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# Osmosis: Chewy naked egg, in or out?

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**Abstract**

The experimental method is the right way to learn biology. Osmosis is an important biological concept that can be used to understand other biology concepts and requires experimental activities so students can understand it better. The implementation of experimental activities will be guided by a digital-based Student Worksheet (E-LKPD ECO). This study aimed to develop LKPD-EC on osmosis experiments with chicken egg media for class XI students. This research is development research (RnD) using a four-D model, namely the definition, design, development, and Disseminate phases. However, this development is only limited to the development stage because this research is only to see the feasibility of LKPD-EC media. Good validation results from experts score 89.08% of the assessment of material experts and media experts and 92.63% of student responses with very decent criteria. From these data, the development of Experimental Student Worksheets (LKPD-EC) on the Osmosis Experiment is very feasible to be used as an alternative in the learning process so that it can be tested in supporting the maximum learning process.

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## INTRODUCTION

Learning biology is seen from its features; students must be able to express the phenomena around them (Anjarwati et al., 2023; Rahayu et al., 2020; Supriyatin et al., 2019), have concrete experiences (Shen et al., 2018). Besides that, learning biology in terms of its characteristics also demands a focus on student activities (Juanda et al., 2021; Khoiriyah et al., 2022) through direct and contextual learning obtained from experience to improve students' abilities to organize, communicate and interpret observations (Inganah et al., 2023; Limiansi et al., 2020). One of the right methods for this quality is the practicum method. Consistent with (Crowe et al., 1998), in science education, laboratory activities (practicum) are an integral part of teaching and learning activities, especially in the field of biology. One of the methods used in learning is the experimental method, especially to improve students' competence in learning biology.

Hands-on activities are effective in improving various student skills, such as student achievement (Susantini et al., 2019), student scientific attitude (Dewi et al., 2020), and student quantitative literacy (Mukagihana et al., 2021; Sugianto, et al., 2022). In addition, lab methods allow students to connect observable objects and domains with the mind domain (Lauridsen et al., 2019; Neves et al., 2021) by building different psychomotor skills, higher-order reasoning, and characterizing learning outcomes (Xue et al., 2022). Human resources must possess skills that can be raised through this experimental activity in the 21st century (ND Safitri et al., 2023; Rasoolimanesh et al., 2022; Sah et al., 2023; Song et al., 2016). This skill is best achieved when experimental activities are carried out properly. Students generally learn better in a hands-on way. Experimental activities are beneficial for students and make it easier for teachers to access and assess various kinds of knowledge and characteristics possessed by each student (Lauridsen et al., 2019). Be it a cognitive, emotional, or psychomotor assessment.

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However, in practice, the experimental method still has several obstacles, such as: 1) school administration has not been effective; 2) the type of experiment is too simple and routine; 3) irrelevant to students' interests and abilities; 4) Experimental instructions 5) Lack of attention to evaluation (Asif & Aji, 2019; Galve & Vela-Tafalla, 2020; Wirdawati, 2017). In addition, the experimental method requires a longer time investment and special tools and materials, so it is rarely applied. Although there is room for improvement in minimizing these limitations, this practical method is suitable for application in biology learning activities. One of them is the concept of osmosis.

Osmosis is an abstract (and hard to observe) subject of biology. Based on facts on the ground when learning biology in class XI SMA Yayasan Assyfa Learning Center (YALC) Pasuruan on osmosis material, students experience difficulties understanding the concept, especially when solving everyday problems. This is in line with research conducted by (Vujovic et al., 2018), stating that high school students mainly use the concepts of diffusion and osmosis with misunderstandings and learning difficulties to solve related problems. Biologically, the term osmosis occurs when photosynthesis begins with the movement of water from the roots to the leaves (Contreras-Martínez et al., 2022). Furthermore, the concept of osmosis will be much easier when teachers can use the relationship between objects and activities around them and the concept of osmosis itself. In this study, the researchers used media that was very easy to get, easy for them to find, and, more importantly, what they usually eat, where later students would understand that other osmosis concepts can be found in seepage events in everyday life, such as food, namely eggs. Eggs come from chickens and are rich in protein. Besides being relatively cheap and much needed by the body, eggs also have a major role in osmosis. Osmosis events in the egg will occur when the egg is immersed in a vinegar solution. The liquid concentration in the egg is lower than the vinegar solution (hypertonic), so the vinegar solution that enters the egg is more concentrated and becomes semipermeable (Biesheuvel et al., 2022; Senán-Salinas et al., 2022). From this, we can conclude that osmosis is the movement of solvent from high to low concentration across a semipermeable membrane. The egg infiltration in the experiment causes changes in the shape and physical appearance.

