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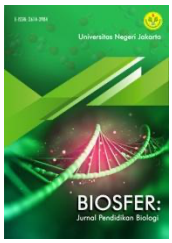

STEM e-worksheet innovation: Encouraging collaboration in excretory system learning

Anisa Minatani[1,2*], Supriyatin[1], Rusdi[1]

[1] Biology Education, Faculty of Mathematics and Natural Science, Universitas Negeri Jakarta, Indonesia
[2] SMAS Muhammadiyah 4 Jakarta, Indonesia

*Corresponding author: anisa831@guru.sma.belajar.id

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ABSTRACT

Excessive use of gadgets leads to individualism and less exploration and thinking among students due to the easiness offered by the gadgets. Moreover, students have low collaboration skills so that less able to cooperate. The study aims to produce a STEM-based e-LKPD in the Excretory System that is effective in enhancing students' collaboration skills. The research method used is Educational Design Research with Hannafin Peck model. Data collection is conducted through a need analysis questionnaire to students and interviews with teachers. The development of the STEM-based e-LKPD uses Canva and Flipbook. Media and content experts work on the feasibility test of the product. Product trials are conducted on small groups of 15 students, large groups of 32 students, and educators. The effectiveness test employs the control group pre-test and post-test design using an instrument consisting of 8 questions on collaboration skills. The MANOVA test indicates a Pillai's Trace value is smaller than 0.05 suggesting a significant difference between compared groups. The average N-gain of collaboration skills is 71.36. The results can be concluded that the STEM-based e-LKPD is effective in improving collaboration skills.

INTRODUCTION

The influence of information technology and communication in the 21st century has changed the landscape of various life aspects and significantly affects student skills (Chung et al., 2016; Kumar Basak et al., 2018; Worrell et al., 2015). Students face increasingly diverse and complex problems. One of the problems is the excessive use of gadgets. High-intensity use of gadgets in the modern era is assumed to contribute to the individualization of students, hinder their self-potential development through exploration and interaction, and lower their thinking and collective discussion skills, resulting in negative impacts on the mastery of collaboration skills. Students tend to interact more with other people through the internet. Face-to-face is conducted when there is an emergency. This social life will affect students' mindset when they enter the employment world. They will struggle to interact or develop work relationships with others competently, even though collaboration should be completed immediately and goals can be achieved optimally (Moradian et al., 2020; Tîrziu & Vrabie, 2015). Students in the 21st century should possess knowledge and metacognitive as well as critical thinking, creative thinking, communication, and collaboration skills (Greenstein, 2012; Hidayat et al., 2019; Redhana, 2019; Vithanapathirana & Nettikumara, 2020). One of the 21st-century skills that needs to be developed by teachers is collaboration. Collaboration skills allow group synergy to produce wiser and quality decisions instead of individual decisions (Maya & Charles, 2015; Kropp et al., 2016; Le et al., 2018). A study by Makrakis and Kostoula-Makrakis suggests that 21st-century students require "4C" skills (critical thinking, communication, collaboration, and creativity). These skills will allow students to prepare themselves to face 21st-century society through in-depth learning in everyday life (Ghobrini, 2020; Lo et al., 2016).

Students must have collaboration skills as their provision to enter the working world. Collaboration skills are crucial for cooperation in various groups to face the globalization era in the 21st century (Muiz et al., 2016). Kevin Dunbar identifies common goals and constructive exchange from various perspectives as two main indicators of the success of scientific collaboration (Dunbar, 2000).

Teachers influence the improvement of the 21st-century skills of students (Hampson et al., 2011). They are a significant factor in the success of education (Hattie & Timperley, 2007; Meilia, M., & Murdiana, 2019; Yuliani & Lengkanawati, 2017). Teachers apply several approaches to learning, such as STEM. In the STEM approach, students have an opportunity to understand the impact of technology and to learn and recognize current innovations related to biology. A new study indicates the benefits of STEM education as an educational innovation that provides opportunities to students. For example, Bush and Cook (2019) underline that STEM education has contributed to involving student participation in problem-solving activities that connect their prior knowledge and skills to new learning experiences to explore new concepts in STEM. Zaharin et al., (2019) opine that students can gain 21st-century skills through STEM activities.

