Development of Cyber Pedagogy-Based MOOC Content for Educational Game-Integrated Learning Training among Education Practitioners

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ABSTRACT

This study develops and evaluates Cyber Pedagogy-based Massive Open Online Course (MOOC) content designed to enhance the competence of education practitioners in integrating game-based learning into instructional practices. The research applied a Design and Development Research (DDR) approach using the ADDIE model, covering the stages of analysis, design, development, implementation, and evaluation. The quality of the developed MOOC was assessed using the Learning Object Review Instrument (LORI), which comprises eight dimensions: Content Quality, Learning Goal Alignment, Feedback and Adaptation, Motivation, Presentation Design, Interaction and Collaboration, Usability and Accessibility, and Reusability and Effectiveness. Data were obtained from 45 practitioners participating in MOOC-based training. Results indicate that all dimensions achieved an average score above 3.00 on a four-point scale, signifying a good level of quality. The highest mean scores were found in Learning Goal Alignment (3.389), Presentation Design (3.373), and Content Quality (3.333), while Usability and Accessibility (3.156) was the lowest. Overall, the findings demonstrate that Cyber Pedagogy-based MOOC content effectively supports structured, engaging, and adaptive digital learning experiences for education practitioners.

I. Introduction

In the current digital era, mastery of technology is a fundamental competency for teachers in creating adaptive learning innovations relevant to the demands of the times. The integration of technology in the teaching-learning process not only serves as a more effective means of delivering material but has also been proven to improve learning outcomes by increasing motivation, active engagement, and student performance in assessments (Prensky, 2001). By utilizing various digital media, teachers can align learning strategies with the dynamics of technological development while developing teaching methods that encourage critical thinking and strengthen students' digital literacy (Al-Azawei, Parslow, & Lundqvist, 2016). Thus, technology plays a strategic role in enriching learning experiences, expanding access to learning resources and supporting the realization of the Pancasila Student Profile as a national education goal (Ministry of Education and Culture [Kemendikbud], 2020).

One form of technology implementation proven effective in increasing student interest and learning motivation is the use of digital game-based learning media. Various studies show that game-based learning significantly improves student motivation, self-efficacy, and academic performance (Kim & Lee, 2022). A recent meta-analysis also indicates that educational games in the STEM context have a medium-to-significant effect on learning outcomes relative to conventional instruction ($g \approx 0.62$) and that strong game design elements reinforce learning outcomes (Chen, Lin, & Lin, 2023). Furthermore, a recent scoping review reveals that although there is strong enthusiasm for educational game development, there is no standard methodology to serve as a reference for systematic development in this field (Chen & Tsai, 2023).

Moreover, game-based learning also strengthens computational thinking skills, primarily through role-playing games that encourage students to think systematically, reflectively, and creatively (Ang, Zaphiris, & Mahmood, 2023). Thus, game-based learning functions

not only as an entertainment medium but also as a constructive pedagogical vehicle for developing 21st-century competencies.

However, the implementation of game-based learning media among teachers still faces various obstacles, particularly in access to learning resources and in training in educational game development. Most available training platforms are commercial, with relatively high costs and limited content to basic technical aspects (Hidayat & Suryani, 2022). This condition creates a disparity in teachers' ability to use game-based technology effectively and contextually relevant as a learning medium (Ramadhani, 2023). Recent studies also show that teacher training in game-based learning is still rarely structured systematically and tends to focus only on perceptions without measuring actual learning outcomes (Romero, 2023; Hidayat, Elmunsyah, Bariroh, & Sutikno, 2022; Hidayat, Hakiki, Nashrullah, Elmunsyah, & Sutikno, 2020). Therefore, alternative solutions that are inclusive, affordable, and have a comprehensive learning structure are needed.

One approach with great potential to address this challenge is a Massive Open Online Course (MOOC) grounded in cyber pedagogy. MOOCs enable open, flexible learning that can be accessed anytime, anywhere by learners from various backgrounds (Siemens, 2013; Elmunsyah, Hidayat, Ulfa, Surakhman, & Wakhidah, 2020). Research in Indonesia shows that MOOCs for teacher training in ICT competencies successfully improved teachers' attitudes, knowledge, and practices in creating digital learning resources (Susilawati, Hidayati, & Hayati, 2023). The cyber pedagogy approach integrates modern pedagogical principles with the use of internet technology to create meaningful interaction between participants and facilitators and encourage community-based collaborative learning (Sharma & Gupta, 2023; Zhang & Song, 2023). Recent studies also show that implementing education management grounded in cyber pedagogy in vocational secondary schools contributes to the development of teachers' professional capacity (Wibisono & Lestari, 2024).

