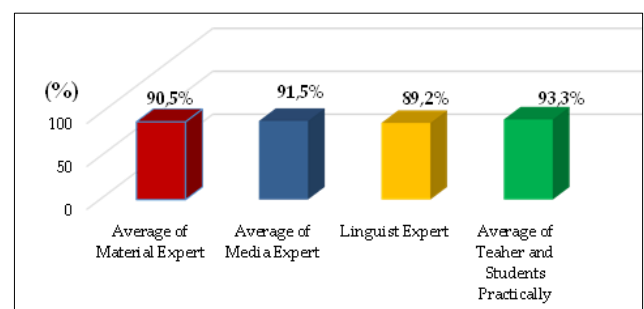

Fig 9: Overall Percentage Diagram of Feasibility and Practicality Assessment Results

According to Figure 9, the overall diagram of the results of the response trial and expert validation, shows that the average percentage of material experts 1 and material experts 2 is 90.5% with the category "very feasible", the average validation results of media experts 1 and media experts 2 get a percentage of 91.5% with the category "very feasible", and linguists with a percentage of 89.2%. The conclusions from the tests of material experts, media experts, and linguists show that the binformatics e-module is very feasible to be used as teaching material at MA Unggulan Singa Putih Munfaridin. Meanwhile, the practicality test of the bioinformatics e-module on the teacher's response and the average response of 10 students received a percentage value of 93.3% which indicates that the bioinformatics e-module is practically used by teachers and students as teaching material at MA Unggulan Singa Putih Munfaridin.

Student Instrument Quality Test
Student Response Instrument Validity Test

The validity test is carried out to find out the instrument used in this study really measures what you want to measure. In this study, the instrument validity test was carried out on 10 students at MA Unggulan Singa Putih Munfaridin with 24 questions, and the results of the validity test obtained that it

has valid criteria and can be used to measure what will be measured. In 24 statements, 23 statements received valid criteria, and 1 statement received invalid criteria. No improvements were made to the assessment instrument, because overall it received the appropriate criteria (valid).

Reliability Test of Student Response Instrument
The reliability test of the student response instrument carried out on 10 students in class X MA Unggulan Singa Putih Munfaridin was obtained using the Cronbach's Alpha formula approach by correlating the SPSS version 27 application which is presented in Table 9 below:

Table 9: Reliability Test Results via SPSS

Reliability Statistics	
Cronbach's Alpha	N of Items
.961	24

Based on Table 4.7, the results of the student response reliability test which obtained a Cronbach's Alpha value of 0.961 with a total of 24 questions can be concluded that the reliability criteria are high, which means that the bioinformatics e-module is feasible or reliable to be used as teaching material for students in class X.

3.4. Revisi Product Revision of Bioinformatics Electronic Module
Bioinformatics e-module products that have been assessed by expert validators, teacher responses, and students are then revised according to notes, suggestions, and impressions from language expert validators, media experts, and material experts. The results of the feasibility assessment notes by experts on bioinformatics e-module products are presented in Table 10 below:

Table 10: The results of the feasibility assessment notes by experts on bioinformatics e- module products

No.	Expert Assessment	Improvement Notes
1.	Material Expert Validation	Improve the font "Fredoka" or writing from a bold font and cannot be italicized (Italic) to a Times New Roman type font so that the writing can be made Italic for foreign terms and the writing becomes clearer
		Improve foreign terms that were not Italic to Italic form
		Almost all writing on the bioinformatics e-module changed the font to Times New Roman
		Avoiding double definitions such as the definition of biotechnology and modern biotechnology.
		Correct the definition of Molecular Docking according to reliable references
		Initially after the explanation of the kinds of in silico testing and molecular docking material there were no examples of visualization and detailed explanations, then given a new page sheet to provide examples of visualization results of test results.
		Page 36, on the lack of Bioinformatics is written incompletely so that it seems to give the meaning of information that is hanging and unclear.
		Previously "in Indonesia, statistical training for bioinformatics experts" was changed to "In Indonesia, there is a lack of statistical training in the field of bioinformatics.
2.	Media Expert Validation	Same as in the notes from the material expert validator, so that the author provides examples of visualization images of test results to make it easier for students to understand and illustrate the interaction between protein molecules and targeted ligands
		Media expert validator 1 & media expert 2, both gave notes to revise the font or writing form from the original form, namely the Fredoka font type to Times New Roman font.
3.	Linguist Validation	Improvements to the Electronic Module Instructions: (1) Previous Page, (2) Next Page, (3) To Last Page, (4) To First Page, (5) Zoom In / Zoom Out, (6) Search, (7) Share to Share, (8) Text, (9) Print, (10) Email, (11) Fullscreen to Fullscreen, (12) Sound to Sound. (13) Barcode Scan can be added.
		Improvements to Learning Outcomes: (1) Website & Application. Page. (2) Responsive becomes Responsive, (3) Alternative becomes Alternative. Page 7
		Improvements to Learning Outcomes Page. (1) in the sub-chapter of observing there is an incomplete sentence at the end of the sentence ... from the object he ... there is no continuation. (2) In Sub-Chapter 5, in the first sentence there is a repetition of the sentence Evaluate conclusions through ... (3) The word communicate can be replaced with communicate.

