Didaktika: Jurnal Kependidikan
P-issn 1978-0214; E-ISSN 2657-196X

Development of Circulation System E-Dioclass to Foster Critical Reasoning and Cognitive Learning Outcomes

Farida Nuraini[1], Mimien Henie Irawati Al Muhdhar[1], Zainudin Hassan[2], Murni Sapta Sari[1], Deny Setiawan[1], Cicilia Novi Primiani[3], Wachidatul Linda Yuhanna[3], Feni Tin Faizah[4]

[1] Universitas Negeri Malang, Indonesia; mimien_henie@yahoo.co.id
[2] Universiti Teknologi Malaysia, Malaysia; p-zainudin@utm.my
[3] Universitas PGRI Madiun, Indonesia; primiani@unipma.ac.id
[4] SMAN 2 Batu, Indonesia; fenitinfaizah@gmail.com

Keywords:
Critical Reasoning Dimensions; Cognitive Learning Outcomes; Google Classroom; Circulation System

Abstract

Critical reasoning skills are still relatively low among students and have a significant impact on cognitive learning outcomes. This study aims to produce E-Dioclass learning media on the PBLPOE model of circulatory system material integrated with SDGs number 3 to develop critical reasoning dimensions and cognitive learning outcomes of phase F students that are valid and practical. The research model used is the Lee & Owens development model with five stages, namely analysis, design, development, implementation, and evaluation. The analysis stage aims to identify the needs of teachers and students. The design stage aims to design E-Dioclass media. The development stage is to realize the design in the form of a storyboard to become a prototype. The implementation stage is to apply the media in four meetings. The evaluation stage is to determine the effectiveness of the media. E-Dioclass media is a Google Classroom-assisted media that can be accessed online through electronic devices. The results of E-Dioclass media validation by media experts, material experts, and biology education practitioners obtained an average score of 95.7%. The results of the practicality test obtained a score of 81.6%. Therefore, E-Dioclass media is declared valid, practical.

Kata kunci:
Dimensi Bernalar Kritis; Hasil Belajar Kognitif; Google Classroom; Sistem Sirkulasi

Abstrak

Kemampuan bernalar kritis masih tergolong rendah di kalangan siswa dan berdampak signifikan terhadap hasil belajar kognitif. Penelitian ini bertujuan untuk menghasilkan media pembelajaran E-Dioclass pada model PBLPOE materi sistem sirkulasi terintegrasi SDGs nomor 3 untuk menumbuhkembangkan dimensi bernalar kritis dan hasil belajar kognitif siswa fase F yang valid dan praktis. Model penelitian yang digunakan adalah model pengembangan Lee & Owens dengan lima tahap, yaitu analisis, desain, pengembangan, implementasi, dan evaluasi. Tahap analisis bertujuan mengidentifikasi kebutuhan guru dan siswa. Tahap desain bertujuan merancang media E-Dioclass. Tahap pengembangan untuk merealisasikan desain dalam bentuk storyboard hingga menjadi prototipe. Tahap implementasi untuk menerapkan media dalam empat kali pertemuan. Tahap evaluasi untuk mengetahui keefektifan media. Media E-Dioclass merupakan media berbantuan Google Classroom yang dapat diakses secara online melalui perangkat elektronik. Hasil validasi media E-Dioclass oleh ahli media, ahli materi, dan praktisi pendidikan biologi memperoleh nilai rata-rata sebesar 95,7%. Hasil uji praktikalitas memperoleh skor 81,6%. Oleh karena itu, media E-Dioclass dinyatakan valid, praktis.

Article history:
Received: 01-07-2025
Revised 18-12-2025
Accepted 29-05-2026

Corresponding Author: (Author yang komunikasi dengan editor)
Mimien Henie Irawati Al Muhdhar
Universitas Negeri Malang, Indonesia; mimien_henie@yahoo.co.id

PENDAHULUAN

A strategy that emphasizes the need to integrate sustainable ideas into the educational process to equip students with knowledge, skills, attitudes, and principles to support sustainable development is the definition of*Education for Sustainable Development*(ESD) (Ekantini & Wilujeng, 2018). The success of ESD implementation depends on the curriculum and the role of teachers, but this is not optimal if it only focuses on cognitive aspects without training skills and attitudes (Vioreza et al., 2023). The Independent Curriculum prioritizes a learning approach that places students at the center of the learning process to develop quality human resources by integrating the Pancasila Student Profile as a basis for character formation (Rosmana et al., 2022). One of the main dimensions of the Pancasila student profile is critical reasoning skills, namely the ability to analyze, evaluate, and draw conclusions objectively (Kemendikbudristek, 2022).

A preliminary study in class XI Bio 2 of SMAN 2 Batu showed an average critical reasoning ability of 66.6 students, which has met the Learning Objectives Achievement Criteria (KKTP) but still needs to be improved. These abilities include three main indicators: obtaining and processing information, analyzing and evaluating reasoning, and reflecting on thoughts (Kemendikbudristek, 2022). These abilities are closely related to higher-level cognitive processes, especially analyzing (C4) and evaluating (C5), thus impacting students' cognitive learning outcomes (Raturoma & Laisnima, 2023). Cognitive learning outcomes reflect thinking abilities from the basic level (C1) to higher-level abilities (C6), so cognitive improvement is an indicator of the effectiveness of learning activities that require appropriate learning strategies and media (Pranyoto & Geli, 2020).