Based on this background, implementation experiments still dominate research in educational games, while systematic, structured, and replicable development guidelines for educators are not yet available. This creates a methodological gap that hinders the broader integration of games into learning. Therefore, there is no systematically designed Cyber Pedagogy-based MOOC model to improve teacher competency in digital educational game development. Existing training is limited to basic technical aspects, is unstructured, and does not evaluate learning outcomes in real-world settings. This gap highlights the need for innovation, where media developed through a comprehensive, inclusive, and pedagogical online learning approach supports teachers' ability to integrate game-based learning and achieve curriculum-aligned learning objectives effectively.

Broadly speaking, this research focuses on developing Cyber-Pedagogy-Based MOOC content for a digital game development course for educators. This research is highly relevant to Sustainable Development Goal (SDG) 4, Quality Education, as it seeks to expand access to innovative digital learning and support improvements in teachers' professional competencies (Ministry of Education and Culture (Kemendikbud, 2020). The novelty of this research lies in integrating the Cyber Pedagogy concept into the design of MOOC content (Sharma & Gupta, 2023; Zhang & Song, 2023; Wibisono & Lestari, 2024), specifically developed to equip teachers to design and develop digital game-based learning media. Thus, this research not only contributes to the development of innovative online learning models (Siemens, 2013; Susilawati, Hidayati, & Hayati, 2023) but also plays a strategic role in strengthening educators' digital capacity in 21st-century education.

II. Method

A. Research and Development Method

The ADDIE model was selected for this study based on several methodological considerations and research characteristics that require a systematic, flexible, and measurable development process, particularly for developing Cyber Pedagogy-based MOOC content for teacher training in the design and creation of digital educational games. Compared to other models such as Dick & Carey, Borg & Gall, or 4D, ADDIE is more efficient for producing large-scale digital learning content that requires in-depth needs analysis, structured cyber interaction design, modular content development, and measurable formative and summative evaluation. Its iterative nature supports continuous improvement of game-based learning content and is highly compatible with the pedagogical and technical needs of modern MOOCs.

This study employs a research and development method that not only aims to produce a specific product but also to rigorously test its effectiveness in achieving the intended educational outcomes (Sugiyono, 2013). The product developed is Cyber Pedagogy-based MOOC content for the Digital Educational Game Development course, designed to strengthen the competencies of education practitioners. To ensure systematic and iterative refinement, the study adopts the ADDIE instructional design model, which consists of five interrelated stages Analysis, Design, Development, Implementation, and Evaluation providing a structured pathway for aligning pedagogical objectives with technological innovation. The analysis stage identifies learner needs and contextual challenges; the design stage translates these findings into a blueprint incorporating cyber pedagogy principles such as

interactivity and collaboration; the development stage produces multimedia learning materials and gamified modules; the implementation stage delivers the MOOC to practitioners with attention to accessibility and engagement; and the evaluation stage measures effectiveness through formative and summative assessments. As illustrated in Figure 1, the ADDIE model functions as a cyclical and flexible framework, enabling continuous improvement of the MOOC content while ensuring that the final product is pedagogically sound, innovative, and empirically validated.

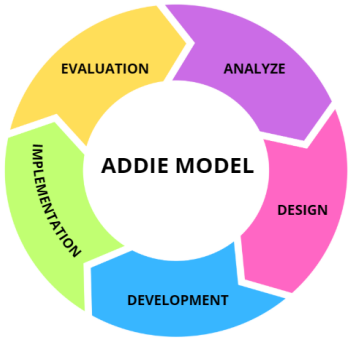

Fig. 1. ADDIE Model

Based on the ADDIE model's steps and development scheme, a product development plan can be outlined as follows:

1) Analysis

The initial stage of the ADDIE model is a needs analysis for product development. The MOOC content was developed due to limited teaching materials and irrelevant learning models. The study encompasses the curriculum, learning conditions, and teaching materials, using observation and interviews to identify the needs of educational practitioners and assess the product's feasibility. The analysis data were obtained through a needs assessment questionnaire regarding the difficulties, preferences, and technological readiness of prospective MOOC participants, including teachers, lecturers, and training facilitators. This instrument was in the form of a questionnaire combining open and closed questions, which aimed to obtain a comprehensive picture of: (1) The material most needed by participants in developing educational games; (2) The presentation format considered most effective (video, interactive modules, forums, or simulations); (3) The level of availability of devices and internet connections owned; (4) Participants' expectations of Cyber Pedagogy-based learning models. The data from this needs assessment served as the basis for developing content design and learning strategies for the MOOC platform.

