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Needs Analysis And Design Of Gamification-Based Learning Management System Edukati To Support Flipped Classroom Of Cell Material

Aulia Hilma Yuanika[1✉], **Saiful Ridlo**

[1]Biology Education Study Program, Department of Biology, FMIPA, Semarang State University, Indonesia

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Abstract

The development of digital technology in the era of industrial revolution 4.0 towards society 5.0 demands biology learning that is more interactive, contextual, and relevant to the characteristics of 21st-century learners. However, high school biology teachers still face the challenge of low student understanding of abstract cell concepts, such as organelle structure-function relationships and cell division mechanisms. This material is often understood as rote, while learning media have not fully supported visualization or interactivity. The integration of the flipped classroom model with a gamification-based Learning Management System (LMS) is seen as a potential solution. This research aims to analyze the learning needs of cell concepts in high school and design a gamification-based LMS that is in accordance with the flipped classroom model. This study used an exploratory descriptive approach at the needs analysis stage involving 42 students of class XI MIPA and a biology teacher, which was then positioned as part of the planning stage in the Alessi & Trollip development model (RnD). The results of the needs analysis were then used as the basis for designing the initial design of the gamification-based LMS (design stage). The results of student needs show three aspects, namely the level of understanding of cell concepts is in the medium category (74.5%), while technology readiness (78.5%) and interest in flipped classroom (79.25%) are in the high category. Based on the needs analysis, the learning media were designed using Moodle "Edukati" LMS with gamification elements in the form of points, leaderboards, and multilevel challenges. The Understanding by Design (UbD) principle was used as a reference in formulating the integration of objectives, assessments, and learning activities. The results showed that the initial design of the gamification-based LMS has the potential to support the implementation of flipped classroom learning on cell material and is worth testing in the further development stage.

✉Correspondence Address:
D6 Building 1st Floor Jl Raya Sekaran Gunungpati Semarang
E-mail: auliahilmayuanika@gmail.com

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INTRODUCTION

The rapid development of digital technology in the era of industrial revolution 4.0 towards society 5.0 has a significant impact on the world of education, including learning Biology at the high school level (Setiawardani *et al.*, 2021). Students in the 21st century are expected to have critical thinking skills, collaboration, digital literacy, and learning independence (Wicaksono & Prasetiyo, 2023). However, the reality in the field shows that Biology learning is still dominated by teachers and the stigma that biology only focuses on memorization, especially on abstract material such as cells (Hulu *et al.*, 2024). This condition creates a gap between the demands of 21st century competencies and classroom learning practices, especially on abstract cell material. Cell material includes the relationship between the structure and function of organelles, and the mechanism of cell division is difficult to visualize so that it often causes misconceptions and difficulties for students in connecting concepts with real phenomena (Afifah & Asri, 2020).

The complexity of abstract cell concepts demands a learning strategy that not only conveys information, but also helps students connect knowledge with real-life activities. The flipped classroom model offers a more balanced approach, where students learn the material first outside of class, then utilize face-to-face time for discussion, lab work, or problem-solving activities (Huang *et al.*, 2018). However, practice shows that teachers often struggle to prepare structured pre-class materials, while students need support in the form of systematic, varied content and formative assessments to ensure initial understanding. Without proper media support, the flipped classroom runs the risk of not being optimized because students' learning preparation at home is not well monitored (Ekici, 2021).

Learning media that can overcome obstacles and support learning achievement is Learning Management System (LMS). LMS can provide a variety of pre-class materials (text, interactive modules, formative quizzes, to videos), as well as facilitate teachers in monitoring student learning achievement. In addition, the achievement of learning objectives using LMS and flipped classroom model can be supported by the integration of gamification in LMS. Gamification is the application of game elements such as points, badges, leaderboards and challenges into the learning environment to increase student motivation, participation and learning retention (Sailer & Sailer, 2020; Gündüz & Akkoyunlu, 2020). The integration of gamification can increase interactivity that encourages student engagement so that when entering a face-to-face class they are better prepared for discussion or practicum activities. Research shows that the integration of gamification in a flipped classroom can significantly increase student engagement, intrinsic motivation, and learning outcomes (Elzeky *et al.*, 2022). LMS platforms such as Moodle are the main choice in implementing gamification in the flipped classroom with the most commonly used game elements being points, badges, and leaderboards (Ekici, 2021).

Based on this background, the purpose of this research is to analyze the needs and design a gamification-based Edukati LMS that supports the implementation of a flipped classroom, especially in learning Biology of cell material. The results of the research are expected to be an empirical basis for the development of innovative learning media that are relevant to the demands of 21st century education.