The development of technology in the digital era requires teachers to innovate in applying teaching media used in learning. The use of teaching media has undergone many changes starting from the physical form, and now there are many online forms that can be accessed anywhere. Modern technology has brought considerable renewal in science education, both in terms of learning methods, content creativity, and the design of the form of teaching media used. The benefits of developing technology allow students to be eager to learn and think forward, besides that technology also facilitates interaction between teachers and students, and can access other learning resources (Astuti et al., 2023) [4].
The application of digital technology in education can increase learners' interest and motivation to learn, as well as broaden their horizons and understanding of scientific concepts (Mercado et al., 2019) [26]. For example, integrating technology in science learning allows learners to more easily analyze and understand data representations, which are important skills in science. In addition, inquiry-based approaches with the application of technology have been proven to be more effective in learning activities than traditional methods, as they encourage students to actively participate in the learning process (Zotou, 2018) [40]. This strongly supports the statement that science learning not only improves learning conceptually, but is able to improve relevant scientific skills (Adolph, 2016) [1]. On the results of a preliminary study conducted on September 20, 2023 through interviews with biology teachers and classroom observations, it was found that the learning process has problems in biotechnology material, especially bioinformatics material at MA Unggulan Singa Putih Munfaridin Kec. Kraton- Pasuruan obtained data, namely: (1)

lack of media, teaching materials and learning resources for learning bioinformatics; (2) teachers need alternatives to answer the problem of lack of media, teaching materials, and learning resources for learning bioinformatics material; (3) bioinformatics material needs to be introduced to students in the form of learning materials designed in accordance with the latest technological advances; (4) bioinformatics is a variety of learning to determine the potential of a compound as a drug candidate by utilizing local plants.

Science learning has important components including scientific attitudes, scientific processes, and scientific products. The scientific process in science learning is the science process skills. The Pancasila learner profile with a critical reasoning attitude is most suitable for practicum-based science learning (Maisarah & Prasetya, 2023) [24]. Science process skills are divided into 2 types, namely basic science process skills and integrated science process skills. Basic science process skills are suggestions, facilities, and methods used to form new knowledge, while integrated science process skills are activities aimed at identifying variables, collecting, processing data, analyzing research, formulating hypotheses, designing research, and conducting experiments (Barus et al., 2024; Inayah et al., 2020) [6, 19]. According to Wijaya, et. al. (2021) said that the current generation of students shows high enthusiasm for the use of modern technology in various aspects of life. This condition should be optimally utilized by educators to design and develop technology-based learning media. The development of teaching materials must keep up with the times, therefore its novelty is very important and needed (Wijaya et al., 2021) [37].

Furthermore, the results of the preliminary study were followed up with in-depth interviews conducted on August 20, 2024 to Mrs. Ni'matul Ula as a biology teacher at MA Unggulan Singa Putih, Prigen District, Pasuruan Regency related to the learning problems of biotechnology material. The results of in-depth interviews related to problems based on needs analysis obtained data that bioinformatics learning requires electronic modules (e-modules). E-modules are learning materials that are assembled for self-study, systematically formulated into concise learning units in order to achieve certain learning objectives. The form of e-module is presented in the form of electronic or digital format with learning activities in which it connects the horizon of knowledge through the internet as a navigation to make students more interactive, besides that the presentation is also accompanied by various supporting media, such as step guides (tutorials), videos, audio and animated images, which aim to optimize the learning experience (Gunadharma, 2011) [13]. The preliminary study stage, in-depth interviews, and observations are the first and essential processes in formulating and determining teaching materials that are in accordance with the character of students, the applied curriculum, and learning objectives.

