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MOOC Content Development: Algorithm Analysis and Design Using Project Based Learning (PjBL)

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Abstract: MOOC Content Development: Algorithm Analysis and Design Using Project Based Learning (PjBL) aims to develop PjBL based MOOC content for the Algorithm Analysis and Design course using the ADDIE model. Validation by three experts resulted in a Content Validity Index (CVI) exceeding 0.85, which confirms its alignment with learning objectives and PjBL principles. The implementation of PjBL significantly increased student engagement, with 82% of students reporting increased active participation and 85% indicating an increased understanding of algorithms. The integration of interactive media, including videos and online quizzes, contributed to higher student satisfaction, reflected in an average grade of 4.1. These findings highlight the effectiveness of PjBL in MOOCs, demonstrating its ability to encourage active learning, deepen conceptual understanding, and enhance the overall student experience. Structured instructional design facilitates a more engaging and meaningful learning process, reinforcing the relevance of PjBL in modern online education. Therefore, incorporating PjBL into MOOCs presents a promising strategy for improving learners' motivation, participation, and mastery of complex subjects such as algorithm analysis and design.
Keywords: MOOC, Project Based Learning, ADDIE, Algorithm, Interactive Media

Pengembangan Konten MOOC: Analisis dan Desain Algoritma Menggunakan Project Based Learning (PjBL)

Abstrak: *Pengembangan Konten MOOC: Analisis dan Desain Algoritma Menggunakan Project Based Learning (PjBL) bertujuan untuk mengembangkan konten MOOC berbasis PjBL untuk mata kuliah Analisis dan Desain Algoritma dengan menggunakan model ADDIE. Validasi oleh tiga ahli menghasilkan Indeks Validitas Konten (CVI) melebihi 0,85, yang menegaskan keselarasannya dengan tujuan pembelajaran dan prinsip-prinsip PjBL. Implementasi PjBL secara signifikan meningkatkan keterlibatan siswa, dengan 82% siswa melaporkan peningkatan partisipasi aktif dan 85% menunjukkan peningkatan pemahaman tentang algoritma. Integrasi media interaktif, termasuk video dan kuis online, berkontribusi pada kepuasan siswa yang lebih tinggi, tercermin dalam nilai rata-rata 4,1. Temuan ini menyoroti keefektifan PjBL dalam MOOC, menunjukkan kemampuannya untuk mendorong pembelajaran aktif, memperdalam pemahaman konseptual, dan meningkatkan pengalaman siswa secara keseluruhan. Desain instruksional yang terstruktur memfasilitasi proses pembelajaran yang lebih menarik dan bermakna, memperkuat relevansi PjBL dalam pendidikan online modern. Oleh karena itu, menggabungkan PjBL ke dalam MOOCs menyajikan strategi yang menjanjikan untuk meningkatkan motivasi, partisipasi, dan penguasaan peserta didik terhadap mata pelajaran yang kompleks seperti analisis dan desain algoritma.*
Kata kunci: *MOOC, Pembelajaran Berbasis Proyek, ADDIE, Algoritma, Media Interakti*.

1. Introduction

Massive Open Online Courses (MOOCs) have become a transformative force in education, offering learners worldwide the opportunity to acquire specialized knowledge without the limitations of geography. As Rulinawaty et al. (2023) point out, MOOCs have democratized access to education, making it more inclusive and flexible. Huimin et al. (2024) and Chen et al. (2025) emphasize that MOOCs have fundamentally reshaped the educational landscape by enabling individuals to acquire in-depth knowledge in highly specialized fields such as algorithm analysis and design. In addition to offering access to such knowledge, Alyoussef (2023) highlights the importance of MOOCs in equipping learners with essential analytical and programming skills, which are becoming

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increasingly relevant in today's digital world. However, as Stracke & Trisolini (2021) argue, to fully harness the potential of MOOCs, it is crucial that the course content is developed systematically. One effective methodology for achieving this is the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. When paired with pedagogical approaches such as Project-Based Learning (PjBL), the ADDIE model can significantly enhance the quality and impact of MOOCs by ensuring that the content is engaging, relevant, and practical (Bukhori et al., 2022).