RESEARCH METHOD

This research was conducted at SMA Negeri 12 Semarang in the even semester of March-May 2024/2025 academic year. The research subjects were the XI MIPA class of SMA Negeri 12 Semarang who had received cell material and one biology teacher who had experience teaching the material. The selection of the subjects was based on the consideration that the grade XI students have had biology learning experience and face challenges in understanding the abstract concept of cells. The teacher was chosen as a key informant to explore the needs, constraints, and expectations of digital learning media. The results of analyzing student needs were followed by designing a gamification-based LMS. The research procedure refers to Alessi & Trollip's research and development which is a structured software development model. This model is often used to design products that focus on the development of software or technology-based learning media through three main stages, namely the planning stage, the design stage, and the development stage (Alessi & Trollip, 2001). However, this stage focuses on the first two stages, namely planning and design as listed in

Figure 1. The planning stage aims to identify the needs of students and teachers related to learning cell concepts and the obstacles faced in conventional learning. The design stage focuses on designing a gamification-based LMS that supports the flipped classroom learning model by taking into account the results of the needs analysis and the principles of effective instructional design (Sailer & Sailer, 2020).

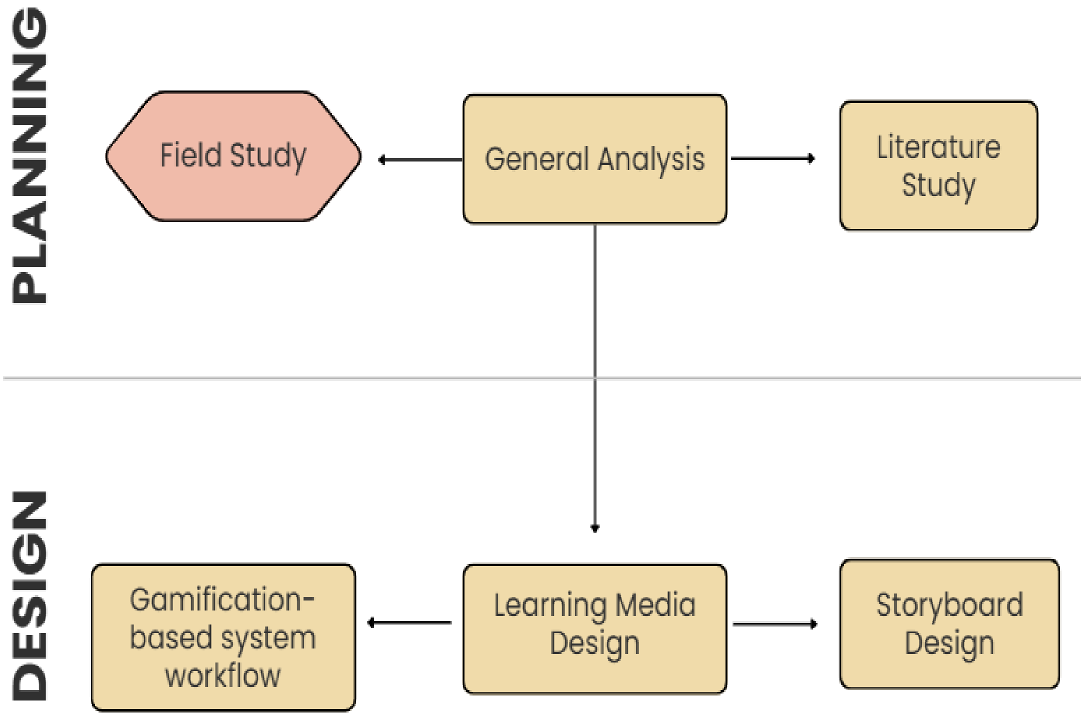

Figure 1. Research flow

The student needs questionnaire was developed based on the results of the initial interview by measuring three aspects, namely the level of understanding of cell concepts, technology readiness (device and internet access), and interest in the flipped classroom. This questionnaire adopts Likert scale and has been widely used in similar research to measure students' motivation and readiness in gamification-based learning and flipped classroom (Zainuddin, 2018). Meanwhile, semi-structured interviews were conducted with teachers to explore their needs and difficulties in cell learning, as well as expectations for gamification-based digital media. Semi-structured interviews allow for the exploration of richer and more contextualized qualitative data (Sankalaite *et al.*, 2020).

