JPBIO (Jurnal Pendidikan Biologi)
Vol. 10, No. 1, April 2025, 35 – 49 //e-ISSN 2540-802X
http://jurnal.stkippersada.ac.id/jurnal/index.php/JBIO/index

ROCED: Robot card biology education as a media for biology learning

Check for updates

Solihin *, Adelia Siti Nur Apriliani, An Nabila Nur Jannah

Biology Education Study Program, Faculty of Tarbiyah and Teacher Training, Universitas Islam Negeri Syarif Hidayatullah Jakarta, Indonesia

* Corresponding author: solihin@uinjkt.ac.id

Article Info

Article History:
Received 12 December 2024
Revised 19 February 2025
Accepted 18 April 2025
Published 30 April 2025

Keywords:
Development of Media, ROCED Robotict, Biology Education

ABSTRACT

The use of innovative and interactive learning media, such as robotics, is essential to increase learning achievement in Biology subjects. This study aims to develop ROCED robotic learning media in biology subjects. The method used is R&D. However, this study is limited to the development stage. This study involved four candidates, consisting of 2 biology teachers, 1 material expert, and 1 informatics expert. A total of 14 vocational high school students were involved in providing responses related to the use of ROCED media. Qualitative data were collected through questionnaire interviews and documentation studies. Quantitative data were analyzed using a validity test. The results of the study showed that the ROCED robotic learning media were feasible to use in the biology learning process. In terms of material, it had a score of 85%, in terms of language, it had a score of 86.6%, the robot design had a score of 88.3%, and in terms of durability, it was 86%. The results of the media feasibility test showed a score between 80% and 93.33%, which indicates that this media is practical to use to support interactive learning and is liked by students.

Citation: Solihin, Apriliani, A.S.N., & Jannah, A.N.N. (2025). ROCED: Robot card biology education as a media for biology learning. *JPBIO (Jurnal Pendidikan Biologi), 10*(1), 35-49. DOI: https://doi.org/10.31932/jpbio.v10i1.4227

INTRODUCTION

Learning media is widely discussed and recommended in the learning process (Surata, 2020). Various media types are created and even integrated between one media and another to create meaningful learning. Media development is based on how the interaction between teachers and students builds knowledge both in the classroom and in the environment (Hafzah et al., 2020). Constructivism theory explains that learning is a process of someone constructing knowledge based on experience, previous knowledge, and interaction between students and the environment (Hafzah et al., 2020). Several studies in the world of education assume that the latest media development today is technology-based (Jalil, 2018). Technology gives an instant impression to teachers in doing anything, including making learning media.

Various social media can be used as learning media. However, talking about the progress of technology-based media seems to give the impression that teaching aids and manual media seem old and backward (Leotman et al., 2017). This idea becomes taboo when we have to see schools with facilities that do not support the advancement of technology (Bara et al., 2021). The author tries to develop media in schools that are inadequate in facilities. Tripblock learning media was created 9 years from 2014 by looking at the local wisdom values of the local community. During the 9 years, several Tripblock media were produced, including KAPOLDA, DT (Diamond Touch), CARCO (Card Ecology), and others. Tripblock Media has its strategy in the learning process (Karnadi et al., 2021b). Tripblock media has a design and is integrated with its syntax in the learning process. The innovation in this study is the development of one type of tripblock media, namely CARCO media, into ROCED media. CARCO (Card Ecology) is one of the tripblock learning media, which has so far made a positive contribution to biology learning by presenting ecological concepts in the form of interactive boxes and cards. To increase the effectiveness and attractiveness of this media, further development is directed at changing CARCO into a robot-based media called ROCED. The use of robot media in learning has been widely recommended. Belpaeme et al. (2018) in his research explained that learning media always develops from time to time.

Learning using robots can improve students' understanding of certain concepts, according to Surya et al. (2023). Lego robot training at SMP Bani Hasyim Malang Regency succeeded in increasing students' interest and understanding of technology and robotics, with 80% of participants interested in studying further. According to (Murti & Handayani, (2022), explained that developing educational game media "Robot Petualang Nusantara" can improve students' cultural literacy. This research focuses on the development of innovative learning media that are appropriate to the conditions of schools with low facilities, to increase student motivation and understanding of learning Biology. The media developed is ROCED, an interactive robot designed to support the teaching of ecological concepts. The main innovation in this study is the transformation of CARCO (Card Ecology) media into ROCED (interactive-based robot), which: 1) provides a multisensory learning experience. 2) Increases student engagement through robotic interaction. 3) Adapting learning materials according to the needs and conditions of students in a limited school environment. The development of ROCED learning media is needed because most of the Biology learning process, especially in ecology material, is still one-way and does not actively involve students. ROCED media is designed to answer the need for interactive, adaptive, and interesting learning media, which can increase student motivation and involvement in understanding abstract concepts. ROCED is also a form of innovation from CARCO media, which has been used previously but has been developed into a robotic platform to provide a multisensory and more contextual learning experience.