The ADDIE model has long been recognized as a cornerstone in instructional design due to its structured and results-oriented approach. According to Branch (2009), the model starts with analyzing the learners' needs, followed by designing and developing learning materials that cater to those needs. Once the content is delivered, the evaluation phase plays a critical role in refining and improving the course based on feedback. Sebbeq & El Faddouli (2024) note that the flexibility of the ADDIE model allows developers to adjust course content dynamically in response to learners' needs, which is especially important in MOOCs, where students come from diverse backgrounds and have varying levels of prior knowledge (Azevedo et al., 2024). Furthermore, integrating Project-Based Learning (PjBL) into MOOCs offers a valuable complement to the ADDIE model. PjBL, as Subandi et al. (2021) highlight, is a learner-centered approach that engages students in real-world projects, fostering critical thinking and collaboration. Isnani (2023) supports this by explaining that PjBL encourages deeper engagement with the material. In the context of algorithm design, PjBL allows students to apply theoretical knowledge by working on practical problems (Weng et al., 2024). Although MOOCs may face challenges in facilitating direct interaction, Almulla (2020) suggests that collaborative projects can help overcome this barrier. Simbolon & Koeswanti (2020) argue that project-based tasks not only enhance engagement but also bridge the gap between theory and real-world application, ensuring a more enriching learning experience. Thus, combining PjBL with the ADDIE model creates a robust learning environment where learners can acquire both technical knowledge and practical skills, better preparing them for professional success.

2. Methods

This research uses the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) to develop MOOC content for the Analysis and Design Algorithm course with a Project Based Learning (PjBL) approach. The ADDIE model is chosen for its comprehensive framework, covering needs analysis, designing solutions, developing materials, and evaluating outcomes. The study aims to assess the effectiveness and validity of the developed MOOC content, including teaching instruments and the MOOC product. Validation is carried out through expert reviews and empirical validation, based on feedback from students participating in the course. This ADDIE model consists of five stages that can be seen in Figure 1, which illustrates the overall learning development cycle.

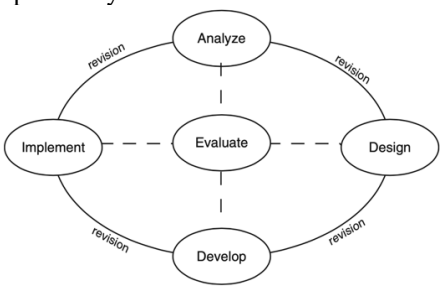

Figure 1. ADDIE Development Concept
Source: Branch (2009)

This research utilizes the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) to develop Massive Open Online Course (MOOC) content for the Analysis and Design Algorithm course with a Project Based Learning (PjBL) approach. The ADDIE model was chosen for its comprehensive framework, covering needs analysis to learning outcomes evaluation. Each phase has clear objectives, including problem analysis, learning solution design, material development, and implementation. The study aims to evaluate the effectiveness and validity of the MOOC content, including teaching instruments and the overall product, using expert and empirical validation based on student feedback. The stages in the ADDIE model are described in more detail in Figure 2, which shows the specific steps to be performed in each instructional design stage in figure 2.

	Analyze	Design	Develop	Implement	Evaluate
Concept	Identify the probable causes for a performance gap	Verify the desired performances and appropriate testing methods	Generate and validate the learning resources	Prepare the learning environment and engage the students	Assess the quality of the instructional products and processes, both before and after implementation
Common Procedures	1. Validate the performance gap 2. Determine instructional goals 3. Confirm the intended audience 4. Identify required resources 5. Determine potential delivery systems (including cost estimate) 6. Compose a project management plan	7. Conduct a task inventory 8. Compose performance objectives 9. Generate testing strategies 10. Calculate return on investment	11. Generate content 12. Select or develop supporting media 13. Develop guidance for the student 14. Develop guidance for the teacher 15. Conduct formative revisions 16. Conduct a Pilot Test	17. Prepare the teacher 18. Prepare the student	19. Determine evaluation criteria 20. Select evaluation tools 21. Conduct evaluations
	Analysis Summary	Design Brief	Learning Resources	Implementation Strategy	Evaluation Plan