Learning processes in planning and working in groups, handling differences in opinions in a discussion, and participating in the discussion, such as giving suggestions, listening to others who are talking, and supporting other opinions, are included in the collaboration skills (Greenstein, 2012). Enhancing collaboration can use learning media approaches. A learning medium of collaborative learning-based e-LKPD is often related to project-based learning, where students work in a group or team to solve certain tasks or projects. According to Syamsurizal et al., (2014) LKPD can develop 21st-century skills in learning presentation with both experiments and non-experiments. This supports the development of an interactive STEM-based e-LKPD that can help students improve their 21st-century skills.

Based on the results of interviews with teachers and students in March 2024, students never used the STEM-based e-LKPD in the learning process but utilized more video and props media. Practicum activities are only for certain materials. The results of the needs analysis questionnaires indicate that some students lack understanding of work steps in the practicum. Students face difficulties in processing data and concluding experiment results, and still feel awkward using laboratory equipment. Additionally, students' collaboration skills are low due to the lack of group discussion in the learning process. Suggesting that the teaching and learning process in the school tends to be teacher-centered and creates one-way communication. The domination of lecture method by teachers leads to passive students who merely focus on the teacher's explanation (Firman et al., 2023).

According to the above studies and facts, collaboration skills can be developed or trained in learning so students can be professional when they enter the real working world. Collaboration skills are professional skills that are learnable and teachable (Vance & Smith, 2019). The use of STEM-based

e-LKPD can improve collaboration skills. Collaboration skills will shape students' character, namely mutual respect, appreciation, tolerance, responsibility, honesty, and openness in learning (Djoko, 2013). Therefore, the enhancement of collaboration skills in Biology learning in the excretory system in high school using the STEM-based e-LKPD is imperative since it has not been used in this area. This study aims to enhance student collaboration skills in Biology learning in excretory systems using STEM-based e-LKPD.

METHODS

Research Design

The research was an Educational Design Research. The model employed was the Hannafin Peck, consisting of 3 phases (Figure 1), namely: (1) need analysis; (2) design or planning; and (3) development and implementation. These three phases are connected with evaluation and revision.

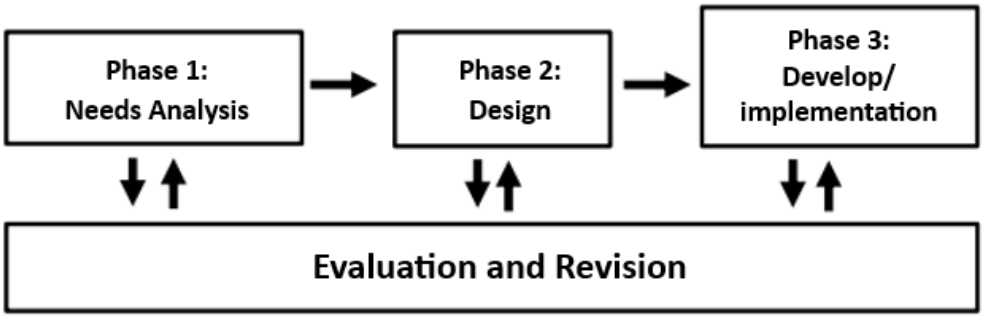

Figure 1. Steps in the Hannafin Peck Development Model

Participant

The research participants consisted of two Biology teachers of Grade XI, six expert validators, and 35 students of Grade XI-MIPA. The media validators validated the developed media, i.e. the STEM-based e-LKPD, to enhance collaboration skills. The validators assessed whether the developed media is feasible or not for use. The second participants in the research were teachers who played a role in providing assessments for the STEM-based e-LKPD and testing the media to the students in class. The last participants were students in the experimental samples. The developed e-LKPD media will be implemented for students to observe whether there is an influence of the media on the students' skills.

Instruments

The collaboration skills were measured using questionnaires that consisted of several questions based on the collaboration skill indicators. They were compiled according to the synthesis of supporting theories of collaboration skills. The synthesis process produced conceptual definitions that will be used to formulate indicators measuring collaboration skills. The observation items referred to the collaboration skills indicators. The theoretical validations were performed to gain accuracy of the collaboration skills measurement using observation sheets. The instrument validation was carried out by two evaluation experts, both qualitatively and quantitatively. The results of the qualitative expert examination are indicated in Table 1.