2) Design

This stage encompasses a comprehensive planning and design process based on the ADDIE model for developing Cyber Pedagogy-based MOOC content for the Digital Educational Game Development course. Planning is carried out by mapping learning needs, participant characteristics, the material structure, and forms of cyber interaction that are relevant to modern pedagogical principles. The resulting conceptual design and development flow are illustrated in Figures 2 and 3, which depict the logical relationships among ADDIE stages and the integration of Cyber Pedagogy elements into the learning module design. This visual representation serves as a systematic initial reference to ensure that each MOOC component is structured coherently, standardized, and aligned, thereby improving teacher competency in digital educational game development.

Fig. 2. Mockup Main Menu Display

3) Development

The Development phase in the ADDIE model is the process of operationalizing the instructional design into a concrete learning product ready for use in a Cyber Pedagogy-based MOOC environment. At this stage, all pedagogical concepts, structures, and strategies formulated in the design phase are realized into a complete digital learning component. Development is carried out through several main sub-processes, including authoring text-based module content that adheres to the curriculum structure and principles of cyber pedagogy; producing media in the form of videos, animations, infographics, and other visual elements; and integrating interactive activities such as formative quizzes, project-based assignments, and educational game simulations. An initial prototype of the educational game has also been developed, taking into account aesthetics, gameplay, feedback, and its alignment with learning objectives. Each content component undergoes an internal verification process to ensure narrative consistency, material accuracy, and pedagogical suitability.

In addition to content development, this phase also involves usability testing and technical refinement sub-processes to ensure the MOOC is easily accessible, responsive, and compatible with various user devices. Functional trials are conducted to check navigation clarity, media suitability, and interface integration stability. The results of the initial trials served as the basis for iterative improvements to optimize the learning experience, tailored to the characteristics of the training participants. Revisions were carried out continuously through collaboration between a team of technology developers, pedagogical experts, and educational game experts,

ensuring that the final product not only met technical quality standards but also aligned with modern digital learning principles and the professional needs of teachers in developing educational game media.

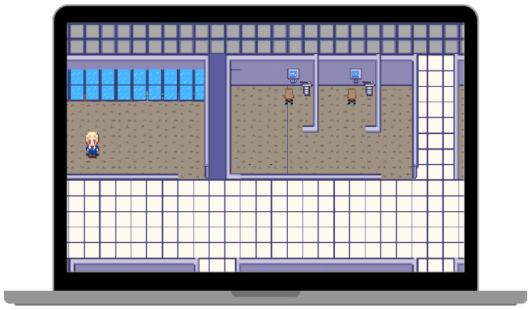

Fig. 3. Game Design Display

4) Implementation

The Implementation phase is the process of operationalizing and organizing the developed learning content, ensuring it can be accessed and used by training participants in real-world situations. At this stage, the Cyber Pedagogy-based MOOC content for the Digital Educational Game Development course is integrated into the selected e-learning platform and then configured according to the previously designed curriculum structure, navigation flow, and pedagogical strategies. Course implementation involves uploading materials, structuring learning modules, activating interactive features, and configuring the learning management system to support collaborative activities, cyber communication, and formative and summative assessment.

Implementation also includes providing user guides, initial participant orientation, and technical support mechanisms to ensure smooth access and participation. Participants progress through the course at a predetermined pace, from exploring the material to participating in interactive activities, completing project-based educational assignments, and completing learning evaluations. At this stage, participant engagement is also monitored through the platform's analytics features, such as activity logs, access times, interaction patterns, and completion rates, to assess the initial effectiveness of the implemented content. Thus, the Implementation stage is not just a launch process, but a critical phase that ensures the pedagogical, technical, and structural functions of the MOOC run harmoniously in accordance with the Cyber Pedagogy-based digital learning design.

5) Evaluation

The Evaluation phase is a comprehensive assessment process designed to measure the feasibility, effectiveness, and quality of the development and implementation of Cyber Pedagogy-based MOOC content in the Digital Educational Game Development course. Evaluation is conducted through two main approaches: formative and summative evaluation. Formative evaluation is performed continuously at each development stage, encompassing expert assessment of material validity, multimedia component trials, platform technical feasibility checks, and pedagogical reviews of cyber-interaction designs. This process serves as an initial checkpoint to identify the strengths and weaknesses of each component, enabling iterative improvements before the final product is implemented.