Based on the research results, several misconceptions about the concept of osmosis among students were found. The water content must be the same, and solute precipitation occurs and stops when the molecules of the two solutions reach equilibrium, resulting in the effect of temperature on the percolation process (Goh et al., 2022). In addition, students also have a partial and incomplete understanding of osmosis (Ulfa et al., 2020), which often needs clarification with the concept of diffusion. The authors found that infiltration and diffusion field activities occur simultaneously. Therefore, understanding the concept of osmosis requires students to be involved in direct activities. This is because it is proven that students can learn the concept of osmosis better with constructivist learning methods (one of which is a laboratory approach) compared to traditional methods (Brodersen et al., 2022); practicum encourages students to learn independently and learn actively through the learning process. During the learning process at school, the teacher must be willing to meet with students every day. Readiness can be shown by the availability of learning tools owned by the teacher, including curriculum, lesson plans, teaching materials, media, approaches, strategies, methods, techniques, learning tools, and making E-LKPD.

E-LKPD (Electronic Student Worksheet) is one of the sources and learning materials that can be accessed digitally via the internet (Hasanah, et al., 2022; Saputri & Zulkardi, 2019; Syaifuddin et al., 2022). The E-LKPD contains a series of activities in the form of short materials and practice questions (Humaidi et al., 2022; Nurdiyanto et al., 2019). E-LKPD can help teachers overcome boredom, monotony, and the passive attitude of students shown in the learning process (Mala et al., 2019). E-LKPD provides materials, summaries, and instructions for implementing learning tasks completed by students related to the Basic Competency (KD) to be achieved (Harun & Suparman, 2019). Good/appropriate E-LKPD for use in the learning process are 1) capable of increasing student participation or activity in the teaching and learning process (Apertha et al., 2018); 2) change the learning conditions from teacher-centered to student-centered (Widoarti & Suparman, 2021); 3) and help educators (Fairuz et al., 2020); 4) Students can learn more about discovering concepts and practicing creative thinking through active roles (Diella & Ardiansyah, 2019).

Several pieces of research on developing experimental worksheets based on experiments to overcome students' misconceptions about understanding the concept of the osmosis have been

carried out by (Kurniasih et al., 2020) and (Sari et al., 2019). LKPD developed (Kurniasih et al., 2020), only 24% with the results obtained following the procedures used and complete concerning data analysis and conclusion, thus showing the construction of knowledge. This shows that the suitability of LKPD in the field with learning objectives is still very low and needs to be improved. In addition (Sari et al., 2019), the LKPD that was developed found that the practicum objectives were unclear, sometimes not under the observed events or objects, the desired facts did not appear per the objectives of the practicum and were not following theories, principles, or concepts. In connection with this material and often in practicum, students are not instructed to record every phenomenon found during practicum. Most of them observe it. Furthermore, the worksheets developed by the two of them as a whole had weaknesses where: 1) The practicum objectives emphasized cognitive rather than psychomotor aspects (Sholehah, 2021); (2) Most of them use a deductive approach with an expository model (Saputri & Zulkardi, 2019); (3) Even though the practicum procedures are detailed, some are unstructured, and the instructions are confusing, causing multiple interpretations (Nurdiyanto et al., 2019); and (4) Material selection does not consider its essence, suitability, depth, and complexity (Mala et al., 2019). This will affect the conclusions drawn by students because the conclusions must follow the objectives of the practicum (Fauza et al., 2022; Hasanah, et al., 2022; Sugianto, et al., 2022). If there is a problem with the LKPD, of course, there is a problem with students' skills. Therefore, the order must be analyzed, experimented with, re-created, and alternative worksheets made as a guide for carrying out effective and efficient practices by learning objectives (Haryati, 2018; Puspitasari & Haryani, 2015; Saputri et al., 2018). For learning to be more meaningful for students, especially the concept of osmosis, it is necessary to develop experimental-based E-LKPD media in biology learning, especially on osmosis material.