The test results from the quantitative and qualitative experts were used to revise grids, rubrics, and instruments of collaboration skills. The following table presents the grids and instrument rubrics of collaboration skills after testing.

Table 1.
Instrument rubric of collaboration skills in the form of a questionnaire

Indicator	
Contribute to group discussion	1. Provide suggestions in group discussion
	2. Interest in doing the best for the group
Work effectively	1. Work as a team in completing tasks to achieve common goals
	2. Complete tasks by sharing the tasks and positively depending on each other to achieve common goals
Communicate in group activities	1. Respect the opinions of other group members in completing the tasks

Indicator	
	2. Ask friends when facing obstacles
	3. Compromise in decision-making if differences in opinion occur
Responsible for solving group tasks	Group members are responsible for solving the task on time as required.

Data collection was carried out in the Odd Semester of Grade XI 2024. The research started in the academic year of 2024/205 using the STEM-based e-LKPD media in the experiment class. The research aimed to test the feasibility and quality of the STEM-based e-LKPD media in enhancing the collaboration skills of students in Biology learning in high school. Data generated were numerical data from the observation and interview results against collaboration skill indicators. Next, data were grouped based on the collaboration skill indicators. The observation results were calculated for each number and percentage for each indicator. The grouping was based on collaboration skill categories.

Procedure

The model used was the Hannafin Peck model consists of three phases, namely (1) need analysis, (2) design or planning, and (3) development and implementation. The three phases are connected to evaluation and revision. The first stage needs analysis. In this stage, students' characteristics were tested and assessed by collecting related supporting data, e.g., learning context and specific learning objectives of the excretory system materials to develop products or learning media. The second stage is design, which includes developing a storyline and storyboard, and planning a clear and detailed product framework containing visual display, materials, and content to be developed in the learning media development. The third stage is development or implementation. The product to be developed was a digital student worksheet learning media (e-LKPD) on the excretory system materials. The product development used design websites, namely Canva, live-worksheet, flipbook, and MS Word. The developed product was evaluated using instruments in the form of questionnaires to test its feasibility. Media experts, content experts, students, and Biology teachers would fill out the questionnaires. Next was evaluation, which is the improvement of the developed product that was carried out in each stage. The next step aimed to assess the effectiveness and efficiency of the product for the students. The post-test was carried out on Grade XI IPA to measure the enhancement of their collaboration skills on the excretory system materials in two different classes.

Data Analysis Techniques

Data gained from the results of the media test by the experts were analyzed using the quantitative data analysis technique. The resulted data percentage were converted based on the BSNP assessment scale. The scores of feasibility quality of the STEM-based e-LKPD media were obtained according to the total average score. Once the quality scores were generated, the feasibility of the STEM-based e-LKPD media can be determined based on the interpretation of the feasibility test values from adaptation (Ratumanan & Laurens, 2011; Ristanto et al., 2023).

The research employed the one-group pretest-posttest design. A normality test was carried out on the pretest and posttest scores using the Shapiro-Wilks test at a significance level (α) = 0.05. The scores are normally distributed if the significance value (p) is greater than the significance level (α). The pretest and posttest score results were also tested for their homogeneity using the Levene test with α = 0.05. Data obtained are homogeneous if the significance (p) is greater than the significance level (α). The hypothesis testing employed the MANOVA test with a significance level (α) of 0.05. The test aims to identify the influence of implemented media on learning. If the significance obtained is smaller than α = 0.05, then there is an influence of the developed media on learning. The effectiveness test aims to find out the level of influence of the STEM-based e-LKPD to enhance the collaboration skills of students in the excretory system materials. The enhancement of collaboration skills can be calculated using the normalized N-gain (N) with a formula from Hake (Meltzer, 2002). The average N-Gain values are interpreted based on (Meltzer, 2002).

RESULTS & DISCUSSION

The research was on the development of STEM-based e-LKPD media to enhance collaboration skills. Electronic media or modules allow learning processes to achieve complex skills currently needed

by allowing student-centered learning (Maheni, 2019). The development of the STEM-based e-LKPD used the Hannafin Peck design which consists of several stages. The stages included need analysis, design or planning, and development and implementation. Evaluation and revision occur in each stage.

