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Development of STEM-Based Electronic Student Worksheets in Aquatic Ecology Subjects to Improve Students Creative Thinking

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A B S T R A C T

The 21st century is also known as the era of science and communication. To face the challenges of the 21st century, quality human resources are needed through the education sector. This research aims to: 1) determine the validity of STEM-based e-LKM in the Aquatic Ecology course, 2) determine the practicality of STEM-based e-LKM, and 3) determine the increase in students' creative thinking after using STEM-based e-LKM. e-LKM development is carried out using the ADDIE model at the analysis, design, development, implementation and evaluation stages. The research subjects are material experts, education experts, media experts and students. Expert validity data was collected using an expert validation questionnaire which was analyzed using the Pearson correlation test, data on creative thinking skills was measured by asking students questions. The research results show that the validity of e-LKM is in the very valid category of 3.76 from an average of 3 experts who are validators. And the student's post test score is in the very good category, namely 87.15. It can be concluded that this research produces e-LKM for aquatic ecology courses that are valid and practical.

1. Introduction

The Aquatic Ecology course is one of the Compulsory Expertise Subjects (MKBK) in Semester 5 of the OBE (Outcome Based Education) curriculum in support of the 2020 Independent Campus Learning (MBKM) program with the course code BIO3126 which has a credit weight of 3 credits. with a division of 2 theory credits and 1 practical credit (OBE Biology Education Curriculum., 2020). One of the main materials in the aquatic ecology course discusses typological characteristics, dynamics and interaction of physical, chemical and biological factors as well as oceanography of fresh waters and marine waters which supports

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the achievement of Course Learning Sub-Achievements (Sub-CPMK) 6, Sub-CPMK 7 and Sub-CPMK 8.

The biodiversity of marine ecosystems and freshwater ecosystems, especially in Riau Province, is always used as an example in teaching aquatic ecology courses. The freshwater ecosystem used as an example is the lake ecosystem. The marine ecosystem used as an example is the mangrove ecosystem. According to Zulhalifah et al., (2021) the mangrove ecosystem is composed of abiotic components (temperature, water, light, humidity, air, pH and others) and biotic (mangroves, molluscs, fish, birds and others). Mangrove forests are a collection of various types of mangrove species that exist along the coast or river estuaries. According to Mulyadi., (2010), The ecological function of lake and mangrove ecosystems provides environmental services that can be used as a place to study ecological concepts and become a source of learning. Mangrove ecosystem environment has its own uniqueness as a learning resource so that it motivates students in learning activities (Saputri et al., 2019).

Field practicum activities carried out in aquatic ecology courses use Student Worksheets (LKM) as a learning resource. According to Bare (2021) Student Worksheets (LKM) are one of the instruments that are really needed in classroom learning, the use of LKM for students provides direction and guidance for learning. The results of the researcher's observations show that the field LKM used is still in the form of printed LKM and does not yet support the concept of 21st century learning. According to Septikasari and Frasandy., (2018) 21st century learning is a student-centered teaching and learning process using information and communication technology as a multi-source resource. places students to play an active role in acquiring 21st century competencies, attitudes, knowledge, skills and abilities as well as literacy. Students' critical thinking abilities are very necessary to shape students' cognitive strengths (Agustia, 2024).

The development of digitalization and technology which supports 21st century learning requires students to be able to use technology in learning. The results of the research survey found that 100% of biology education students class of 2021 have 100% smartphones. In line with research reported as by Devanga and Norida., (2020) that 93% of students have Android cellphones, 7% of students have iPhone cellphones, it can be concluded that there are no students who do not have cellphones. This will make e-learning easier. As teaching staff, lecturers as facilitators in the learning process are expected to have the skills to create innovative technology-based learning resources. One of the innovations that can be carried out is the development of e-LKM (Electronic Student Worksheets) which can be accessed easily on various smartphone devices and connected to the internet, which will be an effective innovation to assist in the teaching and learning process in lectures, especially field practicums in aquatic ecology courses. Education is the most important factor in a person's life, because it can distinguish a person's ability to think (Bella, 2023).

