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Development of a Problem-Based Learning (PBL)-Based E-Book on Kodular to Improve Students' Cognitive Abilities

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Abstract

The rapid development of information and communication technology requires innovation in learning resources, particularly in Informatics education at the senior high school level. This study aims to develop a Problem-Based Learning (PBL)-based e-book integrated with Kodular and to examine its feasibility, practicality, and effectiveness in improving students' cognitive abilities. This research employed a Research and Development approach using the ADDIE model, consisting of analysis, design, development, implementation, and evaluation stages. The e-book was implemented with 27 eleventh-grade students of SMA Negeri 2 Blora as the experimental group and students of SMA Negeri Jepon Blora as the control group. Data were collected through expert validation questionnaires, teacher response questionnaires, and cognitive ability tests. The results show that the developed e-book is highly feasible and practical for use in Informatics learning. Furthermore, statistical analysis indicates that students who used the PBL-based Kodular e-book achieved significantly higher cognitive gains than those who learned using conventional materials. These findings suggest that integrating PBL with visual programming platforms such as Kodular in digital learning resources can effectively enhance students' cognitive performance in Informatics education.

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INTRODUCTION

The integration of digital technology in secondary education is increasingly becoming a strategic need, especially in Informatics learning which requires mastery of computational thinking skills, problem solving, and practical application development. The Merdeka Curriculum emphasizes the importance of learning that encourages creativity, collaboration, and technological literacy as the main competencies of the 21st century (Ministry of Education, Culture, Research, and Technology, 2022). Therefore, the development of innovative digital learning resources is an important step to answer these challenges.

One of the relevant approaches in this context is the utilization of visual programming platforms such as Kodular. Kodular allows students to build Android applications through a block-based interface, thereby reducing the cognitive burden related to programming syntax and helping students focus more on logic and problem-solving (Rahmawati et al., 2020; Syarlisjiswan et al., 2021). A number of studies show that Android- and Kodular-based learning media have the potential to increase students' engagement and cognitive learning outcomes (Dimas & Retnawati, 2020; Almaida et al., 2020).

However, the implementation of Informatics learning in schools is still dominated by the use of textbooks and static digital materials that are less interactive. This condition causes the learning process to tend to be procedure-oriented rather than on the development of high-level thinking skills (Gunawan & Ghofur, 2021). As a result, students are not fully facilitated to develop the analytical, creative, and reflective skills that are the main demands of modern Informatics learning.

Problem-Based Learning (PBL) has long been recognized as an effective learning approach to improve students' critical thinking and cognitive skills. Through the presentation of authentic problems, PBL encourages students to explore, analyze, and evaluate solutions independently and collaboratively (Wahyuni & Rosana, 2019; Susanto et al., 2021). When PBL is integrated into digital media such as interactive e-books, the potential for improving the quality of learning becomes even greater (Aiyesi et al., 2020).

Several previous studies have developed Kodular based media or PBL-based e-books, but most of them are still stand-alone and have not integrated the two approaches comprehensively in the context of high school informatics learning. In addition, research that specifically examines the impact of Kodular integrated PBL-based e-books on students' cognitive abilities is still limited (Agustina & Kuswandi, 2020; Semara et al., 2021). Therefore, it is necessary to develop digital learning resources that are not only technologically innovative, but also pedagogically strong.

Based on this background, this study aims to develop a Problem-Based Learning-based e-book that is integrated with Kodular and examine its feasibility, practicality, and effectiveness in improving the cognitive abilities of high school students in Informatics subjects.

RESEARCH METHODS

This study uses a Research and Development (R&D) approach using the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model to develop and evaluate E-Book Problem-Based Learning (PBL) integrated with Kodular for high school Informatics learning.

RESEARCH DESIGN

The ADDIE model was chosen because of its systematic and cyclical structure, thus allowing for continuous evaluation and improvement at each stage of learning product development (Baziukė, D., Rupšienė, I., Kesylė, K., & Norvilienė, A. (2021). In the analysis phase, a study was conducted on curriculum requirements, student characteristics, availability of learning facilities, and instructional needs to ensure the alignment of media development with the demands of the high school informatics curriculum in Indonesia Semara, I. P. T. A., & Widiana, I. W. (2019).

The design phase involves the preparation of the e-book structure, the development of learning scenarios, the creation of flowcharts, and

storyboards by integrating the Problem-Based Learning (PBL) syntax and differentiation of learning paths. This approach aims to ensure that the learning process encourages students' active involvement in problem-solving and the development of high-level thinking skills Nurhaliza, S., & Suyatno, S. (2021).

