



SENORA: Canvasite-Based Challenge Learning for Combinatorics Using MathCityMap and Lawang Sewu Ethnomathematics

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Abstract

The integration of digital technology into mathematics education requires innovative learning media that promote active, meaningful, and student-centered learning. However, mathematics instruction remains predominantly teacher-centered, resulting in limited student engagement and difficulties in understanding combinatorics. This study aimed to develop SENORA, Canvasite-based Learning Management System (LMS) integrating Challenge Based Learning (CBL), MathCityMap, and Lawang Sewu ethnomathematics, and to evaluate its feasibility and effectiveness in supporting combinatorics learning. A Research and Development (RnD) approach based on the ADDIE model was employed, consisting of the Analysis, Design, Development, Implementation, and Evaluation stages. The participants were Grade XI students at SMA Negeri 12 Semarang. Data were collected through interviews, expert validation sheets, observations, and pretest-posttest tests. Product validity was analyzed using Aiken's V, while its effectiveness was evaluated using the Normalized Gain (N-Gain) test. The findings indicated that SENORA was highly feasible for classroom implementation and effectively improved students' understanding of combinatorics through contextual, interactive, and challenge-based learning activities. The integration of Challenge Based Learning, MathCityMap, and Lawang Sewu ethnomathematics also encouraged students' active participation, collaboration, and problem-solving during the learning process. This study contributes to mathematics education by providing an integrated web-based learning model that combines digital technology, contextual learning, and local cultural values to support meaningful mathematics learning.

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INTRODUCTION

The development of technology in the field of education has encouraged more interactive and student centered learning innovations. One way technology is used in learning is through the use of a Learning Management System (LMS). An LMS is a digital platform that can be used to manage materials, assignments, discussions, and learning evaluations in an integrated way. According to Nurhayati (2020), using an LMS can help improve learning effectiveness because students can access materials flexibly anytime and anywhere. Using an LMS in math learning is important because math is a subject that requires logical thinking, analytical skills, and problem solving abilities. However, in reality, math learning in schools is still often teacher centered, making students tend to be passive in the learning process. This situation causes students' ability to understand concepts and solve mathematical problems to still be low. According to Wahyu Hidayat and Rippi Maya Sariningsih (2018), students' mathematical problem solving skills need to be improved through learning that actively involves students in finding solutions to a problem.

Combinatorics is a topic in the Grade 11 high school mathematics curriculum that requires logical thinking and problem solving skills. It involves studying various methods to determine the number of possible outcomes for an event using counting rules, permutations, and combinations. Students often struggle to grasp the concepts and determine problem solving strategies in combinatorics because the subject matter is abstract and demands systematic reasoning. To address these challenges, an instructional model capable of enhancing student engagement in the learning process is required. One such model that can be implemented is Challenge Based Learning (CBL). According to Mark Nichols, Karen Cator, and Monica Torres (2016), CBL is a learning approach that encourages students to solve real world challenges through a process of inquiry, collaboration, and action. This model places students at the center of learning, enabling them to take a more active role in constructing knowledge and discovering solutions to problems.

To support the implementation of Challenge Based Learning (CBL), appropriate digital learning media are needed. Previous studies have shown that Canvasite-based learning media can improve students' motivation, engagement, and conceptual understanding, while Math City Map promotes contextual learning and enhances students' critical thinking and problem-solving skills (Silviana & Mawardi, 2025; Cahyani, 2024). However, studies integrating a Canvasite-based Learning Management System (LMS) with the CBL approach assisted by Math City Map for teaching combinatorics remain limited.

The implementation of Challenge Based Learning (CBL) within a Learning Management System (LMS) is expected to foster more engaging and meaningful mathematics instruction, particularly regarding the topic of combinatorics. Beyond aiding conceptual understanding, a CBL based LMS can cultivate students' critical thinking, creativity, communication, and collaboration skills competencies essential for 21st century learning and the Kurikulum Merdeka (Independent Curriculum). Therefore, it is necessary to develop a CBL based LMS for combinatorics tailored to 11th grade high school students, ensuring the learning process becomes more effective, interactive, and aligned with learner needs.

Based on the background described above, the following problems have been identified: (1) Mathematics instruction tends to remain teacher centered, resulting in limited student engagement during the learning process. (2) Students' conceptual understanding and problem solving skills regarding the topic of combinatorics remain low. (3) The utilization of a Learning Management System (LMS) in mathematics instruction has not been optimized. (4) There is currently no Challenge Based Learning (CBL) based LMS available for the topic of combinatorics for Grade 11 high school students.

The benefits of developing a Challenge Based Learning (CBL) based LMS for the topic of combinatorics are as follows: (1) For students, the LMS can help improve conceptual understanding and mathematical problem solving skills related to combinatorics. (2) For teachers, the LMS serves as an alternative digital learning medium that is both

interactive and innovative. (3) For schools, the LMS supports the implementation of technology based learning and 21st century learning practices. (4) For researchers, this study can serve as a reference for the development of technology based mathematics learning media.