First, the need analysis stage is conducted by performing a need analysis through interviews with teachers at school. The interview results indicate that teachers at SMAS Muhammadiyah 4 Jakarta have not implemented the STEM-based e-LKPD to support Biology learning.

The second stage, which is the media design stage, produced an analysis of materials, syllabus, teaching modules, and storyboard. The material analysis resulted in an adjustment of materials based on learning outcomes, learning objective flows, and results of need analysis. Generally, materials in the STEM-based e-LKPD consist of concepts of the excretory system, excretory organs, technology for treating diseases of the excretory system, disorders of the excretory system, and activities and exercises. These topics are adjusted to the ATP, CP, and learning objectives. The storyboarding was based on the needs analysis and material analysis conducted.

The third stage is development and implementation. The development stage carried out in the development of the STEM-based e-LKPD included media and language validation, content validation, and small group trials. The development of the media started with the making of supporting media, such as text teaching materials, learning videos, and supporting images. The making of the supporting media of images used the Canva application. Integrated materials have been adjusted to the ATP, CP, and learning objectives. The edited material was then made into a concept map and arranged in text form. After all of the supporting media had been developed, they would be compiled into a flipbook form using the Heyzine website as the main application that was used to design the video layout and other features. The development process produced drafts such as various learning activities, questions, games, and content in the e-module, and were presented in the form of a display as illustrated in Figure 5 which also included instructions for completing tasks and activities in the module. The addition of other content, such as supporting images and videos from YouTube as an illustration, will indirectly help students to memorize since they use several senses in the implementation (Purwanti, 2015; Zaenal, 2012). Students can access the STEM-based e-LKPD free by opening the link https:// https://heyzine.com/flip-book/f0e476721f.html.

Validation was carried out after the media was ready, to assess the media and language feasibility. The validation was performed by three expert validators who are lecturers. The validators assess the feasibility of the product in three aspects, i.e., display, media, and language. The content feasibility assessment was validated by three expert validators, namely lecturers of the course. They evaluated the feasibility of the content and concept of the excretory system materials.

The content validation was assessed based on the suitability of the content of the STEM-based e-LKPD to learning outcomes, learning objective flow, and learning objectives according to the national standards of Indonesian education. The results of the content feasibility test indicate a value of 3.56, which is in the valid category. This suggests that the STEM-based e-LKPD is in agreement with the indicators of competence achievement set; therefore, it is feasible for use in learning according to student abilities (Hasanah, & Nulhakim, 2015). An ideal learning media has two main characteristics: accuracy and validation of information, and a well-organized content structure (Ewins, 2005; Lin & Wu, 2016; Ristanto et al., 2023). The research and development of the STEM-based e-LKPD media to improve collaboration skills employed several stages according to the research and development model of Hannafin and Peck. Figure 2 illustrates the results of the feasibility test assessment of excretory system material.

The results of the media and language feasibility test assessment can be seen in Figure 2. The results indicate that the STEM-based e-LKPD media has been equipped with complete and helpful features from various aspects of usability, function, and display. However, several notes provided by the expert validators regarding the STEM-based e-LKPD materials need to be considered. Validator 1 stated that it would be better to put exercises at the end as an evaluation and not at the beginning. Validator 2 suggested the necessity to add material inserts in the e-LKPD to provide students with knowledge of the materials to be delivered so that they are able to do their tasks and activities in the e-LKPD. Further, validator 3 noted that the time available for completing the quizzes is very short and the presentation of the content, especially in quizzes, still contains question boxes that are cut off and less proportional. The material assessment items resulted in a value of 2.85, as indicated in Figure 3. This is due to, according to validators, the content being presented randomly and illogically; thus, students struggle in developing coherent comprehension of the excretory system. Crucial information was not explained in

detail. After the validation, the e-LKPD revision will focus more on validator suggestions to improve the media.

