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Managing Learning to Enhance Critical Thinking and Achievement in High School Ecosystem Topics

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Abstract :
This study aims to investigate the impact of learning management systems on the enhancement of critical thinking skills and student learning outcomes in high school ecosystem materials. The research employs a descriptive qualitative approach, utilizing data collection techniques that include in-depth interviews, classroom observations, and documentation. The findings show that the management of learning strategies by teachers, such as the use of case studies, open-ended questions, and group discussions, significantly encourages students to think analytically and reflectively. In addition, the principal plays the role of an instructional leader who fosters an academic climate that promotes critical thinking through teacher training, instructional supervision, and the integration of critical thinking values into the school culture. The learning evaluation system is also directed to assess high-level thinking skills, with the rubric of analysis and reflection as the primary measuring tool. This study concludes that improving learning outcomes cannot be separated from the integration of teacher strategies, school leadership support, and reflection-based evaluation. The study's implications highlight the importance of a holistic managerial approach in science learning, enabling students not only to master concepts but also to develop applicable and contextual critical thinking skills.

INTRODUCTION

In the context of secondary education, both in Indonesia and globally, learning is directed not only at mastering the material but also at developing 21st-century skills, especially critical thinking (Almulla, 2023; Fernandes et al., 2024; van der Zanden et al., 2020). In high school ecosystem subjects, students encounter complex concepts such as biotic-abiotic interactions, food chains and networks, population dynamics, and the impact of environmental change (Herman et al., 2022; Mambrey et al., 2022; Tasgin & Dilek, 2023). Research indicates that students are generally able to answer content-based questions, but struggle when asked to analyze, evaluate, and synthesize in real-world contexts (Cahyani et al., 2022; Casado-Ledesma et al., 2023; Rapanta & Felton, 2022). On the topic of ecosystems, students are also not used to building scientific arguments, drawing conclusions from data, or offering solutions to environmental problems (Cahyani et al., 2022; Cansoy et al., 2025; Trikoili et al., 2025). A limited variety of teaching strategies, assessments that lack emphasis on critical thinking, and suboptimal instructional supervision (Cáceres et al., 2020; Levy-Feldman, 2025; Naumovski & Naumovska, 2022) all contribute to this obstacle.

Over the past decade, numerous studies have highlighted the link between learning models and the improvement of students' critical thinking skills and learning outcomes in ecosystem topics. Agustini et al. (2025) found that the application of outdoor-based Discovery Learning to high school students in grade X in Palembang improved critical thinking skills and learning outcomes, with both gains being in the moderate category (≈0.66 for critical thinking and ≈0.69 for learning outcomes). The findings align with the meta-analysis by Antofonio & Prudente (2023), which reported a significant effect ($g \approx 0.893$) of the inquiry approach on higher-order thinking skills, despite the diversity of research contexts across educational levels and disciplines. Local studies by Mayarni & Nopiyanti (2021) also showed a very high correlation ($r = 0.812$) between analytical and critical thinking skills in ecosystem learning in high school. However, managerial aspects such as principal supervision and evaluation systems have not been discussed. Meanwhile, Azrai et al. (2025) found significant effectiveness in STEAM-based digital media in improving understanding of ecosystem concepts. However, the research primarily focuses on cognitive achievement rather than comprehensive learning management, which involves teacher strategies, leadership, and evaluation.

Although various studies have confirmed the effectiveness of learning models such as PBL and inquiry in improving students' critical thinking skills and learning outcomes, there is a gap in the literature that explores how learning management as a whole, including the role of teachers as strategy designers, principals as instructional leaders, and learning evaluation systems contribute to students' critical thinking skills in ecosystem materials in high school. Most studies have only highlighted the effects of learning models in isolation, without examining the institutional and school leadership contexts that facilitate or hinder their implementation. Additionally, the role of school principals in fostering an academic climate through critical reflection has not been empirically studied in relation to learning outcomes. This gap is important, considering that a systematic and synergistic managerial approach greatly determines the success of strengthening critical thinking skills at the secondary school level.

This research makes a new contribution by examining learning management as a strategic ecosystem that encompasses teachers, principals, and evaluation systems within a single, interrelated practice unit. Unlike previous studies that focused only on one aspect of learning strategies or one actor, this study integrates the dimensions of principal instructional leadership, management of teacher strategies in the classroom, and the design of a critical thinking-based evaluation system. In addition, this study examines complex and contextual ecosystem topics as learning contexts that demand multidimensional understanding, making them suitable for measuring the success of critical learning. With an exploratory qualitative approach, this study will also explore the practices and direct reflections of actors in the field. Such a combination of dimensions has not been widely found in the Scopus literature, which is generally experimental or quantitatively focused. Thus, the results of this study will enrich managerial perspectives in science education at the secondary level.