Data collection techniques were carried out by distributing questionnaires online using google form to reach all students efficiently and ensure data is collected systematically. Meanwhile, interviews were conducted directly to obtain in-depth qualitative data from teachers and then continued with document analysis such as teaching modules and other learning tools to ensure the suitability of the LMS design with curriculum needs and actual learning in the classroom. The data that has been obtained is analyzed quantitatively and qualitatively. Quantitative data from the student needs questionnaire was analyzed using descriptive statistics of percentages and averages followed by interpretation of the results as in table 1. to objectively describe the profile of student needs, readiness, and interest (Zainuddin, 2018). Qualitative data from interviews were analyzed through the stages of data reduction, categorization, and thematic interpretation to identify key themes related to teachers' needs and expectations (Gündüz & Akkoyunlu, 2020). The results of quantitative and qualitative data analysis were used as the basis for designing relevant and contextualized gamification-based LMS features (Ekici, 2021; Sailer & Sailer, 2020).

Tablel 1. Data Interpretation (Arikunto, 2016)

Percentage (%)	Category
0-25	Very low
26-50	Low
51-75	Medium
76-100	High

RESULTS AND DISCUSSION

Analysis of the Needs of Students and Teachers in Learning Biology Cell Material

Based on the results of the analysis of student needs data presented in table 2. shows that students' understanding of cell concepts is in the medium category (average score 74.5%) indicating that there is still room for improvement in conceptual understanding. The concept of cells in the context of biology learning is a complex material because it involves microscopic structures and dynamic processes that are not easily visualized directly (Reece *et al.*, 2020). These problems can be overcome through learning approaches that not only present information textually, but also support visual and interactive understanding so that students can build more concrete representations of these concepts.

Table 2. Results of Student Needs Analysis

Aspect	Percentage (%)	Category
Concept Understanding	74,5	Medium
Technology Readiness	78,5	High
Interest in the Flipped Classroom model	79,25	High

Furthermore, the analysis shows that students' technological readiness is in the high category (78.5%) with most respondents having smartphone devices and stable internet access. This shows that the digital infrastructure owned by students is sufficient to support the implementation of LMS-based learning. This reinforces Zainuddin's (2018) research which asserts that the success of the flipped classroom model is strongly influenced by technological readiness and student learning independence. Adequate technological readiness supports students' potential to be more active in accessing materials before face-to-face activities in accordance with the main principle of the flipped classroom which emphasizes technology-based independent learning before interactive sessions in class.

In addition, students' interest in the implementation of the flipped classroom model is also high (79.25%). This figure reflects students' openness to collaborative and flexible learning innovations. This result is in line with Ekici's (2021) findings that the integration of flipped classroom with gamification elements can increase intrinsic motivation and student engagement through immediate feedback mechanisms and challenge-based activities. This means that students are not only interested in the new learning model, but also show readiness to actively engage in an interactive and adaptive digital learning system. These results also confirm the need for media capable of facilitating the visualization of abstract concepts and strategies that can increase students' active engagement during the learning process.

Interviews with teachers corroborated the results of the quantitative descriptive analysis above. Teachers revealed that students still often have difficulties in understanding the mechanism of the process and connecting one material with another such as the structure and function of cell organelles, especially because they are abstract and difficult to visualize. Teachers consider that learning will be more effective if facilitated by digital media that can integrate materials, assessments, and interactive activities in one centralized system that fosters active student participation. This opinion is consistent with self-determination motivation theory which states that learning engagement and motivation increase when students feel autonomy, competence, and social connectedness (Marinensi et al., 2022). Teachers also consider that the implementation of gamification has the potential to increase student participation and motivation, especially through features such as points, badges and leaderboards that can create a competitive yet collaborative learning experience (Sailer & Sailer, 2020). Teachers' support for the development of a gamification-based LMS further confirms the relevance of this model as an effective, interactive, and 21st century learning solution.

The results of the needs analysis from both the student and teacher sides show a link between technological readiness, interest in innovative models, and the need for interactive learning media. This reinforces the urgency of developing a gamification-based Edukati LMS specifically designed to support the flipped classroom model on cell material. The system is expected to not only be a means of material distribution, but also an integrative platform that can foster motivation, improve conceptual understanding, and encourage active participation of students in the biology learning process.

Gamification-based Education LMS Design

Based on the results of the analysis of student and teacher needs, the gamification-based Edukati LMS design was developed using the Edukati Moodle platform with the Understanding by Design (UbD) approach. The UbD approach was chosen because it emphasizes learning that is oriented towards deep understanding, not just the achievement of factual content. Through the backward design stage, the development process starts from determining the expected learning outcomes, continues with designing authentic assessments, and ends with developing meaningful learning experiences (Wiggins & McTighe, 2005).