Subsequently, a summative evaluation is conducted with participants after the course has been implemented to assess learning effectiveness, achievement of instructional objectives, and the impact of the training on participants' competency in developing digital educational games. Data collection is conducted through various instruments, including learning outcome tests, game project assessment rubrics, participant perception surveys, analysis of activity logs on the MOOC platform, and guided interviews or reflections. Evaluation results are used to determine the extent to which the MOOC content meets standards for instructional quality, material relevance, ease of access, quality of cyber interactions, and its contribution to strengthening professional competencies. Thus, the Evaluation stage not only serves as a quality measurement process but also provides a scientific basis for improving learning design, program sustainability, and the development of a Cyber Pedagogy-based MOOC model in further research.

The researchers can ensure that Cyber Pedagogy-based MOOC content effectively improves educators' understanding and skills in creating educational digital games and is relevant to modern learning needs through comprehensive evaluation.

B. Research and Development Procedure

1) Implementation Stage

a) Trial Design

The product trial design for this development was conducted to ensure that the research product could yield accurate and valid data. Trials were carried out in several stages: 1) Expert review to ensure the learning media system and materials meet expected standards, 2) Field test used to identify feasibility and effectiveness.

b) Trial Subjects

The trial subjects in this development research comprised three groups: media experts, material experts, and field trial participants. The details of the trial subjects are shown in Table I.

Table 1. Subject of Trial Test

No.	Type of data	Trial Subject	Number of Subjects
1	Media expert test	Learning media expert	1
2	Material expert test	Computer network material expert	1

No.	Type of data	Trial Subject	Number of Subjects
3	Field trial test	Teachers of SMK PGRI Singosari, Malang Regency	45

c) Research Instrument

Research instruments were used to help researchers collect data systematically and objectively. Nine types of data/variables were analyzed. The detailed research instruments are shown in Table II.

Table 2. Data Collection Instrument

No	Type of data	Data collection method	Scoring scale	Data type
1	Needs Analysis	Observation and Interview	-	Qualitative Data
2	Media expert test	Validation of learning media expert	Intervals	Qualitative & Quantitative data
3	Material expert test	Validation of computer network material expert	Intervals	Qualitative & Quantitative data
4	Product Feasibility Test	User Feasibility Testing of research products	Intervals	Qualitative & Quantitative data

d) Analysis Method

This study used descriptive statistics and inferential tests. Descriptive analysis was conducted to describe characteristics and distribute data from validation, group trials, and field trials for proper analysis.

III. Results and Discussion

The results of the Cyber Pedagogy-based MOOC content development for the Digital Educational Game Development for Education Practitioners course are realized as a structured, interactive, and easily accessible online learning environment for all prospective participants. The content developed through the ADDIE stages is integrated into the State University of Malang MOOC platform and can be accessed, as shown in Figure 4, via the official website https://mooc.um.ac.id/course/-view.php?id=460. This platform provides a responsive, organized learning interface that allows users to effectively navigate modules, videos, infographics, interactive quizzes, and other supporting learning resources. The implementation of the Cyber Pedagogy-based design is evident in the structure of learning activities that encourage cyber interaction, collaboration, and pedagogical reflection, aligned with the principles of 21st-century digital learning.

In its implementation, this course is designed to be flexible, allowing education practitioners to follow it without the constraints of space and time, thus supporting the principles of openness and inclusivity that are key characteristics of MOOCs. Participants are allowed to engage with the entire course through self-paced learning, including learning the basic concepts of educational game development, understanding how to integrate pedagogical elements into game design, and practicing creating simple game prototypes. All content is developed to be relevant to the Indonesian educational context, enabling direct implementation in teaching practices at their respective schools. The platform's analytics feature will also allow participants to track their learning progress, while instructors or facilitators can monitor participation and interaction throughout the course.

Access to this course is open and free of charge, and participants must register on the platform to obtain an official user account. This policy is designed to expand the program's accessibility, particularly for teachers, lecturers, and education personnel who need to improve their digital competencies but have limited access to paid training. This free delivery model aligns with the research objectives of supporting equitable ICT competency and strengthening the ability of education practitioners to develop game-based learning media. Thus, the resulting MOOC product serves not only as a research output but also as a tangible contribution to efforts to improve teacher professionalism and the utilization of innovative learning technology in national education.