In the development stage, the e-book is produced using the Kodular platform and further validated by media experts as well as subject matter experts to assess the suitability of the content, display quality, and effectiveness of instructional design. The expert validation process is an important step in development research to ensure the academic and technical quality of the products produced by Semara, I. P. T. A., Widiana, I. W., et al. (2021). The implementation stage includes a classroom learning trial using a quasi-experimental design, while the evaluation stage is focused on analyzing the feasibility, practicality, and effectiveness of e-books as a learning medium Triandro, A. Z., & Isnawati, I. (2020).

This study involved 27 grade XI students of SMA Negeri 2 Blora as an experimental group and a comparable group of students from SMA Negeri Jepon Blora as a control group. Group assignments were carried out through random assignments to minimize potential bias and increase the internal validity of Marlina, L., & Hadi, N. (2020). In addition, Informatics teachers and expert validators are also involved in the process of evaluating the feasibility and practicality of the product, so that the assessment of the e-book is obtained from various professional perspectives.

DATA ANALYSIS

Feasibility and practicality data were analyzed descriptively using percentage criteria. Effectiveness was determined through a comparative analysis of the N-Gain score between the experimental and control groups, supported by non-parametric statistical testing.

Table 1. E-Book Effectiveness Normality Test (test)

Classes	Sig Kolmogorov Smirnov	Sig Shapiro Wilk	Remarks
Controls	0.200	0.212	Normal
Eksperimen	0.000	0.000	Abnormal

RESULTS OF RESEARCH AND DISCUSSION

Research Results

The results of the study show that Problem-Based Learning (PBL)-based e-books integrated with Kodular have a very high level of feasibility based on the assessment of media experts and material experts. These findings indicate that the development of e-books has met pedagogical and technical standards as an effective digital learning resource. The suitability between learning objectives, characteristics of high school students, and curriculum demands are the main factors that support the feasibility of this media. This is in line with the opinion of Susanto, T. T. D., Dwiyanti, P. B., Marini, A., et al. (2021) who stated that digital teaching materials designed based on a constructivist approach will be more easily accepted by students because they are able to facilitate meaningful and contextual learning activities.

From the practical aspect, the teacher's response showed that e-books were very helpful in implementing problem-based learning in the Informatics class. The systematic structure of the e-book, accompanied by problem scenarios and guidelines for using Kodular, makes it easier for teachers to manage learning without having to prepare complex additional teaching tools. These findings corroborate the research results of Agustina and Kuswandi (2020) and Gunawan and Ghofur (2021) who concluded that project- or problem-based interactive e-books are able to improve learning efficiency while supporting the role of teachers as facilitators.

The effectiveness of e-books in improving students' cognitive abilities is reflected in the acquisition of the N-Gain score of the experimental group which is significantly higher than that of the control group. This shows that the

application of PBL integrated with digital media is able to encourage students to be actively involved in the learning process through problem analysis activities, solution design, and reflection on work results. These results are consistent with the findings of Susanto et al. (2021) and Wahyuni and Rosana (2019) who affirm that problem-based learning supported by interactive media contributes positively to improving students' critical and cognitive thinking skills.

a) E-Book Eligibility Test

The textbook feasibility test stage is carried out to find out the feasibility of the textbooks that are developed whether they are feasible or need improvement. The feasibility test of android-based textbooks is carried out by Media Experts and Material Experts to get input and criticism from validators on the product in the form of the textbook developed. This stage is based on the results of filling out a response questionnaire which shows that the textbook is suitable for use in research. The textbook feasibility test instrument developed in this study adopts BSNP which has been proven to be valid, so there is no need to hold another response item trial. The validators of the feasibility test in this study consisted of two Media Experts from the Education and Culture Multimedia Development Center (BPMPK) and three Material Experts in the field of Informatics.

b) E-Book Qualification by Media Members

The feasibility test of the textbook was obtained from filling out a validation questionnaire for media experts consisting of two experts at the Education and Culture Multimedia Development Center (BPMPK), as follows:

Table 2. E-Book Eligibility Aspects by Media Experts

Response Indicators Response Item	Member 1	Member 2	Member 3
Total score of each rater	156	154	141
Average Response Points of each rater	4.88	4.81	4.41
Average point score from three raters		4.7	
N		32	

c) Textbook Eligibility Test by Material Experts

The Textbook Feasibility Test Validator in this study consists of three Subject Matter Experts with the score of each expert as follows:

Table 2. Material Expert Responses

The total score of each rater	212	211	213
Item of each rater's response	4.71	4.69	4.73
Average response items from three raters		4.71	
N		45	

d) E-Book Practicality Test

The E-Book practicality test was given by providing a questionnaire during the development stage.the practicality test questionnaire was given to 10 high school teachers who taught informatics materials for cocular applications. This data collection was preceded by the provision of a kodular application informatics E-Book to the kodular application informatics teacher, after which the data collection was carried out using a practicality questionnaire of 12 responses (which were valid out of 24 items). The practicality test of this study obtained the following response results.