Interactive learning media based on technology and animation have been proven to facilitate students' understanding of complex material in an engaging manner (Afrilia et al., 2022). The use of learning media can provide assistance in conveying new concepts and solving problems in learning, especially in abstract material such as the human circulatory system, which requires visualization for easier understanding (Dewantara et al., 2020). In accordance with Ariesta, (2019), e-learning also contributes positively to student understanding and memory. In the context of biology learning, digital media such as Google Classroom is very effective because it is easy to use, free, and integrated with Google Drive, thus facilitating material distribution (Lestari & Marhamah, 2022). Digital media innovation is important to encourage active student participation, one of which is through the development of E-Dioclass, an interactive media based on Google Classroom for the cardiovascular system material with the addition of electronic Student Worksheets (LKPD) in it (Hilal et al., 2022). Electronic LKPD allows students to learn independently, complete assignments, and build understanding, making it effective in developing critical thinking skills and learning outcomes in the cognitive domain (Rahmadayanti et al., 2022).

Selecting an appropriate learning model, tailored to student characteristics and teaching materials, plays a crucial role in improving students' cognitive achievement and critical reasoning skills (Rahmawati, 2022). One relevant learning model is*Problem Based Learning*

Predict-Observe-Explain(PBLPOE) by integrating real-life problem-solving skills with the stages of prediction, observation, and explanation, and encouraging independent construction of knowledge (Fitriani et al., 2020). The application of E-Dioclass media in the PBLPOE model is expected to support biology learning, especially on the human circulatory system, which is often considered difficult by 62.2% of students due to the use of scientific terms and the complexity of the concept. Therefore, the circulatory system material should be presented not only conceptually, but also linked to a global context, such as the Sustainable Development Goals (SDGs) that promote environmental awareness and well-being (Tareze et al., 2022). This integration aims to ensure students understand the biological relevance of the circulatory system to global issues, particularly SDG point 3 indicator 3.4 concerning reducing deaths from non-communicable diseases and improving mental health, as well as fostering awareness of their role in supporting sustainability.

Based on the explanation, the purpose of this research is to develop visual learning media assisted by Google Classroom by utilizing technology in the PBLPOE model to develop critical reasoning dimensions and cognitive learning outcomes of students of SMAN 2 Batu Phase F on the integrated circulation system material of SDGs number 3 that is valid and practical. E-Dioclass media already has a copyright registration letter or product rights of the Republic of Indonesia with certificate number EC002025043926.

RESEARCH METHODS

The type of research conducted is development research (*Research and development*) using the Lee & Owens (2004) model approach. This model was chosen because it has the specificity to develop educational tools in the form of multimedia-based learning media (Iriani et al., 2022). This research model has five research stages, namely analysis (*analysis*) which contains the needs analysis stage (*need assessment*) and early-late analysis (*front-end analysis*), design (*design*), development (*development*), implementation (*implementation*), and evaluation (*evaluation*) (Lee & Owens, 2004).

Analysis

The analysis phase aims to identify the causes of gaps in the field, which can then serve as a reference for needs. This phase involves data collection using questionnaires to analyze teacher and student needs, along with a preliminary research test to identify students' initial critical reasoning abilities and cognitive learning outcomes.

Design

The design phase aims to plan the concept based on the analysis results and then design the media to be developed. The design phase includes scheduling, project team determination, media specifications, material structure, and configuration control and review cycles.

Development

The development stage consists of pre-production activities to organize*storyboard* media, production to develop media to produce*prototype* E-Dioclass media, while post-production activities include testing the validity of the material and media as well as testing the practicality of the developed media. The validity of the media and material is assessed using a scale*Liked*1-5, which was conducted twice with material experts, media experts, and biology education practitioners. Media that had been proven to be suitable and valid then entered the practicality

testing stage, which referred to Branch, 2009, including individual trials (*one-to-one trial*), small group trials (*small group*), and field trials (*field trial*).

Implementation

This research article is limited to practicality testing.

Evaluation

The final stage is evaluation, which is carried out to assess the quality and effectiveness of the media that has been developed.

Validity tests and practicality tests are analyzed using the following formulas

$$V/P = \frac{Tse}{Tsh} \times 100\%$$

Information:

V/P : validity/practicality

These : total score obtained

TSh : expected total score

The results of the calculations obtained were then analyzed using the criteria according to (Aka et al., 2018) as shown in Table 1.

Table 1.
Validity and Practicality Criteria

No	Validity/Practicality Criteria (Competency Test Data)	Validity/Practicality Category	Level of Validity/Practicality
1	X=100	Very valid/practical	Very valid/practical, can be used without revision
2	80 ≤ X < 100	Valid/practical	Valid/practical, can be used with revision
3	60 ≤ X < 80	Less valid/practical	Less valid/practical, not recommended for use
4	40 ≤ X < 60	Not valid/practical	Invalid/practical major revision, not recommended for use
5	20 ≤ X < 40	Very invalid/impractical	Very invalid/impractical, not used

Source: Adapted from (Aka et al., 2018).

RESEARCH RESULTS AND DISCUSSION

Results

Level of Analysis

The results of preliminary research on October 7, 2024 regarding the needs of biology teachers at SMAN 2 Batu, Mrs. Feni Tin Faizah S.Pd. obtained several pieces of information, namely: (1) teachers have taught critical reasoning dimension competencies and characters, but students' critical reasoning abilities need to be improved, (2) learning models that are often used include PBL, PJBL, and*cooperative*, (3) teachers never integrate the SDGs of healthy and prosperous

living into learning materials, (4) learning resources during the learning process in the classroom still use textbooks from the school.