The difference between this research and the previous one is to develop valid digital-based worksheets for use in learning. E-LKPD can also be accessed *online* and *offline* for both students and teachers by downloading the link shared by the teacher via the *WhatsApp group* so that learning is more *flexible*. In addition, the E-LKPD used also aims to help students understand the concept of osmosis by learning directly through guided experiments in the E-LKPD. The experimental material uses food ingredients, namely raw chicken eggs and a vinegar solution served therein. With the work steps described in detail in the E-LKPD, students will be able to analyze their knowledge through the data added by the researcher. Problems added in questions that can construct knowledge are adapted to the objects and phenomena that appear. So that later, students can find out what parts enter and exit through the semipermeable membrane in the event of osmosis, which will cause the egg to become hard and rubbery if the egg is soaked in vinegar for several days. The vinegar water makes the eggs soft and chewy. Furthermore, the experiment-based LKPD will be presented what objectives are (what students have to learn); work assignments (what must be done); class activities (what was done); and student learning (what is learned). Therefore, based on the background mentioned above, this research aims to develop an experimental-based E-LKPD ECO to overcome the misconceptions of high school students in learning biology on osmosis material that is valid for use in biology learning for class XI SMA.

## METHOD

This research involved 30 eleventh-grade students of SMA YALC Pasuruan on biology subjects in the odd semester of the 2022/2023 academic year. The LKPD feasibility test had media and material expert lecturers, namely biology teachers at YALC Pasuruan. This study aimed to develop an experiment-based Electronic Student Worksheet (E-LKPD OCE) for osmosis material based on the 4-D model (Four-D model). This 4-D development model consists of four stages: definition, formation, development, and dissemination. However, this study was modified and limited to reaching the 3-D stages depicted in Figure 1.

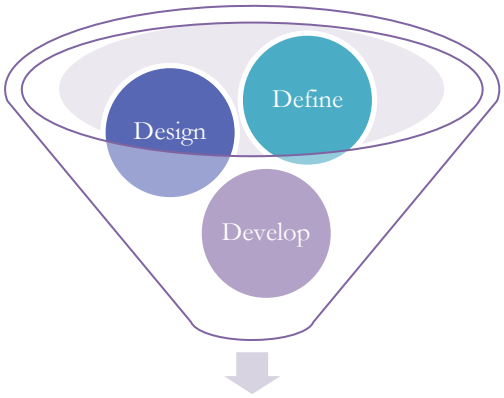


**Figure 1**. Development of E-LKPD ECO Egg and Vinegar Solution (Darmayanti et al., 2022)

In Figure 1, to create or develop E-LKPD media which will be used to facilitate the learning process in overcoming students' misconceptions about osmosis material, at least three stages must be passed:

***Define stage***

The first stage is define. An explanation of the first stage can be seen in Figure 2.