Facts in the field show that teachers tend to use the lecture method in delivering material, and only a few make maximum use of learning media(Report et al., 2021). Based on interviews, 6 out of 10 students stated that teachers often only use textbooks and material summaries. Digital media, such as learning videos, are sometimes used, but high-tech media such as robotics have never been used at all in Biology learning(Damayanti et al., 2024).

The learning process so far has been considered less interesting and has not provided a pleasant learning experience. As many as 3 out of 10 students stated that the learning that took place felt ineffective, and one even said that ecology material had never been taught in a fun way. The learning approach used is still centered on the teacher, so it does not provide enough space for interaction and exploration for students.

Most students feel less motivated to participate in Biology learning. As many as 9 out of 10 students said that learning felt uninteresting. When asked about the possibility of using robotic media, all students (100%) expressed interest and considered that the media would help them understand the material better in a fun way, and be relevant to their needs as a digital generation. Previous studies have shown that the use of analog media, such as teaching aids or homemade media, has a positive impact on student learning outcomes. Students who learn using media are more active, motivated, and show a better understanding of concepts than students who only receive material conventionally. Thus, the development of ROCED media is expected to increase student learning output more significantly, both in terms of cognitive and affective aspects. This research tries to see the development of innovative learning media, showing the importance of adjusting media to real conditions in the field to improve the quality of education.

RESEARCH METHODS

Research Design

This research method is a type of development research that aims to create product innovation to support the learning process (Yoga et al., 2021). Aiming to create a specific product, a needs analysis is needed, and to test its effectiveness, the product is tested on teachers and students at school. The product produced in this study is the ROCED robot. The development stage of the ROCED robot follows the stages of the 4-D development model (Four-D Model) developed by S. Thiagarajan, Dorothy S. Semmel, and Melvyn I. Semmel. 4D development consists of four main stages, namely define, design, develop, and disseminate. This study is limited to the development stage. Researchers are limited by time, funds, and scope. So that the research is more focused first on making the robot and the feasibility of the robot's media.

Population and Samples

The ROCED media development research, the media was validated by 4 validators. Two of them were teachers in the field. One person was a material expert and one person was an informatics expert. Then there were 14 vocational high school students in collecting response data related to the use of the media. In the development research until the development stage, only limited validators and respondents were needed.

Instruments

The research instrument consists of two instruments used, namely a questionnaire on the feasibility of Rosyid media and respondents to students related to the Rosid media. The instrument related to the feasibility of the media consists of 4 aspects, namely the feasibility of the content of the language material, form, and durability. Each aspect is given a leaf with three statements so that it consists of 12 statement instruments. The instrument related to the response to the practicality of the ROCED robot media consists of three aspects, namely the practicality of the robot's form and design. How are the three aspects broken down into three statements in each aspect? The instrument was distributed in the form of a questionnaire to 14 students of Alqudsiyah Islamic Vocational School, Sukabumi Regency.

Procedures

The details of the stages of ROCED media development are explained as follows: 1) The initial stage in the 4D model involves defining a development requirement, which is a needs analysis. This is a key step in product development, where developers must understand the requirements involved, analyze them, and gather information about how deep development needs to be done. This step aims to identify problems and needs in the learning process and find alternative solutions as a starting point for developing robotic media. 2) The design stage is carried out by creating ROCED, which begins with collecting ecological material references, compiling content, and designing an ROCED framework that shows the stages of using ROCED robot media. 3) The ROCED robot that has been created is then improved to the ROCED robot design based on input from validators who are material and media experts. The aim is to assess the feasibility of the ROCED that has been developed. Opinions and suggestions from validators are used as guidelines for improving the ROCED robot in the learning process. After the product is validated, improvements are made until it is ready for initial testing. Initial testing was carried out on 14 students at the Alqudsyiah Islamic Vocational School in Sukabumi Regency.

Data Analysis

Data collection for qualitative analysis was carried out by interviewing biology teachers, distributing student questionnaires, and studying documents and literature. The quantitative data analysis method is Validity Test Analysis. Data validity was obtained from the analysis of the validity questionnaire filled out by the material expert validator and the media expert validator. Meanwhile, the initial trial response data were obtained through the analysis of the response questionnaire filled out by the biology teacher and students. Both the validation sheet and the response questionnaire filled out by the validator and teacher used a Likert scale with five answer choices that corresponded to the content of the question. To calculate the level of validity, the following formula is used:

$$P = \sum x \sum i \times 100\%$$

Description:
P = Percentage
$\sum x$ = Number of responses from selected items
$\sum i$ = Ideal number in items (maximum score)

If the validity percentage exceeds 61%, then the development product is considered valid and worthy of being tested. Practicality data was obtained through analysis of teacher questionnaire responses that had been filled out by biology teachers and students. The quantitative data collected were then analyzed to determine the practicality criteria of the ROCED media. Biology teachers responded to the questionnaire using a Likert scale with five answer choices. The formula used to calculate the level of practicality is as follows:

$$NP = R/M \times 100\%$$

Description:
NP = Percentage Value
R = Total score obtained
M = Maximum score

If the validity percentage exceeds 61%, then the development product is considered valid and worthy of being tested.