The results of the questionnaire on the needs analysis of class XI Bio 2 students at SMAN 2 Batu obtained several pieces of information, namely: (1) students at SMAN 2 Batu with a visual learning style have a percentage of 64.9, (2) students are already familiar with the terms critical reasoning dimensions and SDGs but are still rarely integrated into biology learning materials, (3) each class at SMAN 2 Batu is facilitated with adequate infrastructure and equipment ranging from LCDs, projectors, speakers, and school wifi, (4) the school allows students to bring cell phones, laptops, and tablets to school but with teacher supervision, meaning that cell phones may not be operated during class hours without the teacher's permission.

Early-late analysis stage (*front-end analysis*) was conducted to determine the initial critical reasoning competencies of phase F students of SMAN 2 Batu through a critical reasoning dimension test that refers to the critical reasoning dimension indicators. The results of the preliminary research conducted on October 7, 2024, obtained an average score of 66.6. The initial-final analysis stage (*front-end analysis*) was also conducted to determine the initial abilities of students' cognitive learning outcomes through a multiple-choice test. The test refers to cognitive learning outcome indicators, of the six cognitive learning outcome indicators, only two indicators were used, namely indicators C4 (analyzing) and C5 (evaluating) because both are classified as high-level cognitive learning outcome indicators. Both indicators need to be practiced because they indirectly train students' critical reasoning skills. Indicator C4 received an average score of 64.0, which is in the low category. Indicator C5 received an average score of 69.2, which is in the low category.

Design Stage

The E-Dioclass media development activity began in August-December 2024. The project team consisted of Farida Nuraini as a researcher, Prof. Dr. Hj. Mimien Henie Irawati Al-Muhdhar, M.S. as a supervisor, and involved material expert validators, media experts, and biology education practitioners. The E-Dioclass media developed contains material on the human circulatory system phase F in effective and communicative Indonesian. The E-Dioclass media can be used by students after joining or entering the code shared by the teacher. The menu in E-Dioclass contains learning outcomes, teaching materials, and for each topic there will be attendance, learning objectives, LKPD and games. The teaching materials are arranged using Google Sites which are equipped with attractive and informative illustrations so that they can help facilitate student understanding. The learning structure used in the E-Dioclass media on the circulatory system material is adjusted to the learning outcomes of phase F to compile learning objectives in 4 meetings. The learning tools created include teaching modules and LKPD with the PBLPOE learning model. The configuration control stage and review cycle refer to the Ministry of Education, Culture, Research and Technology (2017) starting from the type of format used in the E-Dioclass media in the form of*website*, format selection*website*because it doesn't require a lot of money,*website*One of the options used is Google Sites because it provides a free domain and users don't need to download additional applications, so it doesn't require additional storage and can be accessed on all mobile devices with an internet connection. Google Classroom was chosen because it provides*platform*It's free and integrated with Google, so you don't need to download additional apps if you're using it on a laptop. However, if you're using

it on a phone or tablet, you can download the Google Classroom app for maximum usability. Canva was chosen to create the LKPD because it provides*platform*Free and easy-to-use editing software. Word Wall is used to create interactive games that allow students to practice problems through play.

Development Stage

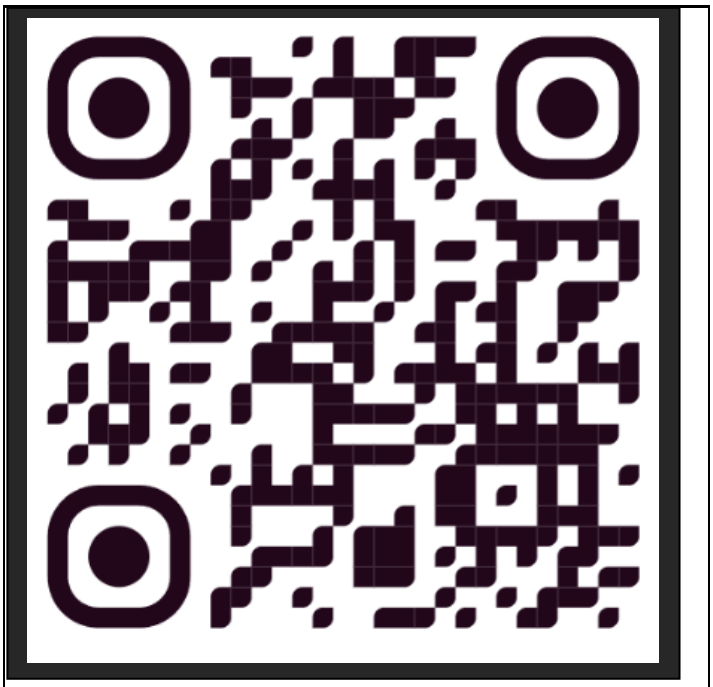
The pre-production stage produces*storyboard*as shown in Table 2.

Table 2.
Storyboard Media E-Dioclass

No	Layout	Keterangan
1.		Initial view of Google Classroom after joining the E-Dioclass class
2.		E-Dioclass display on the “Class Assignments” menu
3.		When you select the "Learning Objectives" menu, a PDF will appear containing the learning objectives.
4.		When you select the "LKPD" menu, several displays will appear.*link*which can be accessed to the application*Canva*
5.		The display when selecting the “Quiz” menu will then go to*website* Word Wall

Source: Processed by Researchers

The Production Stage produces*prototype* which can be accessed by scanning*barcode*which is shown in Figure 1.