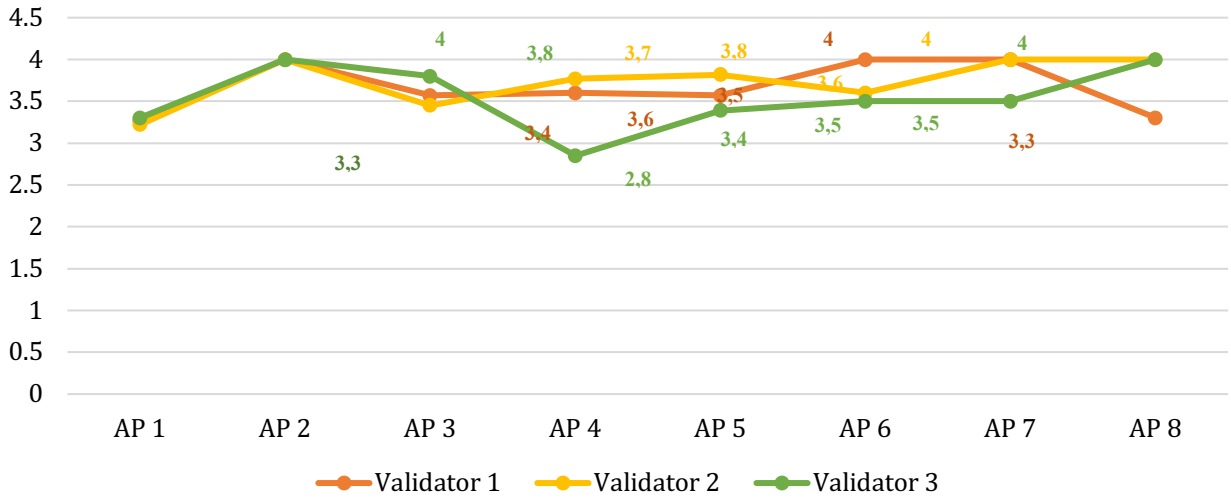

Figure 2. Results of Feasibility Test on Excretory System Material
AP : Assessment aspects
AP 1 : Excretory system materials presented according to the learning outcome
AP 2 : Activities, practices, and questions presented according to Biology learning materials
AP 3 : Excretory system materials conveyed clearly
AP 4 : Excretory system material conveyed according to the concept
AP 5 : Difficulty levels of the materials are according to the capacities of students of Grade XI IPA
AP 6 : Accuracy in using terms in the excretory system materials
AP 7 : Excretory system materials are presented systematically
AP 8 : Excretory system materials are presented effectively and efficiently

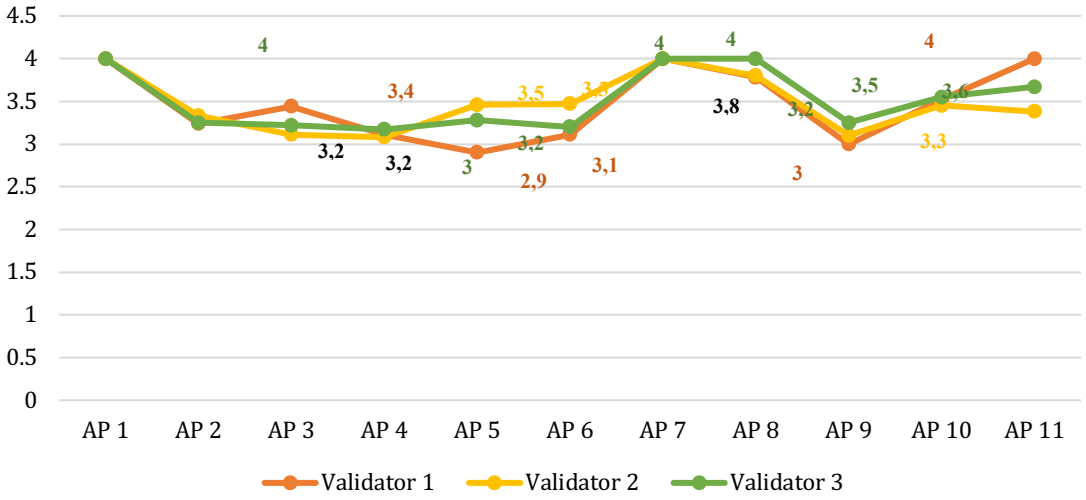

Figure 3. Results of Media and Language Feasibility Test on STEM-based E-LKPD
AP : Assessment Aspects
AP 1 : The appropriateness of the font size (letters or numbers) and font type (type or numbers) selection
AP 2 : The language used is simple and easy to understand
AP 3 : Accuracy of grammar and spelling
AP 4 : Accuracy of sentence structure
AP 5 : Illustrations are presented according to the need of questions or assignments
AP 6 : Images are appropriately placed
AP 7 : Coloring on each page of the STEM-based E-LKPD
AP 8 : Placement of images and videos is easy to access
AP 9 : Videos presented can help students in completing the tasks presented
AP 10 : Layout design is presented precisely
AP 11 : The page size of the E-LKPD is presented precisely