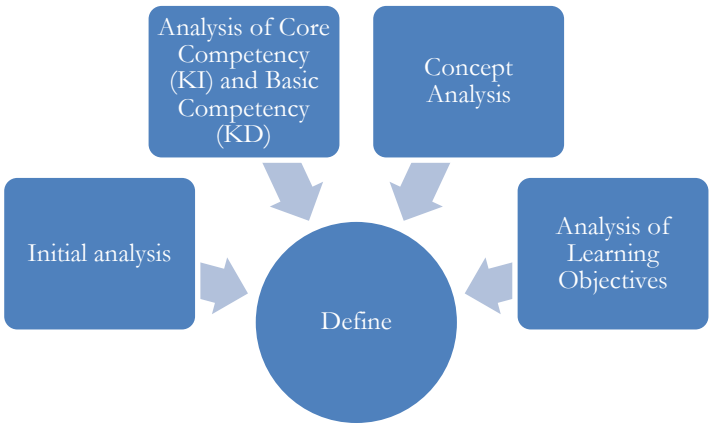


**Figure 2.** The Component of the Define Stage

In Figure 2, the define stage is divided into several steps, namely the initial analysis, the second is the analysis of core competencies and basic competencies, the third step to analyze the concept, and the last is to analyze the learning objectives. These four steps are carried out to help determine and define needs in the learning process and collect various information related to the E-LKPD that will be developed. Initial analysis (front-end analysis) is a preliminary analysis stage carried out to find fundamental problems in the development of E-LKPD. These stages can be carried out by conducting observations and unstructured interviews with biology teachers and class XI students during the learning process. These activities are carried out to find fundamental problems, which are the reasons for researchers to develop a media, activities such as gathering facts and alternative solutions to help determine the first step in developing the right E-LKPD to use.

The second and third analyzes are KI and KD analysis and concept analysis. KI and KD analysis, namely the Core Competency (KI) and Basic Competency (KD) associated with the material developed by the student worksheet. Furthermore, the Concept analysis step is carried out to

determine the contents of the E-LKPD media material to be used. Concept analysis is carried out on learning concept maps which will later be used to achieve certain competencies by identifying and systematically assembling the main components of learning materials.

The final analysis is by analyzing learning objectives (accuracy of teaching objectives). Learning Objectives are analyzed to determine learning success indicators based on material analysis and curriculum analysis. By writing down the learning objectives, the researcher can identify the studies in the E-LKPD, determine the problem grid, and ultimately determine how well the learning objectives have been achieved.

***Design Stage***

After the problem is found from the definition stage, the design stage is carried out. This phase aims to design an E-LKPD based on steps or activities in conducting laboratory experiments that can be used for biology learning. Activities in this phase include: Creating an evaluation tool, selecting media, and selecting the format.

***Develop stage***

This development stage aims to create an E-LKPD using an experimental design. This stage has been revised based on expert opinion and student trials. This phase has two steps:

1. Expert Validation (Expert Opinion): Expert verification of the problem in the form of a feasibility study of biological materials on E-LKPD media before testing, and the validation results are used to correct the media used.
2. Student Response Questionnaire: The questionnaire is intended to identify student responses to the experimental-based E-LKPD used to determine feasibility.

The results of this verification will be used as material for improving the LKPD it develops. The instruments used to collect data in this study were validation and student response questionnaires using the Likert scale test. The validation instrument uses a Likert scale of four combined questions to form a score or value. The validation assessment in this study uses a range of scales: very good = 5, good = 4, enough = 3, less = 2, and significantly less = 1 (Darmayanti, et al., 2022).

Media experts validated the E-LKPD (one Masters lecturer and one computer teacher) and material experts (one lecturer and one biology teacher) on the components of design (structure), material (content), and language modified from research (Sugianto, et al., 2022) to determine the quality of LKPD. The data obtained in this study are in the form of qualitative and quantitative data. Four datasets were collected. Namely needs analysis (based on the results at the definition stage), expert validation data, student response data, and student test results on the learning provided. Qualitative data were analyzed descriptively to find trends during the study, while quantitative data were analyzed through statistical tests.

## RESULTS AND DISCUSSION

The results of the development stages are described as follows:

***Define stage***

There are four steps in the define stage. These steps will become a reference for the need to develop E-LKPD media. *First, preliminary analysis,* based on the results of unstructured interviews with biology teachers and class XI SMA YALC Pasuruan, did not involve students in learning previously carried out by the teacher. The teacher still uses traditional learning patterns, explaining the steps with a few questions and answers and giving examples of questions. As a result, students need to be used to exploring their knowledge and approaches.

Moreover, studying biology usually only works with textbook problems. In addition, for biology activities needed for practical exercises, the teacher only has to instruct them to carry out their experiments in groups at home according to work procedures and instructions in the textbook. After completing the experiment, students will be asked to report and evaluate the results of their experiment.