Gambar 1. Barcode Media E-Dioclass

Sumber: Diolah peneliti

The post-production stage obtained the results of the validity and practicality of the E-Dioclass media. The material validity assessment process was carried out by Dr.drh. Cicilia Novi Primiani, M.Pd. In the first material validation stage, the percentage obtained was 92.0 with a valid category but there were several inputs and comments. Based on these results, improvements were made referring to the input submitted by the validator and then the second stage of validation was carried out and obtained a percentage of 100.0 with a valid category. The detailed validation results by material experts are listed in Table 3.

Table 3.

Validation Results by Material Experts

No	Rated aspect	First Stage Validation	Second Stage Validation
1.	Content Eligibility	90,0	100,0
2.	Presentation	86,7	100,0
3.	Linguistics	100,0	100,0
4.	Integration of Material with Critical Reasoning Dimensions	100,0	100,0
5.	Integration of Material with Cognitive Learning Outcomes	86,7	100,0
Total		92,0	100,0

Source: Processed by Researchers

The E-Dioclass media, which had been deemed valid based on a review by material experts, was then validated by media experts on Dr. Wachidatul Linda Yuhanna. The results of the first stage of media validation obtained a percentage of 82.8 in the valid category but with several improvements. The results of the second stage of media validation showed a percentage

of 100.0 with a very valid assessment category. The detailed results of the validation by media experts are listed in Table 4.

Table 4.
Validation Results by Media Experts

No	Rated aspect	First Stage Validation	Second Stage Validation
1.	Technical Quality	86,0	100,0
2.	Appearance	80,0	100,0
3.	Visual Communication	80,0	100,0
4.	Effects of Media on Learning Strategies	86,7	100,0
5.	Media Integration with Critical Reasoning Dimension	84,0	100,0
6.	Media Integration with Students' Cognitive Learning Outcomes	80,0	100,0
Total		82,8	100,0

Source: Processed by Researchers

The third validation stage was conducted with biology education practitioners, namely Ms. Feni Tin Faizah, S.Pd. from SMAN 2 Batu, and obtained a percentage score of 86.0 with a valid category without any comments or suggestions so that it could be continued to the next stage without any improvements. The detailed validation results by biology education practitioners are listed in Table 5.

Table 5.

Validation Results by Biology Education Practitioners

No	Rated aspect	Score Obtained	Percentage
1.	Material	40	87,5
2.	Media Quality	25	84,0
3.	Linguistics	15	93,3
4.	Media Suitability	45	88,8
5.	Media Integration with Critical Reasoning Dimension	25	80,0
6.	Media Integration with Students' Cognitive Learning Outcomes	10	80,0
Total		160	86,2

Source: Processed by Researchers

The media, which had been declared valid and suitable for use by the validator, then underwent a practicality test consisting of three stages: individual trials, small group trials, and field trials. The percentage of individual trials was 88.6, which was categorized as practical media and could be used with some improvements. The percentage of results from small group trials reached 83.4 and was declared valid but with some revisions. The results of the field trials

obtained a percentage of 80.5, categorized as practical. The detailed results of the practicality test are listed in Table 6.

Table 6.

Practicality Trial Results

No	Rated aspect	Individual Trial	Small Group Trial	Field Trial
1.	Material	86,6	83,4	80,4
2.	Interest	90,6	83,1	85,7
3.	Presentation	93,3	83,8	79,4
4.	Media Integration with Critical Reasoning Dimension	86,6	83,1	76,3
5.	Media Integration with Students' Cognitive Learning Outcomes	86,6	83,7	80,5
Total		88,6	83,4	80,5

Source: Processed by Researchers

Implementation Stage

This research article is limited to practicality testing.

Evaluation Stage

The formative evaluation process resulted in material validity with a percentage of 100.0 in the very valid category, the results of media validity obtained a percentage of 100.0 included in the very valid category, the results of the validity of biology education practitioners produced a percentage of 86.0 which was classified as valid criteria, while the results of the practicality test had a percentage of 81.6 practical criteria. The results of the formative evaluation indicate that the E-Dioclass media can support the biology learning process. The media can be said to be theoretically and practically valid in its application in learning activities to develop critical reasoning and students' cognitive learning achievements.

Discussion

The validation results of the E-Dioclass media indicate that the E-Dioclass media meets the valid and practical criteria for use in learning activities, especially to develop critical reasoning skills and students' cognitive learning outcomes. The innovative E-Dioclass media developed is characterized by containing circulatory system material integrated with SDGs number 3, namely a healthy and prosperous life. The material in the media is delivered using a website display equipped with supporting animations, interactive illustrations and thematic infographics, the presence of which supports students to achieve a deeper understanding of the circulatory system material. This is in accordance with research conducted by Assidiqi & Sumarni, (2020) that the website as a learning medium or material provider platform is a way that can support the success of interactive learning because it is able to present varied and easily accessible content. The material provided on the website can be accessed by students flexibly, both in terms of time and place, because it has been packaged electronically and is available

through an online learning platform (Habibi et al., 2013). This advantage allows personalization of learning according to the pace and learning preferences of each student.