Table 3. Summary of Practicality Test Results by Informatics Teachers of Kodular Application Materials

They respond	Valid Item Number											
	2	**6**	**8**	**9**	**10**	**11**	**13**	**14**	**16**	**20**	**23**	**24**
1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1
5	1	0	0	1	0	0	1	0	0	1	0	0
6	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1
10	0	1	1	0	1	1	0	1	1	0	1	0
Quantity total	1	1	1	1	1	1	1	1	1	1	1	2
Number of questionnaire items	12	12	12	12	12	12	12	12	12	12	12	12
Number of respondents	10	10	10	10	10	10	10	10	10	10	10	10

e) Uji N-Gain

The N-Gain test means the normality of gain test (N-Gain). The N-Gain test is carried out after obtaining Pretest and Posttest scores. The analysis used was a gain normality test. This test is used to test the practicality of a product in this case is the Stage Makeup E-Book, the following formula is used to calculate the normality of gain.

$$\text{N Gain} = \frac{skor\ posttest - skorpretest}{skor\ ideal - skor\ pretest}$$

Table 4. Categories of Interpretation of N-Gain Effectiveness

Presentase (%)	**Interpretation**
< 40	Ineffective
40 – 55	Less Effective
56 – 75	Quite Effective
>76	Effective

Source : Hake,R.R.1999

f) Uji t test N-Gain

The normality test as presented in the subchapter of the analysis requirements, showed that the N-Gain of the experimental group had an abnormal distribution. In addition, the homogeneity test between the control and experimental groups showed that it was not homogeneous. Thus, the data analysis used is a non-parametric analysis, namely the Whitney U Mann Test.

Table 5. Results of the control class Ngain test and experiment using the Mann Whitney U Test

Yes	**Test Statistics**	**Tied variable score**	**Verdict**
1	Mann-Whitney U	88.500	
2	Wilcoxon W	466.500	
3	Z Score	-4.779	
5	Asymp. Sig. (2-tailed)	.000	

Discussion

The success of this e-book is also inseparable from Kodular's role as a beginner-friendly visual programming platform. By eliminating the complexity of textual programming syntax, Kodular allows students to focus more on developing thinking logic and problem-solving strategies. This condition is in line with the results of research by Rahmawati et al. (2020) and Syarlisjiswan et al. (2021) who found that Kodular-based learning media is effective in improving students' understanding of concepts and computational thinking skills in technology-based subjects.

In addition, the integration of PBL in this e-book provides a more meaningful learning experience because students are faced with authentic problems that are relevant to daily life. This approach encourages students to actively build knowledge through a process of exploration and collaboration, rather than just passively receiving information. Aiyesi et al. (2020) and Semara et al. (2021) stated that PBL-based e-books are able to create a learning environment conducive to the development of creativity, learning independence, and high-level thinking skills.

The findings of this study reinforce the view that the use of digital technology in informatics learning is not only technically innovative, but must also be supported by a pedagogically strong instructional design. The integration between PBL and Kodular in one digital learning resource makes this e-book a medium that not only conveys material, but also shapes students' mindset in solving problems systematically. This is in line with the opinion of Haryanto, & Ramadhan, A. (2023). which emphasizes that the quality of learning media is determined by the alignment between technology, learning strategies, and student characteristics.

Although the results of the study showed a significant positive impact, the study still had some limitations. The relatively limited number of samples and the scope of material that is still focused on the development of basic applications are factors that need to be considered in generalizing the findings. In addition, the implementation of e-books is still limited to Android-based devices, so the opportunities for its use on other platforms have not been fully explored. Similar limitations are also expressed by Dimas and Retnawati (2020) who emphasize the importance of developing cross-platform learning media to reach more users.

Therefore, further research is recommended to expand the scope of the implementation of this e-book to different school contexts and different levels of student ability. The development of advanced material covering more complex Informatics topics, such as basic artificial intelligence or simple data analysis, could also be the next direction of development. In addition, a follow-up study needs to be conducted to examine the impact of the use of PBL and Kodular based e-books on students' computational thinking skills, creativity, and collaboration in more depth, as recommended by Anwar and Putro (2021) and Wahyuni and Rosana (2019).

The final result of this development research is in the form of an android-based E-Book. The process of preparing E-Books is made in stages to produce a decent E-Book, so a series of validations are carried out from Media Experts, Material Experts, and *users*. Validation of Media Experts, Material Experts and *users*, is carried out directly in the field to obtain data for the purpose of product revision in the form of Android-based E-Books.

Learning media is very complex that can be used in the learning process, one of which is E-Books. Learning using E-Books will be more effective, efficient and relevant. The learning process using E-Books, students are required to learn independently or accompanied by a teacher who is finally able to solve problems. E-Books are also called media for independent learning or accompanied by accompanying teachers because they are equipped with instructions for learning that are summarized in full, in the form of learning tools or facilities that contain materials, methods, limitations, and ways of evaluating that are designed systematically and interesting to achieve the expected competencies.