The novelty of this research lies in the development of a Challenge Based Learning (CBL) based Learning Management System (LMS) for the topic of combinatorics, designed for Grade 11 high school students. The LMS is not merely a tool for content delivery and assessment; it is designed to facilitate students in solving contextual challenges through the CBL stages: engage, investigate, and act. Furthermore, the LMS incorporates discussion activities, interactive practice exercises, and assessments tailored to the specific characteristics of combinatorics, thereby aiming to enhance student engagement and understanding in mathematics learning.

METHOD

This study employed a Research and Development (RnD) approach based on the ADDIE instructional design model, which comprises five stages: Analysis, Design, Development, Implementation, and Evaluation. The research was conducted at SMA Negeri 12 Semarang, Central Java, Indonesia, during the second semester of the 2025/2026 academic year. The school was selected following preliminary observations and interviews with the mathematics teacher, which indicated that Grade XI students had not yet received instruction on combinatorics.

Participants consisted of 28 students from Class XI F12. The developed product, SENORA, is a web-based Learning Management System (LMS) created using Canva Website (Canvasite). SENORA integrates the Challenge Based Learning (CBL) model, MathCityMap as an outdoor mathematics learning platform, and Lawang Sewu ethnomathematics to provide meaningful and contextual learning experiences. Learning materials include permutations of distinct objects, permutations with identical objects, circular permutations, combinations, interactive learning resources, student worksheets

(LKPD), learning videos, quizzes, MathCityMap activities, a virtual tour, and formative assessments.

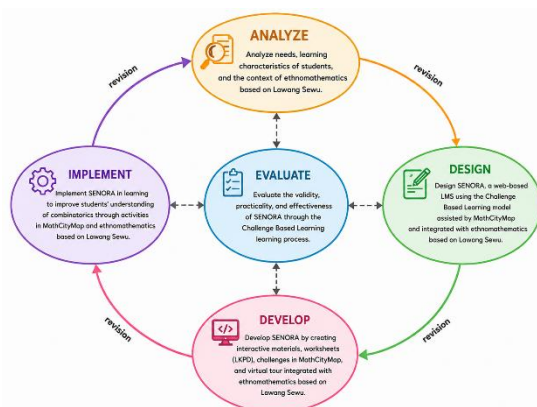


Figure 1. ADDIE Research Procedure

Needs analysis was carried out through a literature review and semi-structured interviews with the mathematics teacher to identify students' learning difficulties, curriculum requirements, and the necessity of developing a digital learning medium for combinatorics.

Based on the findings of the analysis stage, the instructional design was prepared by determining learning objectives, designing the user interface and navigation, developing assessment instruments, and organizing learning activities according to the syntax of the Challenge Based Learning model, including Big Idea, Essential Question, Challenge, Guiding Questions, Guiding Activities, Guiding Resources, Solution, and Publication. Storyboards and interface prototypes were also produced before media development.

Development focused on constructing the SENORA prototype using Canva Website as the main platform. Interactive learning materials, worksheets, MathCityMap challenges, virtual tour content, and assessment activities were integrated into the LMS. Content and media quality were evaluated by one media expert, one mathematics education lecturer as the material expert, and two experienced mathematics teachers. Suggestions provided by the validators were incorporated into the revised version before classroom implementation.

Implementation involved the use of the validated LMS in mathematics learning with 28

Grade XI students. Students completed a pretest before accessing SENORA and a posttest after completing all learning activities. Throughout the learning process, students explored the learning materials independently, solved contextual problems through MathCityMap, participated in ethnomathematics-based activities, completed worksheets, and carried out formative assessments following the Challenge Based Learning sequence.

Evaluation was conducted by examining the validity of the developed media, students' learning outcomes, classroom observations, and feedback from both teachers and students. Information obtained from this stage was used to determine the feasibility and effectiveness of SENORA and to identify aspects requiring further improvement.

Data were collected using semi-structured interview guidelines, media and material validation sheets, observation sheets, and a learning achievement test consisting of four essay questions designed to measure students' conceptual understanding of combinatorics.

Descriptive quantitative analysis was employed to analyze the collected data. Content validity was assessed using Aiken's V, whereas the effectiveness of SENORA was determined through the Normalized Gain (N-Gain) test by comparing students' pretest and posttest scores. Interpretation of the validity and effectiveness results followed the criteria proposed by

Puspasari (2017). SENORA was considered feasible when the validation results reached the "good" category or above and effective when students' learning improvement achieved an N-Gain value classified as "good."