Table 1. Score Interpretation Criteria

Score Range	Category
0–20%	Very Inappropriate
21–40%	Inappropriate
41–60%	Fairly Appropriate
61–80%	Appropriate
81–100%	Very Appropriate

(Adapted from Andriyani et al.).

RESULTS

This research is intended to develop the product development process of ROCED Media development by describing each stage of the device development method using the 4D development model with modifications consisting of three stages, namely definition, design, and development.

Stage 1. Definition

At this stage, it is carried out by evaluating learning problems based on the reality in the field by the applicable curriculum. The researcher reviews several journals in terms of media development, from analog to robotic media development.

Table 1. The Supporting Research Data

No	Title Author	Year	Suggestion
1	Effectiveness of Using Clock Media in Learning to Recognize Time for Class II Students of SDN Banyuajuh 02, Siti Aisyah.	2023	Analog learning media such as clocks, make it easier to understand the material, increase students' interest in learning, and provide support for teachers in explaining material that was previously abstract to be more concrete..
2	Analysis of Students' Scientific Reasoning in the Use of Analog Media for the Urine Formation Process, Lesy Luzyawati, Devitia Hamsyah, and Lian Novita Dewi	2020	There needs to be a habit of learning using analog media so that students' scientific reasoning skills are trained. Scientific reasoning skills in the 21st century can help students in their daily lives or act as young researchers.
3	Effectiveness of Using Media Teaching Aids on the Level of Students' Understanding of the Excretory System Material at SMA Negeri 1 Watopute, Munawar, Jumarddin La Fua, Abdul Kadir, and Halmuniati.	2020	The use of media teaching aids in the learning process can attract students' attention and make students motivated and actively involved in the learning process, easier to remember, tell and understand the material concretely and students can master the material so as to get better learning outcomes
4	Exploration of Indramayu Local Waste as Raw Material for Analog Media Teaching Aids and Its Effectiveness on Biology Learning Outcomes, Nur Subkhi, Anilia Ratnasari, Idah Hamidah	2020	Based on the results of the study, it can be concluded that Exploration of Indramayu Local Waste as Raw Material for Analog Media Teaching Aids is effective on Biology learning outcomes in learning the circulatory system.
5	Ecopreneurship-Based Biology Learning Media, Fajar Adinugraha	2017	For educators (teachers), the activity of making learning media from used goods can be used as an alternative for the ecopreneurship learning model.

Based on table 1. There are several studies related to analog media from 2017 - 2023 with a research focus on analog media. The data proves that the focus of research in analog media is science and techniques in the learning process involving analog media are still relevant to current conditions. The development of analog media needs to be done because it can provide motivation and its own experience in the learning process. According to it can be trained with the process of making analog media. Based on the suggestions of the five researchers, it is necessary to develop analog media into high-tech media such as robotics.

Table 2. Recapitulation of student interviews

Indicators	Interview Result
Implementation of learning	6 respondents stated that in the learning process often use the lecture method, 3 respondents stated that the learning process is less effective, 1 respondent stated that there has been no learning process on the ecology material that is fun.
Teaching materials used	6 responden dri 10 peserta didik menyatakan bahwa penggunaan bahan ajar seperti buku paket dan rangkuman materi sering dilakukan Dua responden lain menyatakan bahwa bahan ajar yang digunakan dalam proses pembelajaran jarang berbentuk digital atau robotik. Dua responden lainnya menyatakan selalu diarahkan pada YouTube atau video tertentu
Media used	5 respondents out of 10 students stated that the media often used in the learning process are tools such as printed or digital books. Two of them stated that sometimes in the learning process they only give lectures. And three respondents explained that the media used are sometimes from LKPD.
Student motivation in studying learning materials	9 respondents out of 10 students stated that the learning process was less enjoyable and less interesting, and 1 person stated that it was boring.
Student responses regarding the development of robotic media	Of the 10 respondents, 100% stated that there was a relationship in the development of robotic media used in the biology learning process.