Through e-LKM it will also help students in studying (Patresia et al., 2020). This is in accordance with the results of the researcher's pre-survey, namely that 100%

of students need e-LKM for practicum learning in the field (attachment 4). The result research by Aldresti et al., (2021) e-LKM is a learning resource that contains learning materials equipped with pictures, videos and can attract students' attention in learning and help understand the material so that an 89% validity value is obtained from e-LKM.

According to Muqaddas et al., (2023), one of the current learning approaches that really supports the achievement of 21st century competencies is Science, Technology, Engineering, Mathematics (STEM) based learning. According to Aina et al., (2021) STEM Education means education that involves these four disciplines. this is because natural science, technology, engineering and mathematics are the basic foundations for the development of Science and Technology (IPTEK) (Baharin et al., (2018); Fathoni et al., 2020). STEM learning expects students to be prepared to face the era of globalization which is growing rapidly from time to time. STEM learning can be integrated with various teaching materials, one of the teaching material innovations that can be carried out is the development of STEM-based e-LKM. e-LKM combined with the STEM concept will provide learning materials that require students to be able to think at a higher level. The results of Maulidia research., (2019) show that the development of STEM-based teaching materials is in the feasible category with a feasibility test percentage of 85% and is categorized as easy for students to understand.

One of the skills emphasized in the 21st century skills above is the ability to think creatively. According to Yustina et al., (2020) creative thinking is a high-level thinking ability, namely the ability possessed by every individual to create a new thing that has not existed before, whether in the form of an idea or an idea that is used in solving a real problem. Creative thinking is a skill in generating and developing new ideas, new ideas as self-development from previously existing ideas as well as problem solving skills from various points of view (Sriyati et al., 2019). The results of the researcher's pre-survey on the level of creative thinking of students taking aquatic ecology courses in the odd semester 2023/2024 were found to be in the low category, namely having an average score of 54% (48% fluency score, 50% flexibility score, 59% original score, 60 % elaboration value).

The UTS and UAS scores of students who took aquatic ecology courses in the odd semester 2022/2023 obtained an average score of 71 with a score range of 50 – 85, there were 26% of students who got an average UTS and UAS score below 65. With less than optimal learning outcomes, it is best to carry out learning innovations that can improve students' abilities and competencies. It is hoped that the development of STEM-based e-LKM can improve students' skills and competencies, one of which is the creative thinking skills of biology education students (Dewi & Mashami., 2019). Based on this background, researchers are interested in conducting research entitled developing STEM-based e-LKM in aquatic ecology courses to improve the creative thinking of biology education students. For this reason, validity and practicality are needed in developing STEM-based e-LKM.

2. Methodology

The type of research is research and development. This type of R&D research is research that produces certain products. In this research, it produces e-LKM and tests the effectiveness of the e-LKM. The development model used is the ADDIE development model. The ADDIE development model consists of 5 stages, namely Analysis, Design, Development, Implementation and Evaluation. This research consists of two stages, namely stage 1: development of STEM-based e-LKM and stage 2: implementation or experimentation of STEM-based e-LKM in aquatic ecology courses.

The analysis stage carried out includes curriculum analysis, student needs, materials, and analysis of teaching materials. Designing e-LKM consists of 2 activities. The next STEM-based e-LKM design is designing RPS, pretest and posttest question grids, creative thinking indicator grids. The development stage is a step to create a STEM-based e-LKM by using relevant sources and validating the instrument. The implementation stage is carried out to see the usability of the STEM-based e-LKM and the evaluation stage assesses the overall development stages carried out. Validation is carried out to determine the feasibility of the e-LKM being developed. Validation was carried out by material experts, educational experts and media experts. The validity questionnaire assessment score criteria as in Table 1 and Validity Assessment Criteria as in Table 2.