The feasibility study of the results of the development of the E-Book is based on the results of the assessment sheet of the response of Media Experts, namely informatics lecturers at Dian Nusantara University and Material Experts from

friends of informatics material teachers, especially cocular applications. In the practicality test by the E-Book user, namely the teacher.

The effectiveness test of the E-Book, specifically the validity of the E-Book developed in this study includes the validity of the content in the form of the conformity between the concepts presented and the concepts and theories as well as the validity of the construct, namely the suitability of the transformation or translation of concepts and theories into an operational form. The validity of a product developed can be determined based on the results of validation activities.

The next stage after a validation test was carried out, it was concluded that the android-based E-Book has become the final product and is very suitable for use by students to improve the cognitive abilities of the cocular application. The conclusion is feasible on the android-based E-Book, obtained from the validation results of three media experts and three material experts. At the validation stage, media experts are two E-Book learning experts from Udinus and one teacher who is an expert in the field of coding applications.

Validation of Material Experts, who *are experts* in the field of cocular application materials. The results of the validation of material experts based on the content feasibility aspect got a score of 4.68 with very feasible criteria, the feasibility aspect of presentation got a score of 4.67 with very feasible criteria, the linguistic feasibility aspect got a score of 4.76 with very feasible criteria, the contextual scoring aspect got an average score of 4.70 with very feasible criteria and the average of all aspects in the material validity test obtained a score of 4.71 with the criteria Very decent.

Purnasari, PD, & Sadewo, YD (2020) revealed that one of the goals of development research is to promote the science and practicality of the final product. Learning media is a tool, means or various types of components in the student environment that can stimulate learning . Andayani, T., & Riyanto, S. (2020) E-Books can be said to be good and interesting if there are characteristics of the textbook, namely *self instruction, self contained, stand alone, adaptive, and user friendly.* Based on the explanation above, the E-Book practicality test was carried out on E-Book users, namely teachers of the Informatics Study Program at SMA.

The user validation stage is carried out by the Informatics Study Program (Prodi) teacher. User validation at this stage the interest indicator gets a score of 86% with very practical criteria, the material indicator gets a score of 92% with very practical criteria, the language indicator gets a score of 89% with very practical criteria, the competency indicator gets a score of 86% with very practical criteria, based on all the indicators that have been mentioned it is included in the aspect of student response, After the average score is the result of user validation, the user gets a score of 88% with very practical criteria.

The main goal of learning using E-Book media is to increase the efficiency and effectiveness of teaching and learning activities in schools, both time, funds, facilities and energy, in order to achieve the goal optimally (Susanti & Kurniawan, 2020). The effectiveness of the E-Book developed is related to the purpose of E-Book development, which is related to improving the quality of learning and problem solving in classroom learning. This research aims to improve the cognitive ability of high school students' kodular applications, especially the Informatics Study Program. The results of data analysis show that android-based E-Books are effective and significantly applied to learning activities. The effectiveness of a class is influenced by four main factors called the "four trump cards of effective teaching", namely outcome, clarity, participation and enthusiasm. The e-book is compiled with a systematic approach so that it is easier for students to learn to master the subject matter according to the method for different students. The success achieved by students provides satisfaction for teachers because they feel that they have done their profession well.

Based on the android-based E-Book effectiveness test stage. The independent test table of the t test sample using the Mann Whitney U Test can be concluded that the experimental class has a higher N-gain than the control class. This study shows that the E-Book developed is in the category of effective in improving students' kodular application skills.

Android-based E-Book textbooks can be used by Senior High School (SMA) students. This

category of E-Book is very feasible, very practical, effective and significant for improving cognitive abilities in codular applications. The results of this study are in agreement with the research conducted by Aminah, S., & Mulyatiningsih, E. (2019) that android-based E-Books can improve students' cognitive abilities in kodular applications

CONCLUSION

This study concludes that the Problem-Based Learning E-Book developed that is integrated with Kodular is feasible, practical, and effective in improving the cognitive abilities of high school students in Informatics learning. The application of the ADDIE model ensures a systematic development process, producing learning resources that answer curriculum needs, pedagogical effectiveness, and technological relevance.

From a practical perspective, E-Books can serve as an innovative instructional resource for Informatics teachers who want to implement a project-oriented and differentiated approach to learning. The findings also provide implications for curriculum developers and education policymakers in promoting digital learning resources that encourage active learning and real-world problem-solving skills.

Future studies are recommended to expand the scope of implementation, integrate additional Informatics topics, and explore the impact of similar learning resources on students' creative thinking and computing abilities.

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