Table 2. is the result of interviews conducted with 10 students, various views were found regarding the implementation of learning, teaching materials, media used, learning motivation, and responses to the development of robotic media. This reflects the real conditions of the biology learning process in the classroom, especially in the ecology material which is the focus of this study. In terms of learning implementation, 6 responses were stating that the lecture method is still often used by teachers in teaching. This shows that the learning approach that tends to be one-way is still dominant. In addition, three respondents felt that the learning process was less effective, while one respondent considered that learning in the ecology material was not yet enjoyable. This shows the need for an invasion of learning methods to be interactive and interesting to increase the effectiveness of learning. In terms of teaching materials, 6 out of 10 respondents stated that teaching materials such as textbooks and material summaries are materials that are often used in the learning process. This identifies that conventional teaching materials are still the main choice. However, 2 other respondents stated that the materials were rarely in the form of digital or robotic media, while 2 other respondents stated that the media was often directed to learning through videos or YouTube. This fact shows that there are efforts to utilize technology even though it has not been optimally integrated into teaching materials. In terms of learning media, 5 out of 10 respondents stated that the media often used were tools such as printed or digital books. 2 respondents stated that learning often only used lecture methods without adequate supporting media, 3 other respondents explained that the media used were sometimes in the form of student

worksheets or LKPD. This shows that the variation of learning media is still limited by the dominating traditional media, which tends to be less interesting for students. Student motivation in learning learning materials is an important concern. 9 respondents stated that the learning process was less enjoyable and interesting. Even one respondent explicitly stated that learning was like a boring activity. This data highlights the need to develop methods and media that can increase the appeal and motivation of students in learning, especially in ecological material which is often considered abstract. 100% of the responses stated their support for the use of robotic media in biology learning, this shows that students have a great interest in technology-based media innovations which are believed to be able to make learning more interesting and relevant to their needs. Robotic media is considered capable of providing a more effective learning experience so that it can answer the challenge of low learning motivation. From these findings, it can be concluded that the learning process dominated by lecture methods and traditional media has not been able to meet student needs optimally. This shows enthusiasm for the development of technology-based learning media, especially robotics as an alternative that can create a more enjoyable learning experience. This support shows great potential for integrating robotic media in biology learning, especially in ecology materials, to increase learning effectiveness.

Stage 2. Desaign

At this stage, the researcher begins to compile the concept of discourse and tasks that have been designed into the form of ecological cards, the selection of concepts written on the ecological cards based on the specifications of the instructional objectives that have been set at the definition stage. Researchers who will be included in the ecological card. In addition, researchers make other new ecological cards or certain instructions that require students to carry out the instructions.

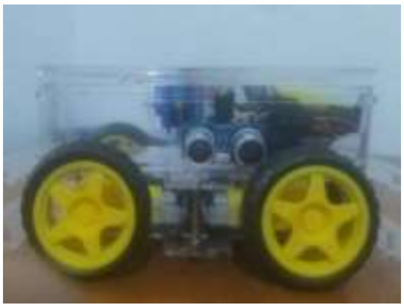
In selecting media, choosing based on the results of the previous needs analysis, concept analysis, learning media analysis, and the results of the literature that has been done previously. It is a robotic media called ROCED, which is the result of the development of CARCO media or what is called Card Ecology. The development of ROCED media includes:

1. The box in CARCO is changed into a box that can open and close automatically.
2. The box moves with the mobilization towards students using a remote control and an Arduino smart car.

This stage is based on previous activities, which include the preparation of ecological cards, game cards, or certain instructions that must be carried out by students. Furthermore, researchers look for learning media that can support the ecological card box to move to face students and open and close automatically. In this block diagram design plan before carrying out the design, several systems need to be completed, including hardware systems and software systems.

Table 3. ROCED Robot Developed

No	Ficture	Information
1		Figure 1. Appearance of opening and closing the CARCO ROCED box cover. Opening time is 10 seconds.

2		Figure 2. Shows the cover making 100 degrees.
3		Figure 3. Shows the box cover
4		Figure 4. This is a front view of the proximity sensor.
5		Figure 5. This is a front view of the proximity sensor with the closest distance being 2 meters.
6		Figure 6. This is a front view of ROCED media.

7		Figure 7. This is a top view of the ROCED media.
8		Figure 8. This is the appearance of the ROCED media with the box opened.

Stage 3. Development

The development stage is carried out after the design of the objectives produces a product that is developed based on suggestions and input from the validator. Validation is carried out by expert validators consisting of 2 material experts and 2 learning media experts. Then the ROCED media is used by several students at SMK Al Qudsiyah to obtain responsive data about the ROCED media.

Tabel 4. ROCED Media Feasibility Analysis Results

No	Indicators	Quality ROCED% Validator				Average	Criteria
		1	2	3	4		
1	Feasibility of material content	93,3	80	80	86,7	85	Very worthy
2	Language	93,3	80	80	93,3	86,6	Very worthy
3	Robot shape	86,7	86,7	86,7	93,3	88.3	Very worthy
4	Known	80	86,7	86,7	93,3	86,6	Very worthy

Table 4. shows the results of the media quality assessment of 4 variables which state that this learning media has very feasible criteria for all indicators assessed, namely the feasibility of the content of the material, language, robot form, and robot durability. The indicator of the feasibility of the robot material content obtained an average score of 85%, this indicates that the material presented is relevant to support learning objectives. In terms of language, the average value obtained was 86.6%, this reflects the use of language that is appropriate to the level of student education, easy to understand, and effective in conveying information on the media. In terms of the form of the robot learning media, it is considered very feasible with an average score of 88.3%, this indicates that the physical design is attractive, and ergonomic and supports educational functions and interactions in learning. As for the durability aspect, it obtained an average score of 86.6%, this indicates that the robot learning media has a sturdy structure and is resistant to repeated use so that it can be used sustainably in various learning conditions.