Figure 2. ADDIE Instructional Design Procedure
Source: Branch (2009)

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Table 1. Expert validation grid

No.	Assessed Aspect	Indicator	Question Item	Scale	Reference
1	Appropriateness of Content to Learning Objectives	Material content is in line with instructional objectives	Is the material presented relevant to the learning objectives set?	1-5	Gagne et al. (2005)
2	Project Suitability with PjBL	Project assignments reflect the application of project-based learning	Does the project given to students reflect the principles of PjBL?	1-5	Thomas (2000)
3	Completeness of Learning Materials	The material covers all aspects needed to understand the algorithm.	Does the material cover all the important concepts in algorithm analysis and design?	1-5	Babori et al. (2016)
4	Content Interactivity	Interactive content and supports student collaboration	Are the materials interactive and support collaboration between students in completing the project?	1-5	Jonassen (2009)
5	Suitability of Learning Media	The media used is in accordance with the characteristics of the material and students	Does the media used (video, text, simulation) support algorithm learning well?	1-5	Mayer & Fiorella (2022)
6	Quality of Learning Evaluation	The evaluation provided is in line with the instructional objectives	Are the evaluation methods (tests, projects, quizzes) appropriate to the learning objectives?	1-5	Black & Wiliam (1998)

The Implementation Phase focuses on preparing the learning environment and students for the project-based learning (PjBL) process. During this stage, lecturers receive training on the use of the MOOC platform and managing PjBL projects, while students are introduced to the course structure and projects they will be working on. This approach encourages active learning, enabling students to tackle complex problems and refine their skills. Technology, through online courses, offers flexibility, enhancing the overall learning experience. Continuous evaluation tracks student progress throughout the course. The Evaluation Phase assesses the effectiveness of the learning content and process. Formative evaluation ensures the quality of the content during development, while summative evaluation is conducted after implementation to measure the achievement of learning outcomes. Evaluation criteria include learning outcomes, student engagement, and satisfaction with materials and instruction. Various instruments, such as learning outcome tests, project rubrics, satisfaction surveys, and interviews, provide a comprehensive understanding of the student experience. The evaluation results aim to provide recommendations for further improving and developing MOOCs and to assess the effectiveness of PjBL in improving students' skills in the Analysis and Design Algorithms course. Table 2 shows a grid of student responses illustrating the results of measuring their level of satisfaction and engagement in the learning process.

Table 2: Student response grid

No.	Aspects Measured	Indicator	Question Item	Scale	Reference
1	Engagement in Learning	Students are actively involved in completing the project	Do you feel actively involved in completing algorithm-based projects?	1-5	Marks (2000)
2	Understanding of Algorithm Material	Students feel they understand the material taught	Do you feel that your understanding of algorithms has improved after attending this lecture?	1-5	Babori et al. (2016)
3	Relevance of the Project to the Real World	Projects correspond to real-world situations	Is the project you're working on relevant to a real-world problem?	1-5	Blumenfeld et al. (2011)
4	Learning Media Assistability	Learning media helps understand algorithm concepts	Does the learning media (video, simulation) help you understand the concept of algorithm?	1-5	Mayer & Fiorella (2022)
5	Collaborative Engagement	Students engage in collaboration with other students	Did you find the collaborative process in this project beneficial to your learning?	1-5	Johnson et al. (2000)
6	Satisfaction with MOOCs	Students are satisfied with the learning experience using MOOCs	How satisfied are you with the learning done through the MOOC platform?	1-5	Hew & Cheung (2014)

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By combining quantitative and qualitative approaches, this research aims to gain a more comprehensive understanding of the effectiveness of teaching using MOOC (Massive Open Online Course) integrated with Project Based Learning (PjBL) approach. Expert validation followed by empirical testing of students will reveal various important aspects in the application of this learning model, both in terms of material quality, interaction, and its impact on student skill development. This research is expected to contribute significantly to the development of online learning that is more adaptive and relevant to industry needs, as well as strengthening the education system in the digital era. In addition, the results of this study are expected to be a reference for educational institutions to design more innovative learning programs, which not only improve the quality of education, but also prepare students to face the challenges of an increasingly competitive world of work.