The website used to deliver the material not only contains images and text, but is also equipped with posters with the aim of making it easier for students to receive and implement the integrated SDGs material. According to Astuti, (2018) the use of posters as a medium for conveying information is considered more effective because the message is easy to understand with clear images, the use of concise phrases and sentences will make it easier for students to understand. The poster display in visual form will be able to influence and motivate everyone who sees it, especially because of the color, layout, and communicative visualization, so that it can stimulate the desire to implement the message of the poster (Simarmata et al., 2022). The circulatory system material integrated with the SDGs of a healthy and prosperous life has the hope that students are able to implement the related material in their daily lives, both in maintaining health, recognizing a healthy lifestyle, to the importance of blood donation and an active lifestyle. According to Tareze et al., (2022) the policy of implementing SDGs in the lives of students aims to ensure that each individual gets a good quality of life and also emphasizes the importance of the relationship between humans and the natural environment to care for and protect each other. The SDGs are not solely the responsibility of the government but also involve the participation of all levels of society, including students. Therefore, teachers need to carefully prepare their learning, including by integrating educational habits into the school environment (Nasrullah et al., 2025). The goal of implementing SDG values in learning materials is to shape students' awareness and concern for global health and environmental issues.

Learning activities utilizing E-Dioclass media can foster critical reasoning skills and improve students' cognitive achievement. E-Dioclass media, equipped with the Student Worksheet (LKPD) menu in the PBLPOE learning model, can train students' critical reasoning skills through the provided problems. The PBLPOE model was chosen because all phases within the model can accustom students to critical reasoning and develop problem-solving skills (Fitriani et al., 2020). These phases include problem orientation.*(Orientation of the problem),* organizing students*(Organization of Students),* prediction*(Prediction),* investigation or observation*(investigation/observation),* explanation or submission of reports*(Explanation),* analysis and evaluation*(Analysis and Evaluation).* The relationship between the PBLPOE model LKPD contained in E-Dioclass and students' critical reasoning abilities can be seen in the phase*orientation of the problem*, which aims to foster students' curiosity and critical reasoning skills through problems in the E-Dioclass LKPD that are actual and in accordance with real-life problems (Wahyuni et al., 2015). The problem-based learning model can be used in this E-Dioclass media, because it can empower students to work collaboratively, conduct research, integrate theory and practice, and develop solutions to the specified problems and their critical thinking skills (Şenel & Adilogullari, 2015). In addition, the problem-based approach provides space for students to construct their own meaning from the learning experiences they have had.

The use of appropriate media in the learning process can significantly impact students' ability to effectively solve critical problems (Nurfadhillah et al., 2021). This is because effective media facilitates students' access to a wider and more diverse range of information sources, enabling the development of independent analytical thinking (Kusumaningtyas, 2022). According to Dewi & Nugroho (2020), Google Classroom-based learning media can effectively

improve students' analytical skills in learning, but the use of such media must be carefully prepared to achieve the desired learning objectives. Furthermore, according to Erlangga et al. (2021), the use of Google Classroom in problem-based teaching and learning significantly improves critical reasoning skills compared to conventional methods. Google Classroom can help optimize students' critical reasoning skills by enabling them to learn independently, explore additional learning resources, and enhance interaction through in-depth discussions and reflection (Aini et al., 2023). Features such as digital quizzes, automatic assignment submission, and direct feedback from teachers also accelerate the reflective learning cycle. These discussion and reflection activities can utilize E-Dioclass media by using the "communication forum" menu. Interactions between teachers and students, as well as students, can take place directly through this menu, more privately, as they won't be visible to the entire class, as the comments section is reserved for individual students (Rizkianti & Mustika, 2022).

Learning activities using LKPD available in E-Dioclass media are adapted to the PBLPOE learning model, so that it can be a practice for students to reason critically. According to Rikmasari et al., (2022), students' analytical and evaluation abilities improve after implementing a learning model integrated with POE, whether using media or not. However, to facilitate understanding during the learning process, it is very important to include concrete examples when delivering lesson materials and the use of learning media is highly recommended as a means to optimize learning. The implementation of the problem-based learning model, students are trained to analyze articles and dig up relevant information as a basis for examining the given problem, so this can foster C4 (analyzing) abilities and can provide significant improvements in cognitive learning achievement (Farhan & Arisona, 2022). According to Rostyanta et al., (2020) the use of Google Classroom-based learning media can accustom students to think and analyze independently. According to Zakaria & Ningsih (2024), Google Classroom facilitates the delivery of material and the exploration of ideas. Furthermore, students are given individual assignments to facilitate independent learning. With these capabilities, students not only master the content but also relate the material to real-world problems around them.

Students' low critical reasoning skills can be caused by a lack of interest in reading due to learning resources or media that are less interactive, less motivating, or boring (Azizah & Alberida, 2021). Students' low interest in reading can affect their critical reasoning skills (Anisa et al., 2021). Teaching methods used by teachers, such as lectures and summarizing, can also impact students' low interest in reading and learning (Agustami et al., 2017). Furthermore, a lack of curiosity in students can also affect their critical reasoning skills. Teachers can foster this curiosity by helping students review the material they have learned and analyze images (Waridah & Selvia, 2024). Students' critical reasoning skills are essential for understanding complex biology material and are relevant to everyday life problems (Rahayuningsih, 2022). The use of efficient and relevant media has the potential to be a solution in efforts to improve students' critical reasoning skills. E-Dioclass media provides student worksheets (LKPD) that can train students to obtain and process information, as well as think critically to find solutions to problems they encounter. This is in accordance with Ai'syah et al. (2022), which shows that the use of interactive learning media can improve students' critical reasoning skills. The presence of interactive features in the media makes learning more enjoyable and meaningful. Thus, E-Dioclass media can be an effective tool in improving students' critical reasoning skills

and cognitive learning outcomes.