Table 5. Validator Input Results

No	Before Revision	After Revision
1	Figure 1. Appearance of opening and closing the CARCO ROCED box cover. Opening time For 10 seconds.	Figure 1. Appearance of opening and closing the CARCO ROCED box cover. Opening time For 2 minutes.
2	Figure 2. Shows the cover opening 100 degrees.	Figure 2. Shows the cover opening 180 degrees.
3	Figure 3. Shows the box cover	Figure 3. Shows the box cover no changes
4	Figure 4. This is a view of the front of the proximity sensor.	Figure 4. This is a view of the position where the battery must be glued so that it does not move.
5	Figure 5. This is a front view of the proximity sensor with the closest distance of 2 meters.	Figure 5. This is a front view of the proximity sensor with the closest distance of 1-25 cm.
6	Figure 6. This is the front view of ROCED media.	Figure 6. This is the front view of ROCED media. There are no changes.
7	Figure 7. This is the top view of the ROCED media.	Figure 7. This is the top view of the ROCED media, there are no changes.
8	Figure 8. This is the appearance of the ROCED media with the box opened.	Figure 8. This is the appearance of the ROCED media with the box opened, there are no changes.

Table 5. shows a comparison before and after the revision of the robot learning media design to improve its functionality and efficiency of use. One of the main revisions is seen in the opening and closing mechanism of the media box cover, previously the opening time only lasted for 10 seconds, but after the revision, the opening time was extended to 2 minutes to provide more flexibility when used, in addition, the opening angle of the cover was also increased from 100 degrees to 180 degrees to provide wider and more comfortable access for students in taking the ecology card, other revisions were made to the proximity sensor display previously the sensor was only able to detect the closest distance up to 2 meters but now it has been refined to open and close the distance between 1 - 25 cm which increases the sensitivity and precision of the sensor. Additional changes were also made to the position of the battery so that it does not move when using the battery in place to ensure the stability of the device. Meanwhile, several other elements such as the front view of the city with the opening of the brain have not changed from the initial design. The revisions made as a whole aim to improve the reliability and ease of use of the media in supporting the technology-based interactive learning process.

Table 6. Shows the results of the study of the quality of robot learning media based on aspects of robot practicality and design. Shows that this media is included in the very feasible category with an average overall score and a range of 80.33%. This practicality gets a high score from most students indicating that the media is easy to use and supports learning activities. In terms of the robot shape, students gave a positive assessment with an average value of 93.33% in several respondents indicating that the design is attractive and ergonomic. The design aspect also gets high aspirations with a maximum value reaching 93.33%, this indicates that the ROCED display is designed professionally and supports the educational goals of the highest overall average value.

Table 6. Student Response in Using ROCED Media

No	Student Name	Quality ROCED%			Average	Criteria
		Practicality	Robot Shape	Design		
1	X1	93,33	93,33	86,67	91,11	Very worthy
2	X2	80,00	80,00	86,67	82,22	Very worthy
3	X3	80,00	93,33	86,67	86,67	Very worthy
4	X4	93,33	80,00	86,67	86,67	Very worthy
5	X5	80,00	93,33	86,67	86,67	Very worthy
6	X6	80,00	93,33	93,33	88,89	Very worthy
7	X7	93,33	80,00	80,00	84,44	Very worthy
8	X8	80,00	80,00	93,33	84,44	Very worthy
9	X9	80,00	93,33	93,33	88,89	Very worthy
10	X10	93,33	80,00	80,00	84,44	Very worthy
11	X11	93,33	93,33	93,33	93,33	Very worthy
12	X12	80,00	80,00	93,33	84,44	Very worthy
13	X13	80,00	80,00	80,00	80,00	Very worthy
14	X14	86,67	93,33	80,00	86,67	Very worthy

DISCUSSION

The results of the study in Tables 4, 5, and 6 show that the robot-based learning media used in the study have very decent quality based on assessments from various aspects. This assessment includes the feasibility of the content of the language material, the form of the robot, and the durability of the robot, each of which contributes to education towards the effectiveness of learning media in supporting the learning process. The score of the feasibility of the content of the material of around 85% shows that the material presented through this robot media is very relevant to the learning objectives, this is in line with the theory of learning media which emphasizes the importance of the relevance of the content of the material that supports the achievement of learning objectives. This relevance ensures that students can gain knowledge that is related to curriculum needs and is related to the real world (Rayungsari, 2024). In terms of language, it has an average score of 86.6%, this shows the suitability of this media with the principle of linguistic rhythm conveyed by Chen et al., (2011) which states that language and learning media must be simplified, clear, and by the level of student understanding to maximize information absorption. In terms of robot design, it has a score of 88.3%, indicating that ROCED is designed attractively, and ergonomically and supports educational functions. According to (Belpaeme et al., (2018) media design theory ergonomic and attractive design elements can improve their experience and motivate students to be actively involved in learning.