A. General Description of Assessment

The selection of the Learning Object Review Instrument (LORI) in this study was based on methodological and theoretical considerations related to the need for a comprehensive evaluation of the quality of Cyber Pedagogy-based MOOC content. LORI, specifically version 1.5, has been shown to have strong construct validity and reliability across various digital learning object contexts, as demonstrated by Leacock and Nesbit (2007). This instrument is designed to evaluate the quality of learning objects through eight dimensions encompassing cognitive, pedagogical, technical, and instructional engineering aspects. Therefore, LORI is considered an appropriate evaluation framework capable of capturing the complex characteristics of MOOC content, which, in this study, combines game-based learning, interactive multimedia, and cyber-pedagogy-based learning design.

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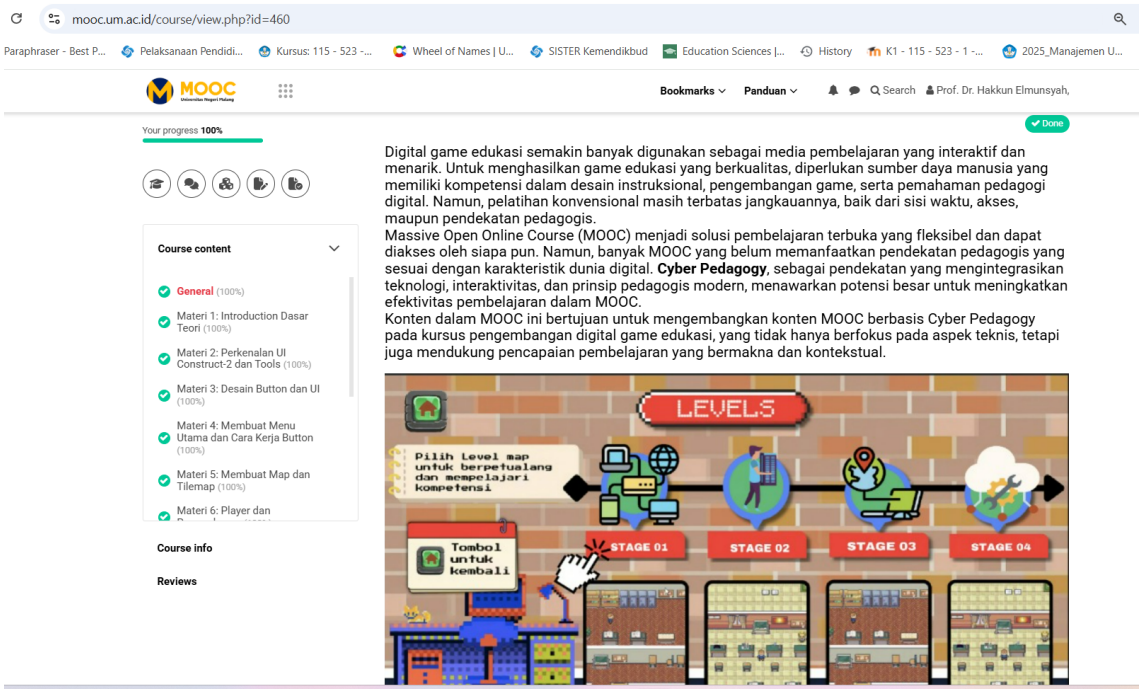

Fig. 4. Research Product

The eight dimensions of LORI provide a systematic, holistic framework for evaluating MOOC content quality, including Content Quality, Learning Goal Alignment, Feedback and Adaptability, Motivation, Presentation Design, Interaction and Collaboration, Usability and Accessibility, and Reusability and Effectiveness. These dimensions are considered capable of representing the evaluation needs of MOOC content, which functions not only as learning materials but also as a digital learning environment that must meet standards of usability, pedagogical meaningfulness, ease of navigation, and support for diverse learning styles of participants. Within this scope, the LORI enables an in-depth assessment of the effectiveness of integrating learning media, such as educational games, text modules, instructional videos, adaptive quizzes, and infographics.

Furthermore, the selection of the LORI in this study is supported by the findings of Kumar and Ritzhaupt (2010), who evaluated instructional designers' perceptions of the quality of learning objects in MOOC and LMS environments. The study demonstrated that the LORI is highly relevant for assessing digital learning objects used on large-scale platforms such as MOOCs, as its dimensions align with modern instructional design principles and the needs of distance learning. Therefore, the use of the LORI in this study not only considers theoretical suitability but also adheres to best practices in evaluating the quality of digital content. This ensures that assessment of Cyber Pedagogy-based MOOC content is conducted with strong, measurable, and scientifically accountable academic standards.

Each dimension consists of items (31 in total) with a score range of 1–4 (1 = poor, 4 = very good). Data were collected from 45 education practitioners (vocational high school teachers) who participated in a field trial of the MOOC during a training activity at SMK PGRI Singosari, Malang Regency.