CONCLUSION

Through this research, it can be seen that the E-Dioclass learning media has been proven valid and practical to contribute to improving critical reasoning skills and cognitive achievements of phase F students. This finding shows that the integration of circulatory system material with SDGs number 3 presented through website-based Google Classroom and animation can significantly facilitate students' understanding of complex material. This success was only known after validation stages by experts and practical tests by students who had completed the material consisting of individual trials, small groups, and field trials.

The results of this study confirm and strengthen previous findings that demonstrate the effectiveness of digital and problem-based learning media in encouraging the improvement of critical reasoning skills and cognitive achievement of students. In addition, this study also contributes a new approach in designing interactive learning media integrated with Google Classroom and an interactive website containing integrated material on SDGs number 3. The new perspective offered is the contextual integration of biology content, Pancasila student profiles, and global sustainability issues in one integrated media that can be accessed flexibly online.

The sample size is one of the limitations of this study, which only covered one class at one school (SMAN 2 Batu) and one educational level (phase F), thus limiting the generalizability of the findings. The material variation also only covered the topic of the human circulatory system, without cross-topic testing or different grade levels. Furthermore, due to the focus on validation and practicality, the study did not include a broad effectiveness test. Therefore, further research is needed with a larger sample size, across educational levels, and implementation in the context of other biology materials. With a more in-depth and comprehensive approach, more appropriate and impactful learning policies can be formulated for the development of more adaptive and sustainable media.

BIBLIOGRAPHY

Afrilia, L., Arief, D., & Amini, R. (2022). Efektivitas Media Pembelajaran Berbasis Video Animasi untuk Meningkatkan Motivasi Belajar Peserta Didik Kelas IV Sekolah Dasar. *Jurnal Cakrawala Pendas*, *8*(3). https://doi.org/10.31949/jcp.v8i2.2559

Agustami, R. P., Wiyanto, & Alimah, S. (2017). Persepsi Guru dan Siswa Terhadap Pembelajaran IPA Terpadu Serta Implikasinya di SMP. *JISE*, *6*(1). https://doi.org/10.15294/jise.v6i1.17069

Aini, A. N., Wirahayu, Y. A., & Budijanto, B. (2023). Pengaruh Model Problem Based Learning Berbantuan Google Classroom terhadap Kemampuan Berpikir Kritis Siswa pada Mata Pelajaran Geografi. *Jurnal Integrasi Dan Harmoni Inovatif Ilmu-Ilmu Sosial (JIHI3S)*, *2*(12), 1236–1248. https://doi.org/10.17977/um063v2i12p1236-1248

Ai'syah, A., Zakia Salma, U., & Dewi, N. R. (2022). *Pengembangan E-LKPD Berpendekatan STEM Menggunakan Google Form dan Linktree untuk Melatih Kemampuan Berpikir Kritis Siswa SMP*.

Aka, K. A., Akbar, S., & Sahertian, J. (2018). Development of Validation Instrument for Interactive Multimedia Learning Implementation Plan. *Proceedings of the 1st International Conference on Early Childhood and Primary Education (ECPE 2018)*. https://doi.org/10.2991/ecpe-18.2018.25

Anisa, A. R., Ipungkarti, A. A., & Saffanah, K. N. (2021). Pengaruh Kurangnya Literasi serta Kemampuan dalam Berpikir Kritis yang Masih Rendah dalam Pendidikan di Indonesia. In *Conference Series Journal* (Vol. 01).

Ariesta, F. W. (2019). Effectiveness of E-Learning Media to Improve Learning Outcomes Natural Science in Primary Schools. *Journal of Education Research and Evaluation*, *3*(2), 88. https://doi.org/10.23887/jere.v3i2.17203

Assidiqi, M. H., & Sumarni, W. (2020). *Pemanfaatan Platform Digital dalam Pembelajaran Daring di masa Pandemi Covid-19. Prosiding Seminar Nasional Pascasarjana UNNES*. https://doi.org/10.21009/JPD.011.22

Astuti, H. (2018). Penggunaan poster sebagai media komunikasi kesehatan. *Jurnal Ilmiah Ilmu Komunikasi*, *Vol.15*(No.1), 7. https://doi.org/https://doi.org/10.47007/jkomu.v15i1.187

Azizah, N., & Alberida, H. (2021). Seperti Apa Permasalahan Pembelajaran Biologi pada Siswa SMA? *Journal for Lesson and Learning Studies*, *4*(3), 388–395. https://doi.org/10.23887/jlls.v4i3.38073

Branch, R. M. (2009). *Instructional Design: The ADDIE Approach*. Springer US. https://doi.org/10.1007/978-0-387-09506-6

Dewantara, R. B., Suarsini, E., Lestari, R., & Biologi, P. (2020). *Analisis Kebutuhan Pengembangan Multimedia Interaktif Berbasis Problem Based Learning pada Materi Biologi SMA*. https://doi.org/10.17977/jptpp.v5i6.13587

Dewi, I. S., & Nugroho, P. A. (2020). Peningkatan Kemampuan Analisis Mahasiswa Menggunakan Model Saintifik Berbantuan Google Classroom di Era Pandemi Covid-19 Pada Mata Kuliah Dasar-Dasar IPA. *Dharma Pendidikan*, *15*(2), 10–18. https://doi.org/https://doi.org/10.69866/dp.v15i2.132