Meanwhile, in terms of media durability, it has an average score of 86%, indicating that the structure and durability ensure that this media can be used in various learning conditions, this is by research conducted by Anwar & Bascou, (2019) which states that durable media in its use has a greater chance of being applied directly.

In Table 5, the revisions made to the rebate design show increased functionality and efficiency. The revision extends the opening time of the media box cover from 10 seconds to 2 minutes, providing better flexibility, this is by research by Murti & Handayani, (2022) which explains that learning media must be easy to use and flexible according to needs. In addition, revisions were also made to the opening and closing of the media from 1000 to 1800, this change increases accessibility for students by allowing them to take the ecology card comfortably, according to the theory of Educational ergonomics, a design that considers the user comfort can increase the efficiency and effectiveness of interaction according to the media. In addition, changes in the sensor at a distance become more sensitive from 2 m detection to 1-25 cm, increasing the media process in detecting objects, this supports the principle of learning technology by Asri, (2018)which states that the integration of appropriate sensory technology can enrich students' learning experiences.

Table 6 shows a high level of practicality with an overall average score between 80% and 93.33%. The practicality of this media makes it easy to use ergonomic designs and the media's ability to support interactive learning activities. The practicality aspect of learning media is one of the important evaluation criteria in practical learning. This encourages students to be more active and explore democracy independently. The majority of students gave a positive assessment of the product design aspect with a maximum score of 93.33% indicating that professional design and communication goals make an aesthetic residence in learning. Educational robots have become an increasingly popular topic in recent years, with various studies exploring their impact on student learning outcomes. These robots are used in various educational contexts to increase student engagement, motivation, and academic achievement. Social robots in education are effective in improving students' cognitive and affective outcomes, with results comparable to human guidance in certain tasks. The physical presence of robots provides advantages that traditional learning technologies do not have. Educational robots are effective in improving computational thinking skills and attitudes toward STEM (Science, Technology, Engineering, and Mathematics) in K-12 students. The use of robot-based learning systems can increase student motivation and engagement in learning activities. Students who use these systems show higher learning performance and motivation compared to PowerPoint-based learning systems. Robots are often used in language learning applications and are preferred because of their ability to physically interact with students. This interaction includes informational and emotional support that can improve cognitive learning outcomes such as thinking, creativity, and self-regulation skills.

ROCED learning media is suitable for use in Biology learning, especially in ecology material. The high validation value shows that ROCED meets the eligibility standards for learning media according to the criteria set by Kurnia AR, (2023)namely valid, practical, and effective. In additi on, these aspects are also by the theory of learning media according to Chen et al., (2011) which emphasizes that media must present relevant, communicative, and visually appealing content to facilitate the learning process optimally. In terms of material content, ROCED has been designed to convey ecological concepts contextually and visually. This is very important considering that ecology material is often considered abstract by students. This media visualizes the material through interactive cards and commands controlled by robots so that students can build understanding through direct experience. This is in line with Bruner's theory (1966) which states that students learn better through the stages of enactive representation (direct experience), iconic (pictures), and symbolic (words/concepts)(Karnadi et al., 2021a). Experience-based learning is also at the core of Piaget's constructivism theory, where knowledge is actively formed by students through interaction with the environment and real objects(Sasmita et al., 2021).

The linguistic aspect is also not overlooked. The use of language in ROCED is considered right on target, by the level of student ability, easy to understand, and does not cause ambiguity. This is by the principle of simplifying language in learning media put forward by (Yatimah et al., 2018)that language in media must be able to convey information concisely and clearly so that students can focus on the essence of the material. The use of communicative language also increases the effectiveness of educational communication between media and students, especially in the context of vocational schools that have heterogeneous levels of language ability.

The interactive and ergonomic design of ROCED is also one of its main strengths. The robot design that can open and close automatically and move closer to students provides an interesting multisensory learning experience. This design refers to the principle of interactive educational media according to Belpaeme et al., (2018)which states that robotic media with motion and sound features can increase students' emotional involvement, making the learning process more personal and enjoyable. The physical appearance of ROCED which resembles a real aid also creates a more lively and contextual learning atmosphere.