Table 1. Validity Questionnaire Assessment Score Criteria

No	Assessment Score	Category
1	4	Very Good
2	3	Good
3	2	Poorly
4	1	Not Good

(Sugiyono, 2015)

Tabel 2. Validity Assessment Criteria

Average Score Interval	Information
$3{,}25 \leq x < 4{,}00$	Vaery Valid
$2{,}50 \leq x < 3{,}25$	Valid
$1{,}75 \leq x < 2{,}50$	Poorly
$1{,}00 \leq x < 1{,}75$	Not Valid

(Sugiyono, 2014)

To find out the results of students' creative thinking abilities, the average percentage of each aspect observed is first determined and then classified according to predetermined criteria to draw conclusions, following data analysis on creative thinking questions, namely:

1. Calculate scores from pretest and posttest answers according to the answer key.
2. Calculate pretest and posttest scores.

$$Student\ Score = \frac{total\ scores\ obtained\ by\ students}{Total\ Score}$$

3. Calculate the average pretest and posttest scores for all students
   Average score = (total student score)/ (total number of students)
4. Calculate the percentage of average pretest and posttest scores for all students.

$$Student\ average\ score = \frac{total\ student\ score}{total\ number\ of\ student\ x\ ideal\ score}\ x\ 100\%$$

Table 3. Categories of Students' Creative Thinking Ability

No	Interval (%)	Category
1	90 ≤ X<100	Very High
2	80 ≤X<90	High
3	65≤X<80	Medium
4	55≤X<65	Low
5	X<55	Very Low

The calculation results are based on the gain index (g), according to the classification by Hake., (2007) shown in Table 4.

Table 4. Normalized Gain Index Values and Their Classification

Normalized Gain Index	Classification
(g) ≥ 0,70	High
0,30 ≤ (g) ≥ 0,70	Moderate
(g) < 0.30	Low

The number of samples involved is 30 students from the class of 2020 who have taken aquatic ecology courses and 2 lecturers who teach aquatic ecology courses. The population in this study were 5th semester students (class of 2021) in the Biology Education Study Program, FKIP, Riau University in the Odd 2023/2024 academic year who were divided into 2 classes and took aquatic ecology courses. The research sample consisted of a control class and an experimental class that received treatment using STEM-based e-LKM. The control class consisted of 39 students and the experimental class consisted of 39 students. The sample was determined by random sampling.

3. Results and Discussion

Results of Analysis of e-LKM Development Design

The development design was carried out to determine the validity of the Aquatic Ecology E-LKM. Development is carried out using the ADDIE (Analysis, Design, Development, Implementation and Evaluation) model which consists of stages (1) Needs analysis; (2) e-LKM development design; (3) Development of e-LKM; (4) Implementation of e-LKM; and (5) Evaluation of e-LKM development.

a) Needs Analysis (Analysis Stage)

Outcome Based Education (OBE) Curriculum Analysis Results

The Higher Education Curriculum is a set of plans and arrangements regarding content, study materials, and learning materials as well as methods of delivery, and assessments that are used as guidelines for implementing learning activities in higher education. The biology education study program currently uses an Outcome Based Education (OBE) based curriculum which was formulated in 2020. It is believed that the Outcomes Based Education (OBE) based curriculum can better answer the challenges of graduate competency. Outcome-oriented learning (OBE) is an educational system approach and learning method where the outcome is the focus and the results can be seen from the learning process, therefore the Biology Education Study Program curriculum has been integrated with Team-based Project or Case Method-based learning. The results of the analysis of the OBE curriculum for the Biology Education Study Program in aquatic ecology courses contain 8 Sub-CPMK.

Results of Analysis of Semester Learning Plans (SLP)

Kemenristekdikti (2017) explains that every learning process plan in higher education is prepared for each course and presented in a Semester Learning Plan (SLP) which includes CPMK, Sub-CPMK, and the material content and learning process that will be carried out. The aquatic ecology course has 8 Sub-CPMKs, based on these Sub-CPMKs there are 3 Sub-CPMKs that need to be developed. The sub-CPMK that will be developed can be seen in Table 5.