In general, the LMS flow design as shown in Figure 2. displays interactive stages that reflect the principles of gamification and flipped classroom. The process starts from login and course selection (My Courses), then students are directed to Material 1 which consists of several activities (Activities 1-3). After completing all activities and reaching a certain passing grade, the system automatically rewards in the form of points or badges and unlocks the next material. Conversely, if they have not met the criteria, the next material will remain locked until the student completes the previous stage. This process creates a progression loop mechanism that motivates students to continue to be actively involved and achieve the target learning outcomes.

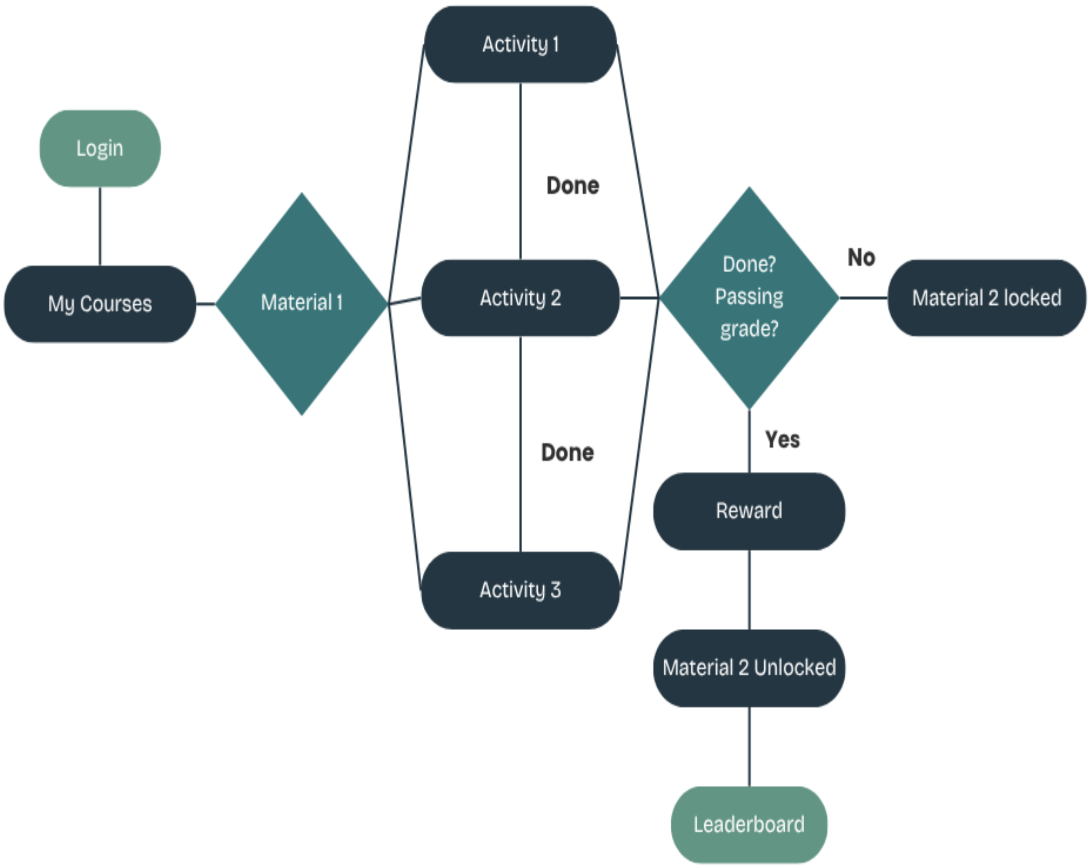

Figure 2. LMS Workflow Design

In addition, the structure of the LMS system as shown in Figure 3. shows that each course includes main components such as Participants, Grades, Reports, Badges, and Competencies. Each element has a complementary pedagogical function. The Course component contains core learning activities such as interactive materials, videos, discussion forums, and quizzes. The Participants component allows teachers to monitor student participation and interaction. The Grades and Reports component serves as a means of continuous assessment. The Badges component acts as a gamification element that recognizes student achievement, while the Competencies component marks skills or achievement indicators that have been met.

The structure is designed to support the three main phases of flipped classroom learning, namely Pre-Class Activities, In-Class Activities, and Post-Class Activities. In the Pre-Class Activities phase, students access materials and animated videos about cell structure, interactive readings, forum discussions, and initial quizzes. This activity aims to build prior knowledge and help students prepare an initial framework of understanding of the material to be learned. According to Zainuddin (2018), the pre-class phase in the flipped classroom allows students to learn at their own pace so that class time can be focused on higher cognitive level activities such as concept analysis and application. Thus, pre-class activities on the Edukati LMS function as advance organizers that facilitate the assimilation of new concepts into existing cognitive structures.