B. Descriptive Statistics Results

Table 3. Average and Category per Dimension

Dimension Learning Goal Alignment	Mean 3.389	Categories Good (almost Very Good)	Cronbach's_Alpha 0.921
Presentation Design	3.373	Good	0.824
Content Quality	3.333	Good	0.793
Motivation	3.289	Good	0.808
Reusability & Effectiveness	3.256	Good	0.792
Feedback & Adaptation	3.252	Good	0.854
Interaction & Collaboration	3.237	Good	0.853
Usability & Accessibility	3.156	Good (the lowest)	0.795

Instrument reliability analysis using Cronbach's α coefficients for each dimension indicated that most dimensions had adequate internal consistency, allowing for valid use of per-dimension scores to support development decision-making in the context of evaluating Cyber Pedagogy-based MOOCs. Adequate reliability indicates that the items within each dimension function harmoniously in measuring the same construct and

provide measurement stability. However, if any dimension has an alpha value below the recommended threshold (<0.70), this indicates potential disharmony between items, which could reduce interpretation accuracy. This situation requires a systematic item audit to identify items that negatively affect internal consistency, thereby improving the instrument's quality before use in further evaluation.

These reliability findings also emphasize the importance of item-level analysis as an integral part of the instrument refinement process. Excel reports that include item-total statistics, including item-total correlations, response distributions, and each item's contribution to the alpha value, can provide a strong foundation for more in-depth structural analysis. Through this approach, researchers can determine whether an item needs to be revised, simplified, or eliminated to improve overall measurement consistency. Thus, instrument reliability not only serves as an indicator of measurement quality but also provides strategic direction for improving the accuracy of MOOC content evaluation and ensuring that data-driven development decisions are made in a more valid and methodologically sound manner.

C. Data Visualization

Figure 5 shows that all dimensions of the LORI instrument received average scores above 3 on a 4-point scale, indicating that each assessment aspect was in the good range. The three dimensions with the highest scores, respectively, were Learning Goal Alignment, Presentation Design, and Content Quality, reflecting the integration of learning objectives, the quality of material presentation, and the appropriateness of content substance in supporting the MOOC effectiveness.

The distribution of respondents' scores ranged from 3.0 to 3.5, indicating a generally positive perception of the MOOC's quality and consistent ratings across respondents. No extreme outliers were found, thus concluding that the data has sufficient stability and reliability for further interpretation and conclusion drawing.

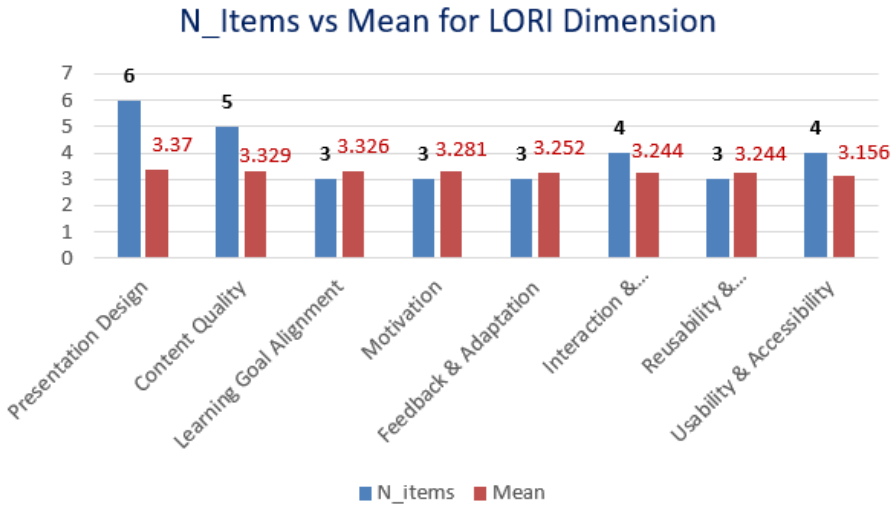

Fig. 5. Average Score per LORI Dimension and Average Distribution of Respondents

The evaluation results using the LORI instrument on MOOC content based on Cyber Pedagogy and game-based learning show a consistent pattern of findings across various assessment dimensions. In general, the content demonstrated strong performance across pedagogical dimensions, including content quality, alignment of learning objectives, and presentation design, reflecting the success of the instructional design process in ensuring cohesion among learning components. Conversely, dimensions related to technical aspects, particularly usability and accessibility, showed relatively lower scores. This pattern of findings suggests that although the pedagogical content has been optimally developed, technical challenges remain to ensure a smoother learning experience for MOOC participants.