Ekantini, A., & Wilujeng, I. (2018). The Development of Science Student Worksheet Based on Education for Environmental Sustainable Development to Enhance Scientific Literacy. *Universal Journal of Educational Research*, *6*(6), 1339–1347. https://doi.org/10.13189/ujer.2018.060625

Erlangga, S. Y., Jumadi, Nadhiroh, N., & Wingsih, P. H. (2021). The Effective of Using Worksheet with the Problem-Based Learning (PBL) Through Google Classrooms to Improve Critical Thinking Skills During the Covid-19 Pandemic. *Proceedings of the 6th International Seminar on Science Education (ISSE 2020)*, *541*(Isse 2020), 427–433. https://doi.org/10.2991/assehr.k.210326.061

Farhan, M., & Arisona, R. D. (2022). Problem Based Learning (PBL) Berorientasi Higher Order Thinking Skills (HOTS) Untuk Meningkatkan Hasil Belajar IPS. *PAKIS (Publikasi Berkala Pendidikan Ilmu Sosial)*, *2*(2). https://doi.org/10.20527/pakis.v2i2.5861

Fitriani, A., Zubaidah, S., Susilo, H., & Al Muhdhar, M. H. I. (2020). Model PBLPOE: A Learning Model to Enhance Students' Critical Thinking Skills and Scientific Attitudes. In *International Journal of Instruction* (Vol. 13, Issue 2). https://doi.org/10.29333/iji.2020.1327a

Habibi, G. A., Kurniawan, A., & Kom, S. (2013). *Pengembangan Media Pembelajaran Berbasis Web untuk Mengoptimalkan Hasil Belajar Siswa pada Mata Pelajaran Fisika Materi Keseimbangan Benda Tegar Kelas XI SMA Antartika Sidoarjo*.

Hilal, T. A., Hilal, A. A., & Hilal, H. A. (2022). Social Networking Applications: A Comparative Analysis for a Collaborative Learning through Google Classroom and Zoom. *Procedia Computer Science*, *210*(C), 61–69. https://doi.org/10.1016/j.procs.2022.10.120

Iriani, T., Saleh, R., & Masdayaroh. (2022). Assessment of E-Procurement Subjects' Missteps for Construction and Consultancy Services Throughout The Surabaya City Area as An Educational Adjunct for Project Tender Courses. *Jurnal PenSil*, *11*(1), 1–9. https://doi.org/10.21009/jpensil.v11i1.25294

Kemendikbudristek. (2017). *Panduan Praktis Penyusunan E-Modul Tahun 2017*. https://awan965.wordpress.com/wp-content/uploads/2017/09/panduan_penyusunan-e-modul-2017_final_edit.pdf

Kemendikbudristek. (2022). *Dimensi, Elemen, dan Subelemen Profil Pelajar Pancasila pada Kurikulum Merdeka*. badan standar kurikulum dan asesmen pendidikan pusat perbukuan.

Kusumaningtyas, S. I. (2022). Penggunaan Google Sites dan Video Pembelajaran Selama Pandemi Covid-19 Pada Materi Dimensi Tiga. *SCIENCE : Jurnal Inovasi Pendidikan Matematika Dan IPA*, *2*(1), 1–9. https://doi.org/10.51878/science.v2i1.914

Lee, W. W., & Owens, D. L. (2004). *Multimedia-based Instructional Design: Computer-based Training, Web-based Training, Distance Broadcast Training, Performance-based Solutions*. pfeiffer. https://books.google.co.id/books?hl=en&lr=&id=QXl4ZtUug6YC&oi=fnd&pg=PR9&dq=Lee,+William+W.,+dan+Diana+L.+Owens.+2004.+Multimedia-Based+Instructional+Design.+San+Fransisco:+Pfeiffer.&ots=RWuZjwcOxL&sig=OK_SyAgxLaNLM4wClBj9jXa5kLM&redir_esc=y#v=onepage&q&f

Lestari, S., & Marhamah, M. (2022). Pemanfaatan aplikasi Google Classroom sebagai alternatif dalam pembelajaran online. *Jurnal Pembangunan Pendidikan: Fondasi Dan Aplikasi*, *9*(2), 146–154. https://doi.org/10.21831/jppfa.v9i2.37057

Nasrullah, A., Fitriani, N., Maimunah, S., Nindia Maretha Haris Tanti, S., Raya Telang, J., Telang Indah, P., Kamal, K., Bangkalan, K., & Timur, J. (2025). PT. Media Akademik Publisher Penerapan Edukasi Suistanable Development Goals (Sdgs) dalam Meningkatkan Kualitas Pendidikan Peserta Didik SDN Ba'engas 1. *JMA)*, *3*(1), 3031–5220. https://doi.org/10.62281

Nurfadhillah, S., Ningsih, D. A., Ramadhania, P. R., & Sifa, U. N. (2021). Peranan Media Pembelajaran dalam Meningkatkan Minat Belajar Siswa SD Negeri Kohod III. *PENSA : Jurnal Pendidikan Dan Ilmu Sosial*, *3*(2), 243–255. https://doi.org/10.36088/pensa.v3i2.1338