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*Second, analysis of KI and KD.* The results were obtained after analyzing the Core Competency (KI) and Basic Competency (KD) in class XI SMA YALC Pasuruan by developing an E-LKPD on osmosis material. Student activities refer to KI three, namely knowledge, and KI four, namely skills, with reference focused on basic competencies 3.7 and 4.7. Student activity, in this case, is to analyze osmosis by identifying how the process of osmosis occurs in everyday life through experiments.

*The third is concept analysis.* Concept analysis aims to discover important concepts about how, why, what, and how matter can occur in the osmosis process. All of this is explained through the procedures and work steps in the experimental activities contained in the E-LKPD. This concept analysis was carried out to make it easier for students to understand the content or content of the material content adjusted to the results of the KD analysis.

*The fourth is the analysis of learning objectives.* This step aims to determine the objectives of the biology learning process following the results of the KI and KD analysis, which are adapted to the 2013 curriculum syllabus. It is hoped that students will be able to understand the important concepts of the process of osmosis, how the osmosis process occurs, and what factors hinder and supports the process of osmosis.

***Design Stage***

The Design (planning) stage is for E-LKPD Planning and what will be used to make ELKPD. There are several ways to plan this LKPD, specifically, E-LKPD content organization, format selection, and E-LKPD design. E-LKPD preparation includes exercises adapted to the material, syllabus, and curriculum compiled from the contents of the LKPD material using several textbook sources taken from textbooks and other relevant reference books. In this study, the researcher developed teaching materials based on the arrangement of experimental-based information when compiling teaching materials.

Furthermore, the initial preparation of the first LKPD includes the title, preface, table of contents, instructions for using the LKPD, conceptual diagrams, process pages, scientific approach procedural assignments, motivational words, metrics, glossary, references, and back cover. E-LKPD media is a form of digital-based print media sized according to the ISO B5 standard (175mm x 250mm) and designed using the Canva application. The E-LKPD design is designed to stimulate students' interest in reading and motivate them to learn, by involving students directly through guided experiments in the E-LKPD in understanding the concept of osmosis as a form of solution to overcoming student difficulties. In this design, the layout is consistent with good use of symbols and typography so that it can be used as LKPD teaching material for independent study, which can be used flexibly because of its nature which can be used online and offline. Consistent with the opinion of Wirdawati, (2017) states that "materials that are perfectly designed and *flexible* can function as learning materials themselves which can be accessed anytime and anywhere''.

***Develop stage***

At this development stage, the aim is to make media in the form of a good E-LKPD to support students in the learning process. This development stage was carried out so that the E-LKPD was measured by the results of student responses to using the E-LKPD based on experimental activities based on the completion of student response questionnaires on osmosis class XI SMA YALC Pasuruan as many as 30 students. The results of the validation of material and media experts as well as the

results of the student response questionnaire in the development of the E-LKPD, can be seen in table 1.

**Table 1.** Percentage of Validation and Response to E-LKPD Development

| | Aspect | Validators | Indicator | Percentage | Total Average Percentage | Category |
|---|---|---|---|---|---|---|
| 1 | Media Validation | Validators 1 | Content, Language, Material | 87.31% | 89.08% | Very feasible and can be tested |
| | | Validators 2 | | 92.25% | | |
| | Material Validation | Validators 1 | Concept, Practical, Knowledge Construction | 89.17% | | |
| | | Validators 2 | | 87.57% | | |
| 2 | Student Response | 30 Class XI Students | Content, Presentation, Language, Graphics | - | 92.63% | Very practical |