This interpretation of the results aligns with the literature, which states that the balance between instructional quality and the technical quality of the system determines the effectiveness of a MOOC platform. Celik and Caglitay (2024), for example, assert that platform quality, including navigation, access, reliability, and system responsiveness, has a direct impact on participants' self-directed learning abilities and their success in online learning. Thus, the LORI evaluation results in this study highlight the importance of strengthening technical aspects to ensure MOOC content is not only academically superior but also inclusive, efficient, and easily accessible to users across a variety of devices, internet connections, and technological backgrounds.

The Learning Goal Alignment dimension received the highest score, at around 3.39 on a scale of 1–4. This score indicates that the learning objectives in each module have been formulated clearly, operationally, and consistently with the learning activities and assessments provided. Good alignment of learning objectives is a crucial indicator in instructional design, as it ensures that participants understand the competencies to be achieved, have a structured learning path, and receive relevant feedback as they progress toward those objectives. The consistency of these results with LORI literature (Nesbit & Leacock, 2003) confirms that the MOOC content meets the instructional congruency standards, which are the foundation of quality digital learning objects.

In addition to goal alignment, scores on the content quality and presentation design dimensions also demonstrated positive performance. This indicates that the material is presented with a high level of accuracy, depth, and relevance, and is supported by visual elements, instructional videos, infographics, and the integration of educational games that enrich the learning experience. Effective display design helps increase cognitive engagement and knowledge retention, two crucial aspects of self-paced MOOC-based learning. However, while this pedagogical dimension is relatively strong, integrating rich media such as games and videos also demands that the platform be technically ready for seamless access.

Technical aspects that receive lower scores should be interpreted not as substantial weaknesses, but rather as indications of priority areas for continued development. Challenges such as a less responsive interface, accessibility on specific devices, or the integration of large multimedia materials need to be further mapped through usability testing and a technical audit of the platform. Improvements in these areas will strengthen the overall learning experience and better align the MOOC with the principles of inclusive digital learning. Therefore, the results of this evaluation provide a strong empirical basis for recommendations for the next stage of development: technical optimizations that support the sustainability and effectiveness of Cyber Pedagogy-Based MOOC implementation for education practitioners.

Interpretation of the evaluation results using the LORI instrument indicates that although the Design Presentation and Content Quality dimensions scored relatively high, approximately 3.37 and 3.33, respectively, on a four-point scale, some aspects still need improvement to ensure optimal presentation quality. Item-level analysis indicates that the multimedia elements used, including instructional videos, infographics, and interactive simulations, do not function efficiently when accessed via low-speed networks or mobile devices with hardware limitations. This implies that although the pedagogical quality of the content has been met, its technical readiness to support an equitable learning experience across varying digital infrastructure conditions still needs strengthening.

These findings are consistent with empirical studies in the MOOC literature that place technical accessibility as a key determinant of the success of large-scale online learning implementations. Research on user experience indicates that mobile-friendly design, lightweight media structure, and optimized display formats have a significant impact on participant retention, engagement, and satisfaction. Thus, the quality of media presentation cannot be viewed as merely an add-on component, but rather an integral part of pedagogical success, particularly in the context of MOOCs aimed at user populations with diverse devices and network conditions.

Furthermore, the findings of this study align with those of a large-scale study published in PLOS ONE (2024), which showed that MOOC platforms with optimal multimedia designs optimized for low bandwidth tend to produce higher learning outcomes than those that do not. The study emphasized that media adaptation to participants' technical limitations is crucial for reducing access barriers and increasing the effectiveness of self-directed learning. Therefore, based on the evaluation results and empirical findings in the literature, improvements in multimedia design and technical efficiency should be prioritized in the further development of MOOCs grounded in Cyber Pedagogy and game-based learning.

The evaluation results for the Usability & Accessibility dimension, which yielded an average score of around 3.16, indicate that this aspect is a priority area requiring further development. Although this score is in the good category, detailed analysis revealed several items with low scores related to media stability (e.g., hangs, lags, or crashes), cross-browser compatibility, and interface clarity and ease of navigation. This condition indicates that several technical components of the Cyber Pedagogy-based MOOC are not yet fully capable of providing a seamless learning experience for all users, especially those using devices with varying specifications or unstable internet connections. In the context of a MOOC aimed at a broad audience, successful implementation depends heavily on the platform's ability to function well under varying technical conditions.