In addition to design, the media's durability aspect scored high, namely 86.6%. This shows that ROCED is not only visually appealing but also structurally sturdy and ready to be used in various learning conditions. The physical durability of the media is important to ensure its continued use in the classroom, as stated by Mujtahid et al., (2021)durable media has significant long-term investment value for schools with limited resources. Student responses to the use of ROCED were also very positive. As many as 100% of students stated that they were interested and enjoyed learning with this robotic media. Student assessments of the practicality, design, and form of the media also showed an average value above 80%. These results are in line with a study by Chin et al., (2014) which found that robotic-based media can increase student motivation, engagement, and learning outcomes because they can present material actively and not monotonously. This finding is also supported by Febtriko, (2017) theory in the ARCS (Attention, Relevance, Confidence, Satisfaction) model, which states that learning motivation can be increased if the media can attract attention, is relevant to student's needs, and provides a pleasant experience.

Meanwhile, from the results of observations and interviews, it is known that the Biology learning process so far is still dominated by lecture methods and the use of conventional media. Most teachers only rely on textbooks, summaries, and sometimes YouTube videos. Interactive media, especially robotics-based media, has never been used. This is a serious concern because conventional methods have proven to be ineffective in fostering students' interest in learning. Gabriela, (2021) in her research stated that students who were taught with audiovisual media showed a significant increase in understanding the material compared to those who only used the lecture method.

The condition of students who experience boredom and disinterest in the learning process shows an urgent need for media innovation. ROCED is here as an answer to this need by presenting technology-based learning that is not only interesting but also strengthens students' learning experiences. The use of ROCED in schools with limited facilities also shows that media innovation does not always have to be expensive or sophisticated, but can be adapted to the local context as explained by (Febryan et al., 2020) about the importance of media that is adaptive to school conditions.

CONCLUSION

Based on the results of the research data analysis, it can be concluded that the ROCED Robot is suitable for use as a biology learning medium, especially in ecology material. ROCED media has been proven to be able to increase student motivation, this can be seen from the practicality value of ROCED media of more than 80% overall. ROCED media has the value of student attraction in the learning process.

ACKNOWLEDGMENT

The researcher would like to express his gratitude to all academic activities that have helped in completing this research, especially to the Puslitpen UIN Syarif Hidayatullah Jakarta, which has provided opportunities for researchers, both material and non-material support. May Allah replace all our good deeds with something better.

REFERENCES

Anwar, S., & Bascou, N. A. (2019). A Systematic Review of Studies on Educational Robotics. *Journal of Pre-College Engineering Education Research (J-PEER)*, *9*(2), 19–24.

Asri, Y. N. (2018). Pembelajaran Berbasis Stem Melalui Pelatihan Robotika. *WaPFi (Wahana Pendidikan Fisika)*, *3*(2), 74. Retrieved from https://doi.org/10.17509/wapfi.v3i2.13735

Bara, T. Wahyono, Rosyid, R., & Prasetyo, M. A. W. (2021). Robot Peraga 12 Gerakan Pengaturan Lalu Lintas Berbasis Arduino Mega 2560. *Technomedia Journal*, *5*(2 Februari), 193–205. Retrieved from https://doi.org/10.33050/tmj.v5i2.1459

Belpaeme, T., Kennedy, J., Ramachandran, A., Scassellati, B., & Tanaka, F. (2018). Social robots for education : A review Social robots for education : A review. *SCIENCE ROBOTICS | REVIEW And*, *3*(August), 1–9. Retrieved from https://doi.org/10.1126/scirobotics.aat5954

Chen, N., Quadir, B., & Teng, D. C. (2011). Integrating book , digital content and robot for enhancing elementary school students ' learning of English. *Australasian Journal of Educational Technology*, *27*(3), 546–561.

Chin, K. Y., Hong, Z. W., & Chen, Y. L. (2014). Impact of using an educational robot-based learning system on students' motivation in elementary education. *IEEE Transactions on Learning Technologies*, *7*(4), 333–345. Retrieved from https://doi.org/10.1109/TLT.2014.234675

Damayanti, A., Nur, U., & Dwi, A. (2024). Development of biology smart card learning media based on character education in immune system material. *BIO-INOVED : Jurnal Biologi-Inovasi Pendidikan*, *6*(2), 179–190.

Febryan, R., Euclerr, R. I., Wardaningsih, Y., & Masya, F. (2020). Web-Based Event Seminar Registration Information System Application. *Jurnal Riset Informatika*, *2*(3), 159–168. Retrieved from https://doi.org/10.34288/jri.v2i3.144

Febtriko, A. (2017). Pemakaian Mobile Robot Dalam Meningkatkan Perkembangan Kognitif Anak Usia Dini Di Taman Kanak-Kanak I . *Jurnal Teknologi Dan Sistem Informasi Univrab*, *2*(2), 2477–2062.