Pranyoto, Y. H., & Geli, S. (2020). Pengaruh Penggunaan Media Sosial Sebagai Media Pembelajaran Terhadap Hasil Belajar Kognitif Mahasiswa Sekolah Tinggi Katolik Santo Yakobus Merauke. *Jurnal Masalah Pastoral*, *8*(1), 30–45. https://doi.org/10.60011/jumpa.v8i1.99

Rahayuningsih, F. (2022). Internalisasi Filosofi Pendidikan Ki Hajar Dewantara dalam Mewujudkan Profil Pelajar Pancasila. *SOCIAL : Jurnal Inovasi Pendidikan IPS*, *1*(3), 177–187. https://doi.org/10.51878/social.v1i3.925

Rahmadayanti, D., Zaini, M., & Kaspul. (2022). Keterampilan Berpikir Kritis dan Hasil Belajar Kognitif: Pembelajaran Sistem Peredaran Darah Menggunakan LKPD-Elektronik. *Practice of The Science of Teaching Journal: Jurnal Praktisi Pendidikan*, *1*(2), 65–77. https://doi.org/10.58362/hafecspost.v1i2.20

Rahmawati, I. (2022). Pengaruh Penggunaan Model Pembelajaran Abad 21 Terhadap Kemampuan Kognitif Peserta Didik Sekolah Dasar. *EDUSAINTEK: Jurnal Pendidikan, Sains Dan Teknologi*, *9*(2), 404–418. https://doi.org/10.47668/edusaintek.v9i2.461

Raturoma, T. L. R., & Laisnima, L. (2023). Hubungan Keterampilan Berpikir Kritis dengan Hasil Belajar Kognitif Peserta Didik Pada Materi Bentuk Molekul Kelas X Di SMA Kristen YABT Manokwari. *Arfak Chem: Chemistry Education Journal*, *6*(1), 487–494. https://doi.org/10.30862/accej.v6i1.441

Rikmasari, R., Sundari, K., & Nuraini, H. (2022). Model Pembelajaran Predict Observe Explain (POE) Terhadap Hasil Belajar IPA Siswa Sekolah Dasar. *Jurnal Cakrawala Pendas*, *8*(4). https://doi.org/10.31949/jcp.v8i2.3187

Rizkianti, N., & Mustika, D. (2022). *Pemanfaatan Fitur Google Classroom Sebagai Platform Pembelajaran Di Sekolah Dasar* (Vol. 4). https://doi.org/10.31004/jpdk.v4i2.4054

Rosmana, P. S., Iskandar, S., Fauziah, H., Azzifah, N., & Khamelia, W. (2022). Kebebasan dalam Kurikulum Prototype. *AS-SABIQUN*, *4*(1), 115–131. https://doi.org/10.36088/assabiqun.v4i1.1683

Rostyanta, R. I., Sutiadiningsih, A., Bahar, A., & Miranti, M. G. (2020). Pengaruh Pembelajaran Dengan Google Classroom Diintegrasikan Video Interaktif Terhadap Keterampilan Berfikir Kritis Dan Bertanggung Jawab. *Jurnal Tata Boga*, *9*(1), 142–153. http://dx.doi.org/10.29407/e.v8i2.16306

Şenel, E., & Adilogullari, I. (2015). *THE RELATIONSHIP BETWEEN ATTITUDES TOWARD PROBLEM-BASED LEARNING AND MOTIVATED STRATEGIES FOR LEARNING: A STUDY IN SCHOOL OF PHYSICAL EDUCATION AND SPORT*. https://www.researchgate.net/publication/274255531

Simarmata, L. S. J., Purba, N. A., & Sihombing, L. N. (2022). Jurnal Pendidikan dan Konseling. *Jurnal Pendidikan Dan Konseling*, *4*(6), 8. https://doi.org/https://doi.org/10.31004/jpdk.v4i6.9263

Tareze, M. A. H., Astuti, I., & Afandi. (2022). Model Pembelajaran Kolaborasi SDGs dalam Pendidikan Formal Sebagai Pengenalan Isu Global Untuk Meningkatkan Kesadaran Sosial Peserta Didik. *Visipena*, *13*(1), 42–53. https://doi.org/10.46244/visipena.v13i1.1978

Vioreza, N., Hilyati, W., & Lasminingsih, M. (2023). Education for Sustainable Development: Bagaimana Urgensi dan Peluang Penerapannya pada Kurikulum Merdeka? *PUSAKA: Journal of Educational Review*, *1*(1), 34–48. https://doi.org/10.56773/pjer.v1i1.11

Wahyuni, D., Sudarisman, S., & Sugiyarto, D. (2015). *Efektivitas Implementasi Pembelajaran Model Problem Based Learning (PBL) Diintegrasikan Dengan Predict ± Observe ± Explain (POE) Terhadap Prestasi Belajar Siswa Ditinjau dari Kreativitas Dan Kemampuan Inferensi Siswa* (Vol. 4, Issue I). https://doi.org/10.20961/inkuiri.v4i1.9544

Waridah, W., & Selvia, A. (2024). Implementasi Profil Pelajar Pancasila Dimensi Bernalar Kritis dalam Proses Pembelajaran di SDN 02 Boli Pintas. *Indonesian Research Journal on Education*, *4*(3), 1167–1172. https://doi.org/10.31004/irje.v4i3.999

Zakaria, & Ningsih, S. M. (2024). Science Learning Using A Flipped Blended Learning Model Based on The Google Classroom (Lms) Learning Management System. *Didaktika : Jurnal Kependidikan*, *18*(2). https://doi.org/10.30863/didaktika.v18i1.5707