Table 5. Sub-CPMK and Environmental Education Lecture Mater that Will be Developed

No	Sub CPMK	Lecture Material	Information
1	Able to describe the scope of aquatic ecology studies	Introduction to Aquatic Ecology	Not developed
2	able to describe the classification of aquatic ecosystems, distinguishing aquatic ecosystems including rivers, lakes, swamps and reservoirs	Classification of Aquatic Ecosystems (Rivers, Lakes, Swamps and Reservoirs)	Not developed
3	Able to describe the physical, chemical and biological characteristics of fresh waters, relate interactions between physical, chemical and biological factors of fresh waters, explain the use of organisms as bioindicators of the quality of the aquatic environment	Freswater Ecosystems	Not developed
4	Able to describe physicochemical factors in lentic waters ecosystems (lakes and reservoirs), describe organisms (plankton, benthos, nekton) in lentic waters, measure physical,	Lentik Aquatic Ecosystems (Lakes, Reservoirs)	developed

No	Sub CPMK	Lecture Material	Information
	chemical and biological factors in lentic waters ecosystems, identify and analyze observational data, analyze the relationship between physical, chemical and biological factors with lentic water quality based on observation results		
5	Able to describe physical and chemical factors in river water ecosystems, describe organisms (plankton, benthos, nekton) in river waters, measure physical, chemical and biological factors in river water ecosystems, identify and analyze observational data, analyze the relationship between physical, chemical, and chemical factors. and biology with river water quality based on observation results	Lotik Aquatic Ecosystem (River)	Not developed
6	Able to describe the typology of marine ecosystems, describe the zoning system in marine ecosystems, Able to describe the physical, chemical and biological factors of marine waters, explain the dynamics of marine oceanographic factors, link interactions between physical, chemical and biological factors and the oceanography of marine waters	Marine Ecosystems, Typology	developed
7	Able to describe the typology of tropical marine ecosystems, comparing the typologies of estuary, mangrove, seagrass and coral reef ecosystems	Tropical Marine Ecosystems	Not developed
8	Able to explain various types of equipment, materials and sampling methods in marine ecosystems, identify and analyze data based on observations, Able to measure physical, chemical and biological factors in one of the aquatic ecosystems, identify and analyze data based on the results of the Field Work Practicum, Able to make reports on the results of the Field Work Practicum, present reports on the results of the Field Work Practicum	Field Work Practicum	developed

Based on the Sub-CPMK for aquatic ecology that will be developed, there are 5 Sub-CPMK that have not been developed, namely: (1) Able to describe the scope of aquatic ecology studies, (2) Able to describe the classification of aquatic ecosystems, distinguishing aquatic ecosystems including rivers, lakes, swamps, and reservoirs, (3) Be able to describe the physical, chemical and biological characteristics of fresh waters, relate interactions between physical, chemical and biological factors in fresh waters, explain the use of organisms as bioindicators of the quality of the aquatic environment. This sub-CPMK is introductory and theoretical in nature to the basics of science studied in the aquatic ecology course. Sub-CPMK (4) Able to describe physical and chemical factors in river water ecosystems, describe organisms (plankton, benthos, nekton) in river waters, measure physical, chemical and biological factors in river water ecosystems, identify and analyze observational data, analyze relationships between physical, chemical and biological factors and river water quality based on observation results.

This sub-CPMK is adapted to the location of the field practicum activities which will be carried out not in the river ecosystem. Sub-CPMK, (5) Able to describe the typology of tropical marine ecosystems, comparing the typologies of estuary, mangrove, seagrass and coral reef ecosystems. This sub-CPMK is a continuation of the material in theoretical form which is carried out in class using the discussion method. Apart from that, the 5 Sub-CPMKs have not implemented STEM-based learning which is implemented using the Project Based Learning (PjBL) learning model, whereas this research aims to develop STEM-based e-LKM which is used in lectures in the form of field practicums with case studies (case method). According to Direktorat Jenderal Pendidikan Tinggi Kementerian Pendidikan Dan Kebudayaan., (2020) learning materials can also be updated or developed according to developments in learning needs. Next, the researchers formulated the Sub-CPMK and indicators from the aquatic ecology course.