RESULTS AND DISCUSSIONS

The research and development of the SENORA Learning Management System (LMS) based on the ethnomathematics of Lawang Sewu for combinatorics learning was conducted in May 2026 during the second semester of the 2025/2026 academic year. The study involved Class XI F12 at SMA Negeri 12 Semarang, consisting of 28 students. The research procedure included a preliminary observation, administration of a pretest, implementation of learning using the SENORA LMS over three instructional sessions and concluded with the administration of a posttest.

The research instruments consisted of the SENORA LMS, pretest and posttest instruments, each comprising four essay questions on combinatorics, as well as media and content validation sheets. Prior to their implementation, all instruments underwent a validation process conducted by two mathematics teachers and one mathematics education lecturer. Based on the validation results, the instruments were declared valid and appropriate for use in the learning process.

Table 1. Content Validation of LMS Items

Grain	Examiner 1	Examiner 2	Examiner 3	$\sum s$	V	Category
1	4	4	3	8	0.888888889	Highly Valid
2	3	4	3	7	0.777777778	Valid
3	3	4	3	7	0.777777778	Valid
4	4	4	3	8	0.888888889	Highly Valid
5	4	4	4	9	1	Highly Valid
6	4	4	4	9	1	Highly Valid
7	3	4	4	8	0.888888889	Highly Valid
8	3	4	4	8	0.888888889	Highly Valid
9	4	4	4	9	1	Highly Valid
10	3	4	4	8	0.888888889	Highly Valid
11	3	4	4	8	0.888888889	Highly Valid
12	4	4	4	9	1	Highly Valid
13	3	4	4	8	0.888888889	Highly Valid
14	4	4	4	9	1	Highly Valid
15	4	4	4	9	1	Highly Valid
16	3	4	3	7	0.777777778	Valid
17	4	4	4	9	1	Highly Valid

18	4	4	3	8	0.88888889	Highly Valid
19	4	4	4	9	1	Highly Valid
20	4	4	4	9	1	Highly Valid
21	3	4	4	8	0.88888889	Highly Valid
22	4	4	3	8	0.88888889	Highly Valid
23	3	4	4	8	0.88888889	Highly Valid
24	4	4	4	9	1	Highly Valid
25	3	4	4	8	0.88888889	Highly Valid
26	3	4	4	8	0.88888889	Highly Valid
27	3	4	4	8	0.88888889	Highly Valid
28	4	4	4	9	1	Highly Valid

Based on the content validity analysis using Aiken's V formula on the 28 LMS instrument items evaluated by three validators, the average Aiken's V coefficient was 0.921 (92%). This result indicates that all instrument items fell within the valid to very valid categories. Therefore, the instrument was considered appropriate, relevant, and suitable for use in the study with only minor or no revisions required.

The pretest was administered on May 4, 2026, to assess students' prior knowledge of combinatorics. The pretest results revealed that the students' initial understanding of the topic was relatively low, as most students scored below the minimum mastery criterion. The mean pretest score was 29.71, indicating that students experienced difficulties in understanding the concepts of permutations and combinations, particularly in selecting the appropriate formulas for solving contextual problems.

Following the pretest, students participated in learning activities using the SENORA Learning Management System (LMS) over three instructional sessions. The learning process was implemented using the Challenge-Based Learning (CBL) model integrated with Canva and MathCityMap, incorporating the ethnomathematical context of Lawang Sewu.

During the first session, students learned the concept of permutations of distinct objects through the context of the numerous doors and windows of Lawang Sewu. They were challenged to determine various possible arrangements and routes based on the available objects. The use of authentic contextual situations helped students develop a more concrete understanding of permutation concepts. In addition, instructional materials presented through Canva enhanced

students' engagement and interest during the learning process.

In the second session, students studied circular permutations and permutations with identical objects through the context of seating arrangements and object patterns found at Lawang Sewu. Through discussions and challenge-based activities provided in the SENORA LMS, students became more capable of distinguishing among ordinary permutations, circular permutations, and permutations with identical elements. Furthermore, activities conducted using MathCityMap enabled students to relate mathematical concepts to real-world situations in their surrounding environment.

During the third session, students learned the concept of combinations through contextual problems involving the selection of plants and other objects within the Lawang Sewu environment. Students demonstrated greater participation in discussions and problem-solving activities. The ethnomathematical approach facilitated their understanding of the fundamental differences between combinations and permutations by connecting abstract mathematical concepts with meaningful real-life contexts.

After completing all instructional sessions, a posttest was administered on May 11, 2026, to evaluate the improvement in students' learning outcomes following the implementation of the SENORA LMS. The results showed that the mean posttest score increased to 82.96, indicating a substantial improvement compared with the pretest results. This finding suggests that the implementation of the SENORA LMS effectively enhanced students' understanding of combinatorics. Table 3 presents the students' pretest, posttest, and normalized gain (N-gain) scores.