The suitability of the experimental-based E-LKPD in Class XI Biology at SMA YALC Pasuruan in table 1 is based on the results of eligibility verification by four media experts and material experts, lecturers, and teachers. The results of validation calculations were obtained based on a closed questionnaire using the Likert scale size as a rating metric. The validator uses the Expert Validation Sheet to evaluate by checking the designated column and writing comments or suggestions for improvement at the end by verifying the feasibility of the experiment-based E-LKPD as a learning medium in Biology subjects. The results of the conformity verification of the experimental-based E-LKPD by material experts will be used as material for evaluating the experimental-based E-LKPD to be implemented in student tests. The results of validating the suitability of the experimental-based E-LKPD by material experts will be used as material for evaluating the experimental-based E-LKPD to be implemented in student tests. After a quantitative descriptive analysis was carried out from the results of validator 1 (87.31%) and validator 2 (92.25%) scores, the total mean of material validation results was 88.37% (table 1) with very valid criteria. That is, classified as very practical for the learning process (Darmayanti, et al., 2022; Vidyastuti et al., 2022; Wulandari et al., 2022). Therefore, the experimental-based E-LKPD that will be developed includes teaching materials aligned with concepts and theories through the 2013 Basic Curriculum Competency.

Furthermore, in addition to paying attention to the suitability of material experts related to the experiment-based E-LKPD, it is also important to pay attention to the suitability of each experimental-based E-LKPD media component to the results of the media expert's validation. Based on media experts with the Linguistic Feasibility component, supported by easy-to-understand language used in the experiment-based E-LKPD and the use of clear sentences in the material presented will be more easily understood by students. This follows research conducted by (Rizki et al., 2022; Ulfa et al., 2020), which states that the use of clear sentences (not using sentences that confuse students) must also be accompanied by a good and correct systematic sentence arrangement (according to Indonesian National Spelling Standard) so that students will more easily understand the material. In addition, in the assessment of the last component in the media, namely in the graphical feasibility assessment, from the results of validator 1 (89.17%) and validator 2 (87.57%) scores, the total mean of media validation results was obtained with a total average value of 89.78 % (table 1) with very valid criteria.

Furthermore, in response to interest in the illustration and color design of the experiment-based E-LKPD and its contents, both the explanation and placement of the experiment-based E-LKPD are interesting and motivate students to use them as teaching materials (MM Effendi et al., 2022; Qomariyah et al., 2023; Widyo et al., 2020). Therefore, based on this description, using the average percentage of content, language, and graphics eligibility, the experimental-based E-LKPD developed obtained an average validation result according to material experts and media experts in table 1, showing a score of 89.08%. So, from these results, it can be concluded that the experimental-based

E-LKPD media developed to assist students in learning the concept of osmosis in biology subjects is "very feasible ."Based on the validation results obtained from the validator, which stated that the E-LKPD developed in draft 1 had very feasible criteria, this research was not continued at the draft two stages so that the media could be continued at the limited scale trial stage.

According to (Umriani et al., 2020), "Quisioners are data collection tools where participants or respondents fill out questions or questions posed by researchers ."Furthermore, according to (Lindenbauer & Lavicza, 2021), the questionnaire is a list of questions in the form of questions given to people, along with answers (respondents) according to user requests, to find out information about problems without worrying about whether the respondent answers or not. Based on student responses in an experiment conducted on 30 students in Class XI SMA YALC Pasuruan. During the limited trial, the researcher introduced the experimental-based E-LKPD to students about the general description of the E-LKPD being developed. In introducing the experiment-based E-LKPD, the researchers also showed examples of objects that resulted from an osmosis experiment with the help of a ready-made egg and vinegar solution. Figure 3 is an example of the finished osmosis experiment results.