The results of the Sub-CPMK formulation and indicators for the Aquatic Ecology course aim to produce a lecture objective that becomes a reference in the lecture process in order to create lectures that are right on target based on the curriculum and based on lecture material. The Sub-CPMK formulation formulated by researchers is divided into 2 meetings based on field practicum lectures in aquatic ecology courses.

Concept Analysis Results

The concepts that will be presented in STEM-based e-LKM are material for the ecology of freshwater ecosystems and marine ecosystems, including an introduction to aquatic ecology, classification of aquatic ecosystems (rivers, lakes, swamps and reservoirs), physical, chemical and biological characteristics. fresh waters, interaction of physical, chemical and biological factors in fresh waters, use of organisms as bioindicators of the quality of the aquatic environment, characteristics of physical and chemical factors of lakes and reservoirs, characteristics of organisms (plankton, benthos, nekton) in waters, classification of marine aquatic ecosystems, physical, chemical and biology of marine waters, interaction of physical, chemical and biological factors in marine waters, use of organisms as bioindicators of the quality of the aquatic environment, characteristics of physical and chemical factors of mangrove ecosystems, characteristics of organisms that inhabit mangrove ecosystems, sampling methods for physical, chemical and biological aquatic factors, analysis and interpretation of result data observation

Results of Analysis of Student Characteristics

Student analysis was carried out to see student characteristics including cognitive, affective and psychomotor abilities. The results of the analysis can be used as an illustration for preparing learning materials. Understanding and knowing the characteristics of students will make it easier for the author to design learning resources that suit the characteristics of students so that a STEM-based e-LKM is produced in aquatic ecology courses that is suitable for students in the Biology Education Study Program, FKIP, Riau University in carrying out practicums.

2. STEM-Based e-LKM Development Design (Design Stage)

The design stage was carried out to design a STEM-based e-LKM for aquatic ecology courses. The results obtained at the analysis stage are used as guidelines for developing STEM-based e-LKM. The design of a STEM-based e-LKM begins with designing an e-LKM storyboard, then continues with designing a systematic presentation of the material as well as indicators and learning objectives to be achieved with several learning activities and is guided by the RPS for the aquatic ecology course. STEM-based e-LKM was created using Canva and Heyzine software (Rita & Fenny., 2023). According to Benitha & Novaliyosi., (2022) Heyzine is an application used for files that have been processed into a complete electronic product.

3. STEM Based e-LKM Development (Development Stage)

Validity Result of STEM-Based e-LKM

The prototype was developed into a draft e-LKM which will be validated. Validation is carried out to assess the feasibility of e-LKM from the aspects of material content, content, language, education and media. The validation stage requires a validity analysis sheet for the device to be developed. The validation sheet is used to obtain information on the quality of e-LKM obtained from the validator assessment. According to Nugroho et al (2021), the validity analysis sheet is a tool used to determine the quality of the instruments used in research and whether learning products are valid or not for use in research, depending on the validation results from experts. Validators are selected based on relevant scientific fields and competencies. Based on the validation results from all validators, it can be concluded that the requirements to fulfill the validity criteria for STEM-based e-LKM have been met. This can be seen from the overall average value of e-LKM validation which is 3.76 in the very valid category. The overall results of e-LKM validation can be seen in Table 6.

Table 6. Overall Results of STEM-Based e-LKM Validation

No	Validator	Score	Category
1	Material Expert	3,80	Sangat Valid
2	Education Expert	3,93	Sangat Valid
3	Media Expert	3,56	Sangat Valid

According to Fitri Farhana et al., (2021) they added that teaching materials that come from real and research results can connect theoretical studies with reality and have a very good impact on strengthening students' understanding of concepts from abstract to a more real level of understanding. Therefore, the STEM-based e-LKM developed can be used for trials at a later stage.

Limited Trial of STEM-Based e-LKM

Limited trials were carried out on validated e-LKM. The limited trial aims to determine the practicality and student perceptions of the results of e-LKM development based on student and lecturer perception assessments.