Table 2. Students' Pre-test, Post-test, and N-gain Scores

No	Name	Pretest	Post-test	Information	N-Gain	Category N-Gain
1	Ahmad Pandu K.	27	80	Increase	0.7260273	High
2	Andien Ayudia N.	30	86	Increase	0.8	High
3	Azizun Nawang A.	22	77	Increase	0.705128205	High
4	Baktiadi Saputra	25	83	Increase	0.773333333	High
5	Bunga Engelliana	38	88	Increase	0.806451613	High
6	Cahaya Dwi R.	19	80	Increase	0.75308642	High
7	Dafa Rafiif Nurwan	22	83	Increase	0.782051282	High
8	Dafa Satya Ramadan	19	77	Increase	0.716049383	High
9	Destya Anita Sari	42	94	Increase	0.896551724	High
10	Diqsa Iqbal Pratama	25	80	Increase	0.733333333	High
11	Dyana Kharin	30	91	Increase	0.871428571	High
12	Fajar Alif Kurniawan	30	86	Increase	0.8	High
13	Faryd Adham G.	19	75	Increase	0.691358025	Medium
14	Javiera Atmakirana A.	30	83	Increase	0.757142857	High
15	Karisma Iftahul J.	27	83	Increase	0.767123288	High
16	Lailatul Haniah	22	75	Increase	0.679487179	Medium
17	Lingga Dewi Safitri	36	86	Increase	0.78125	High
18	Muhammad Alfathan	22	77	Increase	0.705128205	High
19	Naf'an Arifudin	27	83	Increase	0.767123288	High
20	Oktavia Adelia Safitri	50	94	Increase	0.88	High
21	Reta Dwi Oktaviana	36	75	Increase	0.609375	Medium
22	Rizky Chilman P.	22	72	Increase	0.641025641	Medium
23	Shafa Qualima A.	33	88	Increase	0.820895522	High
24	Sylvyana Dzakyaningrum	42	91	Increase	0.844827586	High
25	Veby Valennia	25	80	Increase	0.733333333	High
26	Wawan Zuli Ardi Y.	27	72	Increase	0.616438356	Medium
27	Zahra Aprilia	33	86	Increase	0.791044776	High
28	Zaskia Nala Azahra	44	94	Increase	0.892857143	High

The mean difference between the pretest and posttest scores was 53.25 points, indicating that the implementation of the SENORA LMS positively influenced students' learning outcomes in combinatorics. This improvement may be attributed to the instructional approach, which

extended beyond the application of mathematical formulas by integrating mathematical concepts with local cultural contexts familiar to the students, thereby promoting more meaningful learning experiences.

**Figure 2.** Graph of Pre-test and Post-test Score Improvements

Based on the N-gain analysis of the 28 students in Class XI F12, the mean N-gain score was 0.762 (76.2%). This value falls within the high category ($N\text{-gain} \geq 0.70$), indicating that the SENORA LMS was effective in significantly improving students' mathematical understanding.

Furthermore, the implementation of the Challenge-Based Learning (CBL) model enhanced students' active participation throughout the learning process. Rather than passively receiving instructional content, students actively engaged in solving challenges, participating in discussions, and developing solutions to the problems presented. These activities enabled students to develop a deeper understanding of combinatorics concepts.

Overall, the findings suggest that the SENORA LMS, which integrates the ethnomathematical context of Lawang Sewu, can serve as an effective alternative learning medium for mathematics instruction, particularly in combinatorics. By combining local cultural contexts with digital technology, the LMS facilitates more contextual and meaningful learning experiences, enhances students' learning motivation, and improves their learning outcomes.

CONCLUSION

This study successfully developed SENORA, Canvasite-based Learning Management System (LMS) integrating Lawang Sewu ethnomathematics, the Challenge Based Learning (CBL) model, and MathCityMap for teaching combinatorics in senior high school. The findings showed that SENORA was highly feasible for classroom implementation, achieving a validation score of 92%, which falls into the very good category. The implementation of SENORA also proved effective in improving students' understanding of combinatorics, as reflected by the increase in the mean score from 29.71 on the pretest to 82.96 on the posttest, with an N-Gain of 0.762 (76.2%), indicating a good level of effectiveness. In addition, the integration of Canvasite, MathCityMap, and Lawang Sewu ethnomathematics encouraged students to participate actively, collaborate in solving

contextual mathematical problems, and engage more meaningfully in the learning process. These findings indicate that SENORA provides an innovative and effective digital learning medium for improving students' conceptual understanding of combinatorics and problem-solving skills. This study contributes to mathematics education by presenting an integrated web-based learning model that combines Challenge Based Learning, outdoor mathematical exploration through MathCityMap, and local cultural contexts within a single learning management system. The proposed LMS can serve as a practical reference for educators and researchers in developing culturally responsive and technology-enhanced mathematics learning.

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