The feasibility test from the media and language aspect was evaluated based on the quality of display (design), image display, and completeness and quality of the STEM-based e-LKPD features. The results of the media and language feasibility test are valid with a value of 3.56. The results, which can be seen in Figure 3, indicate that the STEM-based e-LKPD has been equipped with the following features: games, e-books, videos, and images. Images as graphic media are easily digested by students because of their concrete visual nature that prevents ambiguity (Susilana & Riyana, 2008). Shabiralyani et al. (2015) stated that visual aids in learning assisted teachers in correlating learning concepts accurately, and learning becomes more actual and active and motivating for students. Videos are one of the trigger tools in problem-based learning through authentic information presentation (Carmichael et al., 2018).

The media and language expert validators provided several important notes regarding the STEM-based e-LKPD media. Validator 1 stated that the image of the organ on the cover was less suitable for the excretory system material because it tended more toward the respiratory system. Whereas validator 2 pointed out that the learning videos originated from YouTube and need to be checked regarding the size of the video display as well as the inclusion of clear instructions for using the STEM-based e-LKPD. Finally, Validator 3 suggested a consistent use of letters from beginning to end so that the writing looks neat. The average value of the validation test was 3.52 from the content, media, and language expert test, indicating that the learning media is valid and feasible for use after the revision process.

The STEM-based e-LKPD is an e-learning media that utilizes the internet as a platform to share valuable information for distance learning. According to Yanti et al. (2020), the learning process can increase efficiency, improve motivation, facilitate active learning and experimental learning, which are consistent with student-centered learning, and guide to better learning. Additionally, teachers can control, supervise, and give tasks to the students without a face-to-face meeting by using an e-learning system with e-LKPD (Fayanto et al. 2019). Moreover, information compiled in the STEM-based e-LKPD makes learning more interesting since the materials are integrated with images, videos, e-books, games, and sounds; hence, information is easier to comprehend since it is attractively presented and increases students' enthusiasm to follow the learning activities. The advantages of the STEM-based e-LKPD as a learning media refer to the learning effectiveness and efficiency. The use of the STEM-based e-LKPD can reduce learning space and time and enhance learning process quality. Whereas, the disadvantages of the media include the requirement for students to learn independently without assistance from teachers by reading the instructions in the media and the utilization of the internet access for maximum use of the features; therefore, an internet connection is necessary to have effective learning. After the learning activities were carried out, the 32 students and 2 biology teachers filled out the response analysis questionnaire on the use of the STEM-based e-LKPD. The results of the response analysis are indicated in Figure 4. Based on the results, the utilization of the STEM-based e-LKPD is in the excellent category for both students and teachers, with an average value of 86.8 and 88.2, respectively. One of the advantages of electronic-based learning media is complete content supported by videos, PowerPoint, and images. This indicates that the development of internet-based learning media can be used to support learning according to students' needs. Learning media with interesting displays and in-depth information can improve reading habits (Aufa Fandiya et al., 2021).