Practicality Test of STEM-Based

e-LKM After validation of e-LKM, an assessment of STEM-based e-LKM was also carried out by 2 lecturers and 10 students. The purpose of the practicality test is to see to what extent the practicality of the e-LKM berb application device that will be tested on students. According to Nurhadi et al (2021), the level of practicality of the product produced refers to the user or other experts considering that the product used is interesting and useful for teachers and students. The results of student and lecturer assessments are presented in Table 7.

Table 7. Recapitulation of the Practical Value of e-LKM by lecturers and Students

No.	Aspect	Average Lecturer Score	Category	Average Students Score	Category
I	Ease of Use	3,93	very practical	3,69	very practical
II	Time Efficient	4,00	very practical	3,65	very practical
III	Benefit	4,00	very practical	3,72	very practical
Average		**3,98**	**very practical**	**3,68**	**very practical**

The overall practicality results of lecturers regarding the e-LKM assessment aspects, including: Ease of Use, Time Efficiency and Benefits, are classified as very practical, ranging from 3.93 – 4.00 with an average value of 3.98 in the very practical category. The lowest score is in the Ease of use aspect of 3.93, still in the very practical category. Overall, the aspects of time efficiency and benefits of e-LKM as a result of development are considered to be systematic and good, getting the highest score, namely 4.00.

In the practicality test carried out on students, a mean score of 3.68 was obtained in the very practical category, the ease of use indicator received a score of 3.68 in the very practical category, this shows that e-LKM was made easy for students to use in supporting their activities practicum in aquatic ecology courses. The indicators of time efficiency and benefits respectively are 3.65 and 3.72, including in the very practical category with the highest score in the benefits indicator of using e-LKM in aquatic ecology courses. Results of student perception tests as in Figure 1.

Results of Student Perception Tests on STEM-Based e-LKM Development

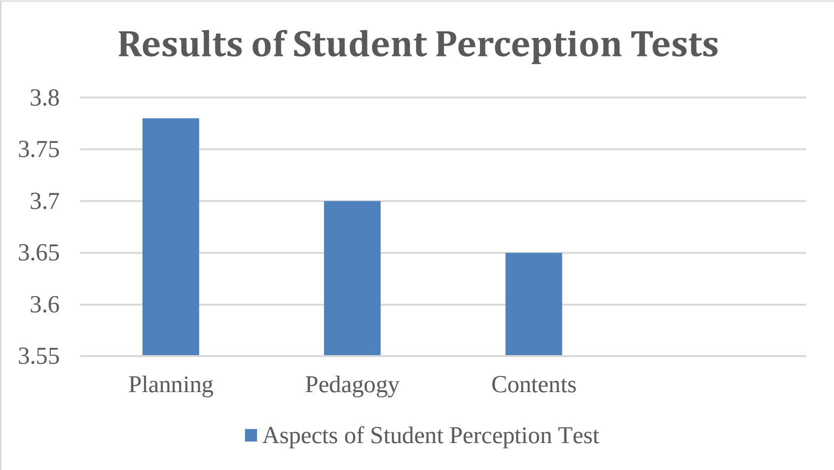

Figure 1. Results of Student Perception Tests

Overall, students' perceptions of the Aquatic Ecology e-LKM were classified as very good, namely the average student stated that they strongly agreed with an average score of 3.65. There are several aspects contained in the e-LKM perception test questionnaire, namely design aspects, pedagogical aspects and content aspects. Based on this aspect, the highest value is the design aspect of 3.78 with the highest indicator being indicator number 6, namely the attractive appearance of the LKM (color and layout) with a value of 3.95. Ratna Paramita et al., (2018) revealed that good language for reading material is needed so that written communication can also run well and not have double meanings. Setiawan & Saddhono., (2018) explains this is useful for achieving the desired goals during the process communicate. Meanwhile, the aspect with the lowest value is the content aspect with a percentage of 3.68 in the strongly agree category.

4. Implementation of STEM-Based e-LKM

Increasing Student Creative Thinking

The implementation of STEM-based e-LKM also assessed the increase in students' creative thinking using STEM-based e-LKM. Assessment of increasing students' creative thinking was carried out through the use of pretest and posttest questions in 2 classes representing the control class and the experimental class. The research results are presented in Table 8.