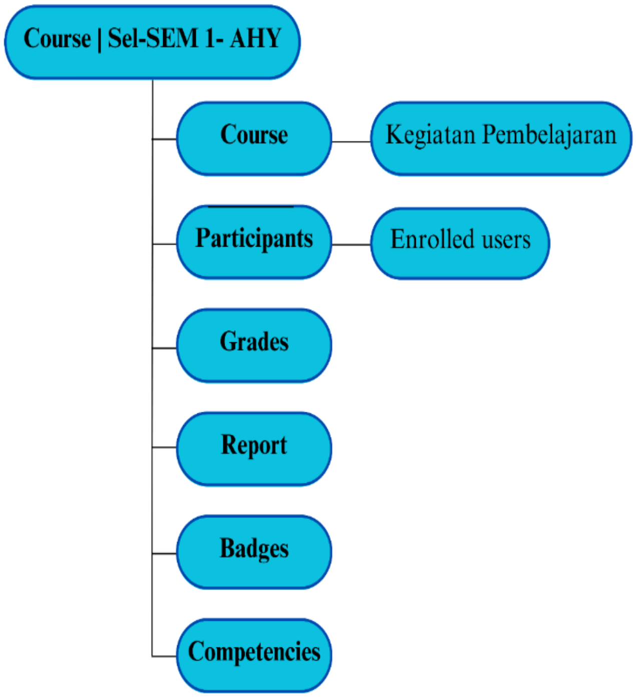

Figure 3. LMS System Structure

Furthermore, the In-Class Activities phase is focused on direct face-to-face activities in the classroom with the teacher acting as a facilitator. Based on the LMS design, this phase does not only rely on online discussions, but also integrates group discussions, hands-on practice, and simulation of cell concepts with simple tools and materials. This approach is in line with the social constructivism theory by Vygotsky (1978), which emphasizes that learning occurs optimally through social interaction and collaboration within the zone of proximal development (ZPD). The teacher's role is to help students reach higher levels of understanding through dialog, demonstration, and joint exploration. In addition, practice and simulation activities at this stage support experiential learning theory (Kolb, 1984), where concrete experiences and direct reflection are the basis for the formation of more stable scientific concepts. Practice and simulation play an important role in connecting theory with real phenomena through visual and manipulative experiences, especially cell material which is abstract.

The last stage, Post-Class Activities, is designed as a reflection room in the Edukati LMS. At this stage, students are asked to write personal reflections on what they have learned, challenges faced, and how the concepts obtained can be applied to other contexts. This reflection activity is important in strengthening students' metacognitive understanding, which is the ability to realize and regulate their own thinking process. According to Schön's (1983) reflective learning theory, the reflection process helps individuals connect learning experiences with conceptual understanding so that meaningful learning occurs. The support of digital features such as reflection rooms in the LMS is a place for students to conduct self-assessment, share experiences, and get feedback from teachers and peers (Huang et al., 2018). Through this phase, learning does not stop at cognitive achievement, but extends to affective and metacognitive dimensions, strengthening the character of a self-regulated learner.

All of the above learning phases are reinforced by the application of gamification elements, such as points, badges, and leaderboards, to maintain motivation and a sense of accomplishment. According to Ekici (2021) and Huang et al. (2018), the integration of game elements in an LMS is effective in increasing student participation and engagement because it turns learning activities into a challenging, progressive, and fun experience. The gamification-based Edukati LMS design is not only a learning tool, but also a learning system that encourages active engagement, deep understanding, and continuous reflection in accordance with the principles of the flipped classroom.

CONCLUSION

This study produced a needs analysis and initial design of the gamification-based Edukati Learning Management System (LMS) to support the implementation of the flipped classroom model in learning Biology of cell material in high school. The results of the needs analysis show that students' concept understanding is still in the medium category (74.5%), while technology readiness (78.5%) and interest in the flipped classroom model (79.25%) are high. This condition emphasizes the need for digital media that is interactive, adaptive, and able to increase student motivation and learning independence. The Edukati LMS design was developed with the principle of Understanding by Design (UbD) through three stages of learning: pre-class (materials, videos and interactive quizzes to build initial knowledge), in-class (discussions, practices, and simulations for concept reinforcement), and post-class (directed reflection through reflection rooms). The integration of gamification elements in the form of points, badges, and leaderboards is theoretically proven to improve intrinsic motivation, social engagement, and learning outcomes. This research contributes to the development of a digital learning model that combines gamification and flipped classroom to improve student motivation, collaboration and conceptual understanding. The design of Edukati LMS has the potential to be a 21st century learning innovation that is adaptive, interactive, and oriented towards learning independence.

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