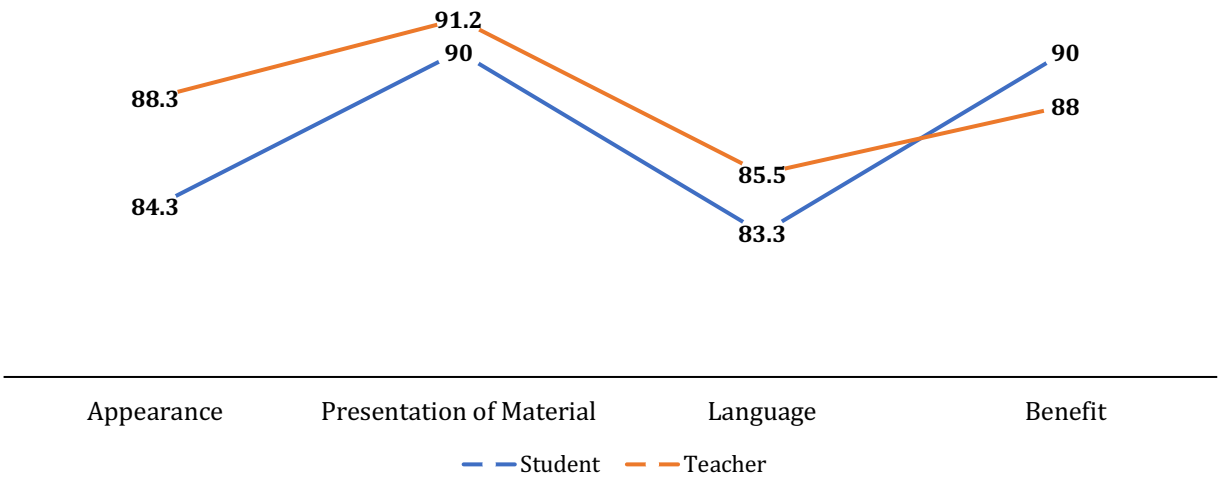

Figure 4. Results of response analysis questionnaire on the utilization of STEM-based e-LKPD

The initial display of the STEM-based E-LKPD shows instructions for use to facilitate students in using the module. The initial display also contains a concept map and the first description of the excretory system. According to Nurlina (2020), the use of a concept map can enhance students' comprehension since it is one of the study methods that develops a meaningful learning process, as a means to familiarize the brain to think conceptually about everything. Solikhatun et al. (2015) state that visual images help students to develop knowledge since information in the images allows them to construct or elaborate their prior knowledge. The STEM-based e-LKPD contains material on excretory systems with images. The images describe organs and disorders in the excretory systems along with information. Kasmiyatun (2016) asserts that images with clear instructions can interpret and memorize the content of text materials that accompany the images; therefore, abstract explanations will be easier to understand by the students. The STEM-based e-LKPD contains videos on the excretory system and a tutorial on making teaching aids for the excretory system to enhance student understanding of the material. According to Apriansyah (2020), the use of videos can help students understand complicated subject materials that are challenging to explain in a concrete. Videos have some advantages in learning, namely, they can accurately describe a process that can be watched repeatedly if deemed necessary; can encourage and improve student motivation; and present and explain complex processes and concepts.

The next stage is the implementation by applying the developed media to 32 students. The implementation stage started with questionnaire distribution and performance assessment by the teachers to the students before the use of the STEM-based e-LKPD. There were 8 aspects to be observed in the collaboration skills. The learning activities continued by implementing the media as a learning media. The students were then provided with a post-test to evaluate their collaboration skills on the studied materials and to measure the success of the developed product. The results of the students' pretest and posttest can be seen in Table 6. Based on the results, there was an increase in student scores between the pretest and posttest.

Table 2.
Results of the Prerequisite Test and MANOVA Test

	Significance level	**Description**
Shapiro-Wilk Test (α=0.05)	0.342	Normal
Levene Test (α=0.05)	0.156	Homogeneous
MANOVA Test (α=0.05)		
Pillai's Trace	0.000	Significant
Wilk's Lamba	0.000	Significant
Hotelling's Trace	0.000	Significant
Roy'sLargest Root	0.000	Significant

The effectiveness test employed the N-Gain test to find out the influence of the STEM-based e-LKPD on the excretory system materials. The N-Gain results are indicated in Table 6.

Table 3.
Results of N-gain on Collaboration Skills Score of Students in Experimental Class

	N	Minimum	Maximum	Mean	Std. Deviation
N-gain_Percentage	35	40.54	91.11	71.3665	11.53694
Ngain_Score	35	00.41	00.91	00.7137	00.11537

Table 5 indicates the results of the MANOVA Test, which is 0.000 < significance level of 0.05. The results suggest that there is an influence on the utilization before and after the implementation of the learning media of the STEM-based e-LKPD on student collaboration skills in the excretory system. The result is supported by the N-Gain result of 0.71 in Table 6. The results indicate that the STEM-based e-LKPD produces moderate effectiveness in enhancing students' collaboration skills in the excretory system materials. This is due to the e-LKPD that requires students to perform numerous activities, including practicum and experiments. Fitriah et al (2019) find that the use of tools and materials is essential for students in practicum. Students who cannot use tools and materials require assistance to perform experiments effectively. The STEM-based e-LKPD contains various activities related to groups thus training students' collaboration skills. According to (Davidsen et al., 2020; Siew & Ambo, 2018), collaboration skills in the aspect of productive work occur during project planning or practicum activities. When students succeed in determining titles and formulating predictions, collaboration skills are trained indirectly (Chenault, 2017; Tosun & Taskesenligil, 2013).