Table 8. Student Creative Thinking Results Based on Preetest and Posttest Scores

No	Class	*Pretest*		*Posttest*	
		Average Score	**Category**	**Average Score**	**Category**
1	Control	67,10	Cukup Baik	75,73	Good
2	Experiment	69,15	Cukup Baik	87,15	Good

Based on the table above, the experimental results show that there has been an increase in students' perceived value of learning outcomes based on the influence of using the Aquatic Ecology e-LKM. The average increase in creative thinking in the experimental class was higher compared to the control class. In the experimental class it increased from 69.15 with fairly good criteria to 87.15 with good criteria. The mean score in the control class increased from 67.10 with fairly good criteria to 75.73. The increase in creative thinking is caused by students' good understanding of Aquatic Ecology material and the e-LKM developed has indicators of creative thinking in the command of using STEM-based e-LKM.

According to Setiawan et al., (2024), creative thinking is a mental activity that presents new ideas for solving problems to someone. The ideas presented can help to find effective solutions. In order to face the challenges of the 21st century, creative thinking is one of the most important abilities that students have (Agustina et al., 2023). Based on the data on increasing creative thinking in the control and experimental classes, N-Gain analysis was then carried out. This aims to interpret the criteria for increasing students' overall creative thinking abilities. The results of the N-Gain analysis are presented in Figure 2.

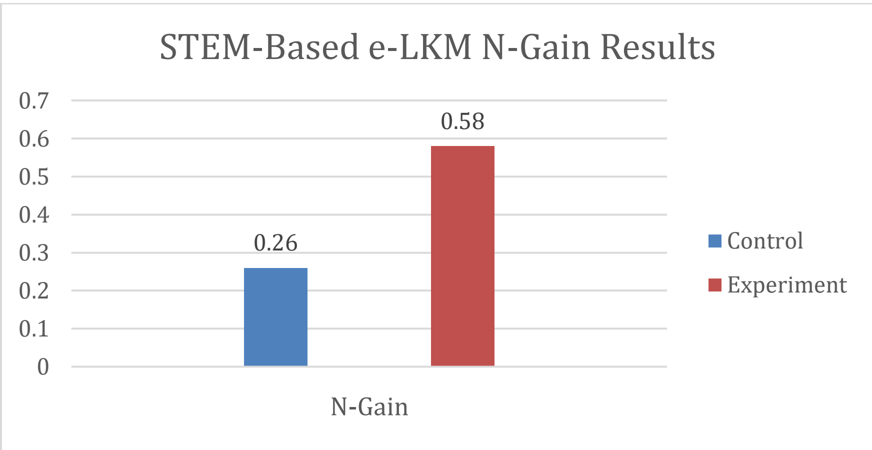

Figure 2. STEM-Based e-LKM N-Gain Results

The N-gain test is used to find out how effective STEM-based e-LKM is in increasing students' creative thinking abilities. The results of the analysis show that the increase in creative thinking in the experimental class is greater than in the control class. The increase in learning outcome scores in the experimental class was classified as moderate with an N-gain value of 0.58, while in the control class it was classified as low with an N-gain value of 0.26. Increasing students' creative thinking abilities is greatly influenced by the existence of innovative innovations, one of which is the use of e-LKM. e-LKM can provide positive results for students' creative thinking because e-LKM is an integration of learning material sources in the e-LKM.

5. Evaluation of Aquatic Ecology E-LKM Development

The Evaluation stage was carried out to assess the development and implementation of STEM-based e-LKM. Evaluation is carried out at all stages of STEM-based E-LKM development, both before implementation, including analysis, design, development, and after implementation. Branch., (2009) explains that the evaluation stage in ADDIE aims to assess the quality of the product development results, both before and after implementation. The complete evaluation results are presented as follows:

a. Evaluation at the Needs Analysis Stage (Analysis)
The Aquatic Ecology Curriculum in the Biology Education Study Program contains 8 Sub-CPMK. The evaluation results obtained by Sub-CPMK will be developed into 3 Sub-CPMK e-LKM The development carried out is in the form of enriching the material at each Sub-CPMK with various data and information related to aquatic ecology. Aquatic Ecology lecture material is presented in the form of STEM-based activities. Development in the form of STEM-based e-LKM. e-LKM was developed based on student needs based on evaluation results of the implementation of the learning process, limited teaching materials, as well as efforts to increase creative thinking and student learning motivation.