3. Result and Discussion

This research aims to develop Massive Open Online Course (MOOC) content based on Project-Based Learning (PjBL) using the ADDIE model to enhance student engagement and understanding of algorithms. Initial analysis through surveys and interviews revealed that traditional one-way learning methods led to low student involvement, with many struggling to grasp algorithms due to a lack of real-world connection (Ginting & Ramadhan, 2024). Research by Prasetya et al. (2024) supports the need for learning models that link theory to practice. In response, the MOOC uses PjBL to offer students opportunities to work on real-world projects, aligning with Horvath & Stoffova (2021) view on practical application. The design stage focuses on creating materials that meet learning objectives, incorporating assessments that gauge students' ability to apply theory through projects, quizzes, and exams. Vijayalakshmi et al. (2022) found that project-based assessments effectively evaluate complex concepts like algorithms. The PjBL approach promotes active learning and skill development, as highlighted by Rahayu et al. (2024). In the development phase, learning modules are created with videos, quizzes, and algorithm simulations to increase interactivity and engagement, helping students apply algorithms in real-world contexts. Figure 3. Module Concept illustrates the module design used in this course, which includes interactive elements such as videos and quizzes to facilitate students' understanding of the algorithm. The results of formative testing conducted with a small group of students revealed that the PjBL-based approach was very effective in improving students' understanding of the material and making them more involved in the learning process. Tirahna et al. (2024) also suggested that the use of interactive learning media can improve student understanding, especially for difficult concepts such as algorithms, by making the learning process more visual and applicable.

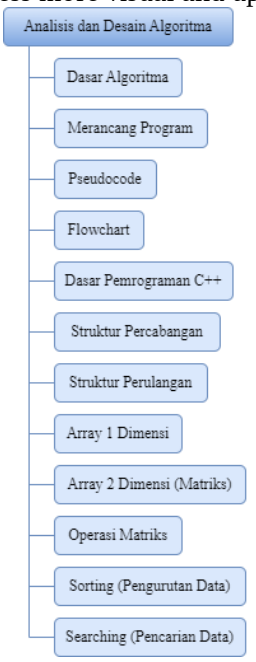

Figure 3. Module Concept

After the development was completed, the MOOC content was implemented on D4 Animation students. The implementation results showed a significant increase in student engagement. A total of 82% of students felt more engaged in PjBL-based learning compared to traditional methods. With an average score of 4.2 on a scale of 5, students felt more active in the learning process and able to apply the theory learned in real projects. In addition, students revealed that the project tasks in this learning allowed them to collaborate more intensively, which improved their collaboration skills. This shows that PjBL not only improves students' technical skills, but also strengthens social skills that are important for the professional world. This result is in line with Sugianto(2022)'s research and also Zhang et al. (2023) who stated that project-based learning strengthens students' social skills and encourages effective collaboration in solving problems.

Collaboration in PjBL-based projects not only improves students' technical skills, but also strengthens the social skills needed in the professional world (Saputri & Maura, 2024).

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Through algorithm-based projects, students can see the direct application of the concepts they have learned as stated by Tafakur et al. (2023)in their research. This reflects the findings expressed by Davis and Roberts (2021), which show that project-based learning helps students better prepare for the challenges of the world of work because they have practiced in a relevant professional context. In addition, Rif'attullah & Ciptaningrum (2024) added that the application of concepts in real-world situations allows students to understand how the theories learned can be applied in professional life, which enriches their learning experience.