The second stage is the design of the electronic module outline which contains the introduction, content, and closing. There are three (3) important activities in this stage, designing the electronic module draft. Researchers designed the draft according to the needs and learning objectives. The second activity is to compile a flowchart of the bioinformatics electronic module by combining project-based learning that is aligned with the curriculum used at MA Unggulan Singa Putih Munfaridin. The third activity is to create a storyboard with the aim of describing the electronic module product with the flow and information contained therein.

The third stage in the preparation of electronic modules is the development stage, where there are four (4) important activities carried out, including data collection, making bioinformatics electronic modules, publishing, and poduk trials. The collection of materials in this research includes making lesson plans, conducting in silico and molecular docking tests whose test results will be included as content, and several other activities such as questions, material summaries, and self-reflection. Making electronic modules is prepared with the help of applications such as Canva, Corel Draw 18, and applications for making barcodes and shortlinks that will be installed on electronic modules. Publishing activities are activities to upload e-modules in pdf format by utilizing Flip PDF Corporase Edition software that can be accessed online on laptops, computers, and smartphones. The last activity at the development stage is product testing by material experts, media experts, and linguists, where expert validators have the criteria of S2 and S3 graduates. The results of the assessment conducted by two (2) material expert validators that the average percentage of the assessment results scored 90.5%. In the assessment conducted by two (2) media expert validators, the average score was 91.5%. And the assessment results from one (1) linguist validator get a score of 86.4%. From the average of the three percentages of the feasibility assessment results by experts, that the electronic module is categorized as "very feasible" to be used as teaching material for bioinformatics electronic modules at MA Unggulan Singa Putih Munfaridin. The next stage is implementation, where this stage is carried out after carrying out a series of assessments by experts and revision of teaching materials. Next, the practicality test of teaching materials was carried out to get the response of biology teachers and 10 class X students at MA Unggulan Singa Putih Munfaridin. The product trial of the electronic module was carried out online by teachers and students, while the results of the teacher response assessment received a score of 95%, and the average percentage of ten (10) student responses received a score of 91.42%, both average percentage results of the practicality assessment received a score of 93.3% which indicates that the bioinformatics electronic module is practically used by teachers and students as teaching materials at MA Unggulan Singa Putih Munfaridin. Furthermore, the researchers tested the validity and reliability of the student response instrument with the aim of knowing that the instrument or questionnaire used was feasible and reliable. The results of the validity of the instrument with 24 questions obtained that 23 were declared valid, while 1 question was declared invalid. No improvements were made to the assessment instrument, because overall it received the appropriate criteria (valid). While the results of the instrument reliability test using the SPSS version 27 application obtained a Cronbach's Alpha value of 0.961 with a total of 24 questions, it can be concluded that the reliability criteria are high, which means that the bioinformatics e-module is feasible or reliable to be used as teaching material for students in class X.

Bioinformatics, part of modern biotechnology, is a field of science that collaborates several disciplines, namely biology, computer science, mathematics, engineering, chemistry, biochemistry, and statistics to analyze and understand biological data, especially genetic and genomic data. Experimental technology has progressed to produce large amounts of data, which are then managed, extracted, and used

as information and an important resource for discovering new knowledge and improving understanding of life (Sardi, 2022) [31]. Before the advent of bioinformatics, biological experiments were only conducted in two ways, namely *in vivo* by utilizing the body of a living being and *in vitro* by utilizing a natural content of a living being (Sardi, 2022; Warsinske, 2016) [31, 35]. One of the applications of bioinformatics in the fields of biology and medicine is testing to find new drugs as carried out by researchers who conduct in silico-based bioinformatics experiments and molecular docking which are used as teaching material development materials in the form of electronic modules. The in silico test approach method aims to predict the binding mode and affinity of a small molecule to the active side of a particular target receptor, thus helping to determine the mechanism of action of a compound. In addition, in the docking process, the conformational structure of the molecular docking visualization results will also be displayed in 2D, 3D, and amino acid resido (Arshad, 2023) [3].