b. Evaluation at the Design Stage (Design)
The design stage produces a blue print in the form of systematics and content design for the STEM-based Aquatic Ecology e-LKM. The evaluation results of the Aquatic Ecology e-LKM were developed as academic LKM with the following systematic completeness: (a) Cover, (b) Table of contents, (c) Foreword, (d) Instructions, use of e-LKM (e) STEM Indicators, (f) Indicators of Creative Thinking, (g) Indicators of Learning Motivation, (h) Practical Rules, (i) Materials, (j) Basic Theory, (k) Tools and materials, (l) Learning Resources & Methods, (m) methods work, (n) activities and (o) Developer Profile. Evaluation at the design stage is also looked at the aspect of implementing standard and easy to understand word usage, in accordance with the rules of good and correct writing.

c. Evaluation at the Development Stage
Evaluation of the development stage is obtained from the validation results of material experts, education experts, and media experts. Includes assessment of display quality aspects, software aspects, usage aspects, content and material appropriateness aspects and linguistic appropriateness aspects. The evaluation results of the STEM-based e-LKM validator are classified as very valid based on the display quality aspect (3.79), software aspect (3.75), usage aspect (3.81), content and material suitability aspect (3.83) and linguistic feasibility (3.83). However, there are several suggestions and input from validators that need to be

improved, where every suggestion and input has been corrected at this development stage.

d. Evaluation at the Implementation Stage (Implementation)
The implementation of STEM-based e-LKM has been carried out in limited trials. The STEM-based Aquatic Ecology e-LKM which was implemented in a limited trial received a very good perception by students. The evaluation results based on the assessment of 20 students through a limited trial of the Aquatic Ecology e-LKM obtained an average score of 78.96 with very good criteria. Meanwhile, according to students who used the Aquatic Ecology e-LKM in the trial (experiment) class, they gave a very good perception with an average score reaching 87.52 with very good criteria. Therefore, the Aquatic Ecology e-LKM that was developed was well received by students as users.

e. Overall Evaluation of e-LKM Development Results
Overall, the development of the STEM-based Aquatic Ecology e-LKM has followed the ADDIE development stages which consist of the Analysis, Design, Development, Implementation and Evaluation stages. The e-LKM design has been prepared and assessed by material expert validators, education experts, media experts, and students who are currently taking water ecology lectures. The implementation of e-LKM in learning is also classified as very good.

The evaluation results based on the results of the analysis of students' creative thinking in the control and experimental classes show that the use of STEM-based Aquatic Ecology e-LKM can improve students' creative thinking. Students' creative thinking (experimental class) using STEM-based Aquatic Ecology e-LKM increased from 69.15 to 87.15 with an increase value classified as moderate (18). Meanwhile, without using e-LKM (control class) it only increased from 67.10 to 75.73 with a relatively low increase value (8.63). Thus, the STEM-based Aquatic Ecology e-LKM can be used to improve students' creative thinking. Overall, the implementation of STEM-Based Aquatic Ecology e-LKM according to observers is also considered very good. However, the increase in students' creative thinking scores after using e-LKM is still relatively moderate. This is because biology education students' interest in creative thinking abilities varies. So the achievement of increasing creative thinking also tends to vary.

4. Conclusion

Based on the results of the research carried out, it can be concluded that the STEM-based e-LKM developed has very good quality, this can be seen from the validation test which obtained the very valid category, and the practicality test with the very practical category. students' perceptions of the Aquatic Ecology e-LKM were classified as very good, namely the average student stated that they strongly agreed with an average score of 3.65. STEM-based e-LKM can improve students' creative thinking abilities in aquatic ecology courses, this is proven by the N-Gain score of 0.58 which shows the increase in students' creative thinking is at a moderate level.

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