This finding aligns with the literature examining technical barriers in massive open online learning. Various studies have shown that issues such as media instability, slow content loading, and differences in browser compatibility can decrease module completion rates and reduce participants' continuance intention. Nesbit & Leacock (2003) emphasized that the technical quality of learning objects is a key determinant of the digital learning experience, even comparable in importance to pedagogical quality. Thus, the findings of this study confirm that strengthening technical aspects is not merely a minor improvement, but rather an essential component in increasing the overall effectiveness of MOOCs.

Consequently, several best practices are recommended to address the identified technical issues. Approaches such as responsive design are necessary to ensure optimal display and functionality across a range of devices, from desktop computers to smartphones. Media optimization through video compression techniques, caching, or a Content Delivery Network (CDN), and cross-browser compatibility testing are technical measures that have been empirically proven to improve the stability and efficiency of online learning systems. Implementing these measures can also reduce network load and improve accessibility for participants with low-speed internet connections.

On the other hand, the evaluation of the Motivation dimension showed a score of approximately 3.29, indicating that integrating game-based elements into MOOCs has increased user motivation. However, it has not yet reached optimal levels. These findings show that the gamification and game-based learning approaches used in the course can create a more engaging learning experience and stimulate participation. However, some of the richer components of gamification, such as more informative progress indicators, meaningful challenges, and contextual reward systems, have not been fully utilized or deeply integrated into learning designs.

Recent literature, including a systematic review published by ERIC (2021), confirms that gamification in MOOCs can significantly increase learner engagement and retention if gamification elements are appropriately designed and integrated with adaptive feedback mechanisms. Therefore, the results of this study indicate a need to develop more comprehensive adaptive feedback mechanisms, including explanations of quiz answers, automated remediation recommendations, and alternative learning paths. The integration of these elements is expected to strengthen personalized learning experiences, increase intrinsic motivation, and support more effective, ongoing learning in MOOCs based on Cyber Pedagogy and game-based learning.

Practically, the recommended priority steps based on the results and literature are:

- Technical improvements: media optimization (video compression, adaptive streaming), responsive design audits, cross-browser and mobile testing. The use of CDNs and caching techniques can improve access stability (Celik & Caglitay, 2024).
- Enrich adaptive feedback: include conceptual explanations for incorrect quiz answers, automatic remediation links, and differential learning paths based on quiz performance (adaptive pathways). This supports the Feedback & Adaptation dimension and increases learning effectiveness (Nesbit & Leacock, 2003).
- Measurable gamification implementation: piloting simple gamification features (badges, progress) in small groups to evaluate their impact on motivation and course completion. Recent evidence suggests potential for increased completion when gamification is designed to be adaptive and relevant (Pitthan & De Witte, 2025).
- Diversified field testing: conduct pilots in urban and rural areas to measure Reusability & Effectiveness and assess the impact of connectivity conditions. Comparative studies can inform content/format modifications for low-connection users (Huimin, Ahmad, & Kadir, 2024).

IV. Conclusion

The analysis shows that the research product, "Cyber Pedagogy-Based MOOC Content Development for Educational Game-Integrated Learning Training among Education Practitioners," has demonstrated strong performance across most dimensions of digital learning quality evaluation, particularly in pedagogical and material design. However, technical and accessibility aspects require improvement. By implementing the recommendations above, this research could achieve the "Very Good" category in the subsequent evaluation. Repeated measurements will be crucial for documenting progress and supporting contributions to game-based digital learning and cyber pedagogy research in the Indonesian educational context. Based on the findings and literature, several recommendations can be proposed to improve the quality of the developed MOOC. First, technical priorities should focus on optimizing the platform for responsiveness across mobile devices, multiple browsers, and slow networks, with media compression, caching, and cross-browser testing as essential strategies to ensure stability and accessibility. Second, adaptive feedback mechanisms should be enhanced by adding automated comments, remedial pathways, and recommendations for follow-up materials based on quiz results, thereby strengthening the Feedback & Adaptation dimension and supporting more personalized learning. Third, gamification and collaboration features should be strengthened by integrating badges, leaderboards, group assignments, and active forums, with mentors serving as facilitators to foster motivation, interaction, and collaboration among participants. Fourth, revalidation and user diversification are necessary by testing the MOOC with different user characteristics, such as urban versus rural participants and those with limited connectivity, to provide evidence of reusability and effectiveness while addressing usability and accessibility challenges. Finally, continuous monitoring and evaluation should be conducted by collecting LORI data after improvements, enabling measurement of changes in each dimension and providing empirical evidence that the product has improved in quality.

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