In this study, based on preliminary studies, it was also found that student character was formed from the habit of students learning independently. Students who study at school are also boarding school students, where by the caregivers Romo Kyai and Mrs. Nyai, the ustadz / ustadzah in the pesantren and teachers at school who always train with independence, skills, creativity, and follow learning according to existing technological developments. In addition, students are given directions to utilize the natural resources found in the school and boarding school environment for learning activities, therefore the preparation of electronic modules also collaborates technology and local wisdom through herbal plants. Since ancient times, jamu has been utilized by the community as a traditional herb to treat various types of diseases. Most Indonesians believe that herbal supplements are a safe choice for consumption because they come from plant materials (Chiba, 2001; Destiani & Suwantika, 2015) [8, 9] Generally, people do not realize that although herbal supplements have benefits, the concentration of compounds in them also has the potential to cause risks, including toxicity, drug interactions, and side effects (Destiani & Suwantika, 2015; Keller, 2014) [9, 20]. Based on research from Dewiyanti, Ari (2020), several herbal plants such as Cinnamomum cassia, Curcuma sp, and so on are proven to have antiviral activity. Bioactive compounds from the flavonoid class are proven to have the most ability as immunomodulators and antivirals against viruses that cause infections in the respiratory tract (Dewiyanti, 2020) [11]. In addition, herbal plants, during the Covid-19 pandemic, have been widely discussed both among the public and academics, several studies have shown that the public response to processing herbal plants into supplements has a high result of around 89%. This is certainly inseparable from the benefits of herbs that have been proven effective in increasing immunity or endurance during the Covid-19 pandemic (Shaleha & Yuliana, 2022) [32].

Plants are also often used as symbols of God's power and parables in the Qur'an to convey wisdom to mankind, one of which is in QS. Al- Isra: 82 and QS. Yunus: 57. Meanwhile, the Qur'an also explicitly mentions various types of fruits and plants with certain intentions, including to explain their benefits and functions, including plants as medicines (syifa') that are useful for humans (Finamore *et al*., 2021) [12]. The Prophet Muhammad mentioned in a hadith the benefits of a herbal can treat 7 kinds of diseases, including diseases related

to the lungs, this hadith was narrated by al-Bukhari No. 5260 in the book of medicine.

4. Conclusion
This research applies the Research and Development (R&D) method with the ADDIE development model and the product developed is an electronic module of bioinformatics learning. Based on the results of data analysis, it can be concluded that the bioinformatics electronic module (e-module) is able to fulfill the availability of bioinformatics learning teaching materials that are included in the chapter of modern biotechnology based on in silico and molecular docking of herbal plant compounds at MA Unggulan Singa Putih school. In the research conducted, there are results of feasibility assessment of bioinformatics electronic modules by material experts getting an average percentage of 90.5%, the results of media expert validation get an average percentage of 91.5%, the results of linguist validation get a percentage of 89.2%, it can be concluded that the results of expert validation show that the bioinformatics e-module is very feasible to be used as teaching material. The results of the practicality test of the biology teacher's response and 10 students at MA Unggulan Singa Putih Munfaridin about the bioinformatics e-module get an average percentage of 93.3%, which indicates that the bioinformatics e-module is practically used by teachers and students as teaching material. The results of the validity of the student response test instrument from 24 statement items showed that 23 were declared "valid" and 1 statement was "invalid", which indicates that overall the instrument or questionnaire for the practicality test is valid to be used as a bioinformatics e-module instrument. The reliability results of the student response test instrument obtained a Crobanch's Alpha value of 0.961 indicating that the bioinformatics e-module is "reliable" to be used as bioinformatics teaching material.

5. Thank-You Note
Ajeng Putri Widowati is the main author who is responsible for collecting data, making instruments, conducting research, and analyzing research data. Atok Miftachul Hudha is the second researcher in this journal responsible for providing guidance on research methods, data analysis, and preparation of electronic module content. Lud Waluyo is the third author responsible for providing input in compiling electronic modules, Yuni Pantiwati is the fourth author responsible for providing advice on the preparation of teaching materials, and research examiners. Rr Eko Susetyorini as the fifth author is responsible as a research examiner, providing input on the concept of preparing teaching materials.

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