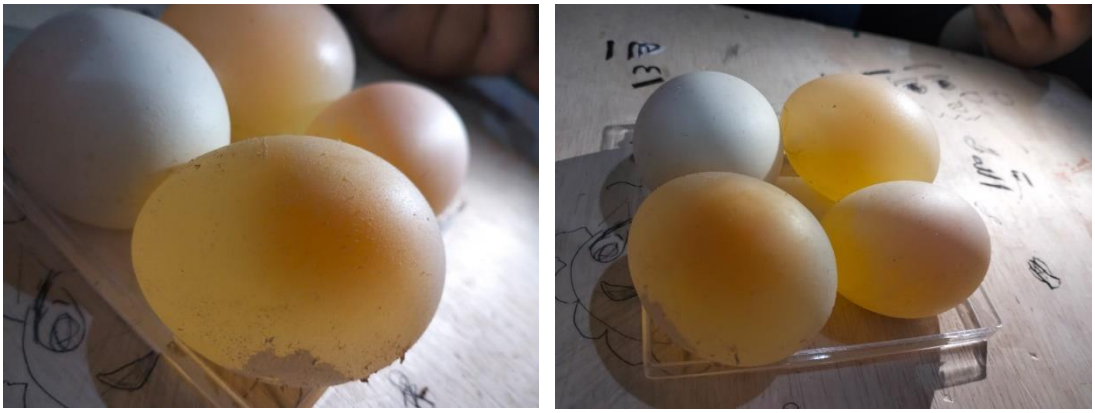

**Figure 3**. Example of Osmosis Experimental Results in Eggs and Vinegar

The researcher explained by showing the results of the osmosis experiment, how it worked, and why that was the case through the developed E-LKPD. Problems added in questions that can construct knowledge are adapted to the objects and phenomena that appear. So that later, students can find out what parts enter and exit through the semipermeable membrane in the event of osmosis, which will cause the egg to become hard and rubbery if the egg is soaked in vinegar for several days. The vinegar water makes the eggs soft and chewy. Furthermore, the experiment-based LKPD will be presented what objectives are (what students have to learn); work assignments (what must be done); class activities (what was done); and student learning (what is learned). Therefore, based on the background mentioned above, this research aims to develop an experimental-based E-LKPD to overcome the misconceptions of high school students in learning biology on osmosis material that is valid for use in biology learning for class XI SMA.

After that, the researcher distributed the experimental-based E-LKPD developed to students via the link shared in the WhatsApp group. Students are asked to observe and study the experiment-based E-LKPD for thirty minutes. Finally, after the students are given the questionnaire answers, the students fill out the questionnaire answers form by providing a checklist in the column corresponding to the parts. This follows research (Jannah et al., 2021) that used student answer questionnaires to analyze the feasibility of LKPD. Based on the questionnaire given to students, according to students' responses, the material's content was very interesting and had very interesting eligibility regarding the components. The material developed is easy to understand and adds insight to students. The presentation component of the experiment-based E-LKPD received student responses by stating that the content of the material presented was following the syllabus and 2013 curriculum. In addition, students also stated that the experiment-based E-LKPD looked very interesting and motivated students to learn. The language component of the experimental-

based E-LKPD in terms of the use of language can be understood according to student responses, does not contain ambiguity, and does not use clear sentences.

Furthermore, based on an experiment-based approach to the graphical components of the E-LKPD, according to students, the writing in the media is very clear. This can be seen from the components of the experimental stage in terms of concept, practice, and the knowledge construction part, which can help students to analyze concepts and factors that support the occurrence of osmosis events. As a result, the experimental-based E-LKPD obtained overall response results, reaching a percentage of 92.63%. Students could easily master the material and every activity and work step during the practicum process in learning biology. This is because students study it by reading the work steps in conducting experiments by looking at the guidelines in the E-LKPD, so students state that the E-LKPD media meets very interesting criteria. The experimental-based E-LKPD was considered very attractive to support learning biology subjects by fulfilling very feasible criteria.

This could not be carried out at the last stage in the development of the experiment-based E-LKPD because this research only reached the development stage, where it only aimed to determine the feasibility of the experimental-based E-LKPD media had been developed.


**Figure 4**. The Display of Experiment-Based E-LKPD Media

## CONCLUSION

The experiment-based E-LKPD in the media validation stage scores 89.08% by the material and media experts and 92.63% of student responses with very decent criteria. From these data, the development of Experimental Student Worksheets (E-LKPD ECO) on the Osmosis Experiment is very feasible to be used as an alternative in the learning process so that it can be tested in supporting the maximum learning process. For further research, this research can continue to determine the effectiveness of the experimental-based E-LKPD media that has been developed in terms of different abilities by adjusting the conditions and characteristics of students in each region.

## AUTHOR CONTRIBUTION STATEMENT

AMH: Designing, conceptualizing ideas, and analyzing data.
KU: Assessment instruments, manuscript drafting, correcting, and final approval.
RD: Editing, reviewing, proofreading, and providing technical support.

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