Gabriela, P. D. N. (2021). Pengaruh Media Pembelajaran Berbasis Audio Visual Terhadap Peningkatan Hasil Belajar Siswa Sekolah Dasar. *Jurnal Pendidikan Guru Sekolah Dasar, Vol. 2, no*(1), 104–113.

Hafzah, N., Amalia, K. P., Lestari, E., Annisa, N., Adiatmi, U., Saifuddin, M. F., No, J. K., Umbulharjo, K., & Yogyakarta, D. I. (2020). *Meta-Analisis Efektivitas Penggunaan Media Pembelajaran Digital Dalam Peningkatan Hasil dan Minat Belajar Biologi Peserta Didik di Era Revolusi Industri 4 . 0 (Meta-analysis Effectiveness of the use of Digital Learning Media in Increasing The Results and*. *6*, 541–549.

Jalil, A. (2018). Robot Operating System (Ros) Dan Gazebo Sebagai Media Pembelajaran Robot Interaktif. *ILKOM Jurnal Ilmiah*, *10*(3), 284–289. Retrieved from https://doi.org/10.33096/ilkom.v10i3.365.284-289

Karnadi, K., Sasmita, K., Badrudin, B., Palenewen, E., & Solihin, S. (2021a). Diamond Touch (DT) based on hyperactive game in applying the concept of life science in early childhood education Diamond Touch (DT) based on hyperactive game in applying the concept of life science in early childhood education. *Journal of Physics: Conference Series*, *1760*(012014), 1–5. Retrieved from https://doi.org/10.1088/1742-

6596/1760/1/012014

Kurnia AR, H. (2023). Pemanfaatan Sensor Ldr Pada Robot Light Follower Dengan Konsep Holonomic Sebagai Media Pembelajaran. *JATI (Jurnal Mahasiswa Teknik Informatika)*, *7*(1), 95–100. Retrieved from https://doi.org/10.36040/jati.v7i1.6061

Leotman, B. D., Syaka, D. R. B., & Priyono. (2017). Pengembangan Robot Edukasi Sebagai Media Pembelajaran Ekstrakurikuler Robotik Studi Kasus Smp Almuslim Bekasi. *Jurnal Pendidikan Teknik Dan Vokasional*, *2*(2), 32–41. Retrieved from https://doi.org/10.21009/JPTV.2.2.4

Mujtahid, I. M., Berlian, M., Vebrianto, R., & Thahir, M. (2021). Educational Props Development for Primary School and Early Childhood Education Teachers: Teachers Satisfaction Aspect. *International Journal of Elementary Education*, *5*(1), 89. Retrieved from https://doi.org/10.23887/ijee.v5i1.33237

Murti, I. G. W. P., & Handayani, D. A. P. (2022). Game Edukasi Robot Petualang Nusantara: Meningkatkan Literasi Budaya. *Jurnal Ilmiah Pendidikan Profesi Guru*, *5*(2), 403–414. Retrieved from https://doi.org/10.23887/jippg.v5i2.49598

Rayungsari, M. (2024). Analysis of the Need For the Application of Audiovisual Media in Facilitating Mathematics Learning in High School. *Al-Irsyad Journal of Education Science*, *3*(2), 2828–5468.

Report, C., Bravo, F. A., & Hurtado, J. A. (2021). Using Robots with Storytelling and Drama Activities in Science Education. *Education Sciences*, *11*(329), 1–16.

Sasmita, K., Palenewen, E., K Karnadi, S. S., & Badrudin, A. (2021). *What ' s App integrity in the life science concept during the covid-19 pandemic What ' s App integrity in the life science concept during the covid-19 pandemic*. Retrieved from https://doi.org/10.1088/1742-6596/1760/1/012028

Surata, I. K. (2020). *Meta-Analisis Media Pembelajaran pada Pembelajaran Biologi*. *4*, 22–27.

Surya, Y., Gumilang, A., Rozaq, A., Sonalitha, E., Rabi, A., Sumarahinsih, A., Aditya, M., & Fahreza, R. (2023). Pengenalan dan Pelatihan Robot Lego pada Siswa Sekolah Menegah Pertama Sebagai Implementasi Pembelajaran STEM di Sekolah. *International Journal of Community Service Learning*, *7*(2), 185–191.

Yatimah, D., Puspitaningrum, R., S, S., & Adman. (2018). Development of Instructional Media Environmental-based Child Blood Type Detector Cardboard (KAPODA) Formal and Informal Education Development of Instructional Media Environmental-based Child Blood Type Detector Cardboard (KAPODA) Formal and Informal E. *IOP Publishing*, *434*(012236), 1–6. Retrieved from https://doi.org/10.1088/1757-899X/434/1/012236

Yoga, P., Daningsih, E., & Marlina, R. (2021). Pengembangan Media Monopoli Untuk Pembelajaran. *Jurnal Pendidikan Dan Pembelajaran Khatulistiwa*, *10*(3).