The evaluation was conducted by measuring content and construct validity through assessment by experts and student perception surveys. The evaluation results show that the developed content has very high content validity, with a Content Validity Index (CVI) value of 0.90. This indicates that the learning materials are highly relevant to the learning objectives. Table 3. Content Validity Index (CVI) Results presents the detailed results of this evaluation, which shows that the materials are highly relevant to the learning objectives. In addition, the evaluation of construct validity shows that the structure of PjBL-based learning is in accordance with PjBL principles, with a CVI value of 0.86, which confirms that this approach is effective in encouraging student collaboration and the application of learned concepts in real-world situations. This result is in line with the research of Muslim et al. (2023), which underlines the importance of content and construct validity in project-based learning to ensure that the material taught is relevant to the learning objectives.

Table 3. Content Validity Index (CVI) Results

No.	Assessed Aspect	Average Expert Score	CVI
1	Suitability of material with learning objectives	4.67	0.90
2	Completeness of material	4.33	0.88
3	Relevance of project tasks to the real world	4.33	0.87
4	Structure of PjBL-based learning	4.33	0.86
5	Content interactivity	4.00	0.85

The student perception survey showed that 85% of students felt that their understanding of algorithm concepts improved after taking the course, with an average score of 4.3 for material understanding. In addition, the level of student satisfaction with the learning media used was also quite high, with an average score of 4.1. Table 4. Student Perception Measured presents the detailed results of the student perception survey measuring engagement, comprehension, and satisfaction with the learning media used in the course. The learning media used, such as modules, learning videos, online quizzes, and algorithm simulations, make learning more interactive and accessible. Students' satisfaction with these media shows that the use of technology in learning has succeeded in making the learning process more interesting and effective. This is in accordance with the research of Prasetya et al. (2025), who found that the use of interactive learning technology can increase student engagement and understanding.

Table 4. Student Perception Measured

No.	Aspects Measured	Average Score	Percentage of Students who Agree (%)
1	Engagement in learning	4.2	82%
2	Comprehension of the material	4.3	85%
3	Satisfaction with learning media	4.1	80%

Algorithm simulation provides an opportunity for students to directly test and see how algorithms work, which is very helpful in understanding difficult material in a more visual and applicative way. Chernikova et al. (2020)stated that simulation in learning algorithms has proven effective in improving students' understanding of complex algorithm workflows. In addition, the use of media such as videos and simulations can reduce barriers in understanding abstract concepts, as expressed by Dai & Ke (2022), who stated that visual media in learning can facilitate student understanding of difficult concepts. Thus, simulation becomes an important tool to facilitate more effective learning.

The evaluation results show that the content and construct of the PjBL-based MOOC have very high validity, indicating the effectiveness of this approach in improving student engagement and understanding. The high content validity indicates that the learning materials are highly relevant to the learning objectives, while the construct validity indicates that the PjBL-based learning structure is effective in supporting the application of the concepts learned in real-world

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situations. This finding supports the theory proposed by Rahma & Haviz (2022), which states that the compatibility between learning objectives and the material taught is very important to achieve optimal learning outcomes. In addition, the results of this study are also in line with the research of Widyaningrum & Hartarini (2024)and Widiyawati et al. (2024), which emphasized that students' active involvement in project-based learning can improve students' critical thinking and problem solving skills.

4. Conclusion and Suggestions

The research concluded that the developed MOOC content, using the Project-Based Learning (PjBL) model, demonstrated high content and construct validity, with a Content Validity Index (CVI) above 0.85, aligning well with learning objectives and PjBL principles. The PjBL approach significantly increased student engagement, with 82% of students feeling more engaged and 85% reporting improved understanding of algorithm concepts. Interactive learning media, such as videos, quizzes, and simulations, contributed to high student satisfaction, with an average score of 4.1. This suggests that the PjBL model effectively enhances student participation, understanding, and satisfaction in online learning. Recommendations include integrating PjBL in more online courses, expanding interactive media, refining content based on feedback, encouraging collaborative learning, applying PjBL in other disciplines, utilizing learning analytics, and supporting PjBL implementation through policy and faculty training.

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