The last stage is evaluation, which is the process of improving the STEM-based e-LKPD media that contains excretory system materials. The improvement was carried out according to the criticisms and suggestions from the expert validators, students, and teachers. The assessment of the STEM-based e-LKPD as a whole can be seen in Figure 4. The results indicate that the highest score was obtained from the media feasibility test, which was 3.68. Based on the total assessment, the average score was 3.57 which is stated as valid. Therefore, the STEM-based e-LKPD is feasible for use in the excretory system learning in Grade XI MIPA. The development aspect was supported by the utilization of the internet which allows for the expansion of insight and exploration and improvement of learning motivation. This is in accordance with Mehdi and Aurelie (2014) stating that e-learning can maintain student learning motivation through broad exploration. Moreover, good responses from teachers and students are also supported by the application of technology and internet provision in the school. Below is the assessment of the e-LKPD media.

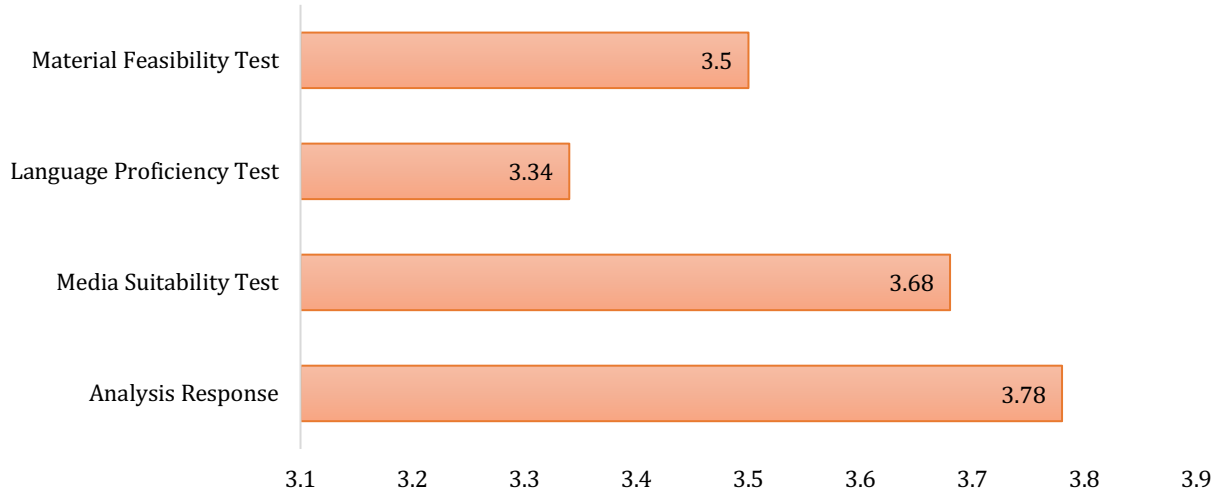

Figure 5. Graph of STEM-based e-LKPD Overall Assessment

This is in line with the results of a study by Bambang, Dewiyani & Pantjawati (2016) indicating that students in the 21st century as an internet generation (virtual world generation) have no difficulties in mastering various technology-based products. Biology learning will be easier, more interesting and more convenient with the application of various technology devices (Mehdi & Aurelie, 2014).

CONCLUSION

Conclusions can be drawn from the research results that validation by the content, media, and, language experts indicate a valid category which is also supported by the valid response from students and teachers. The effectiveness test of the STEM-based e-LKPD in the excretory system using N-gain calculation indicates a moderate effectiveness category. The researchers recommend the improvement of the effectiveness and efficiency of instruments and media through product feasibility tests in larger sample groups. Further, the instruments have the potential to be a foundation for the development of 4C skills relevant to 21st-century learning.

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