Critical thinking skills are a key prerequisite for successful science learning, particularly in ecosystem topics that require a systemic and analytical understanding. However, in practice, the achievement of these skills is still low due to less supportive approaches to learning and classroom management. This research argues that improving critical thinking and student learning outcomes cannot be achieved solely by changing learning methods but requires an integrated managerial approach at both the classroom

and institutional levels. Teachers play the role of designers of reflective learning strategies, principals as directors of critical academic climates, and evaluation systems as a measure of high-level thinking. The core argument of this study is that the synergy between learning strategy planning, instructional leadership, and cognitive reflection-based evaluation largely determines the success of science education. Using a qualitative approach, this study demonstrates that structured and reflective learning management practices will directly contribute to enhancing critical thinking and student learning achievement at the high school level.

RESEARCH METHOD

This study employs a case study design with a qualitative approach to understand in depth how learning management by teachers and principals can encourage critical thinking skills and improve student learning outcomes in ecosystem materials. This design was chosen because it allows for contextual exploration of managerial practices within a real learning environment (Ajgaonkar et al., 2022; Andersen et al., 2022; Marougkas et al., 2023). The type of case study research is exploratory and in-depth, relevant to exploring the managerial strategies of teachers and principals in detail, including reflective teaching practices, analysis-based evaluation, and strengthening the academic culture of critical thinking in schools (Chen & Esmaeilzadeh, 2024; Cleland et al., 2021; Makri & Neely, 2021). The qualitative approach is employed based on the theory of social constructivism, which posits that knowledge is constructed through social interaction and contextual experience (Alhazmi & Kaufmann, 2022; Burns et al., 2022; Urcia, 2021). In this context, learning management is considered a dynamic process that is influenced by values, policies, and practices at the classroom and institutional level. The research setting is a State High School in Jember Regency that has implemented a HOTS-based learning strategy and reflective supervision.

Data were collected through in-depth interviews, participatory observations, and documentation of learning tools and materials. Interviews were conducted with biology teachers, principals, and vice heads of curriculum to explore managerial practices in designing and evaluating learning strategies. Participatory observation was carried out during the learning process in the ecosystem classroom to capture the dynamics of interaction, the use of triggering questions, and assessment strategies. Documentation includes lesson plans, HOTS assessment rubrics, and minutes from the teacher reflection forum. The researcher plays the role of both an observer and a passive participant, maintaining an objective distance while having full access to school activities. Informants were selected purposively based on the criteria of teaching experience and involvement in learning planning (Hicks et al., 2021; Muhoza et al., 2021; Pahwa et al., 2023). Data validity is maintained through triangulation of sources and techniques, member checking, and documentation trail audits (Marougkas et al., 2023; Muhoza et al., 2021; Urcia, 2021).

Data analysis was conducted using the Miles & Huberman interactive model, which comprises three main steps: data reduction, data presentation, and conclusion/verification (Briand et al., 2023; Bustamante et al., 2022; Sari et al., 2022). Data reduction is carried out from the beginning of data collection by sorting relevant information from interviews, observations, and documents. The reduced data were then presented in the form of a thematic matrix that described the relationship between managerial strategies and the improvement of students' critical thinking skills.

Furthermore, conclusions are drawn inductively based on consistent patterns of findings and validated through member checking. This model was chosen because it offers the flexibility of iterative and in-depth analysis of complex phenomena's dynamics. The use of this technique also enhances the credibility of the data by allowing researchers to reflect on the meaning and context of the findings continually. The results of the analysis provide a structured picture of the contribution of learning management by teachers and principals in shaping a learning environment that stimulates critical thinking and improves student learning outcomes.

RESULT AND DISCUSSION

Result

Teacher Learning Strategy Management to Encourage Critical Thinking Skills

Learning strategy management refers to the ability of teachers to design, implement, and evaluate the learning process in a structured manner to achieve specific goals. In this context, the primary goal is to develop students' critical thinking skills, particularly in ecosystem materials that require analysis, evaluation, and problem-solving. The strategy in question includes the selection of learning approaches, methods, techniques, and classroom management that are adaptive to the needs of students. This theme is relevant in the research because it shows that the success of learning depends not only on the material or facilities, but also on the management strategies employed by teachers as classroom managers. When learning strategies are well managed, students will be more motivated to think deeply, reflectively, and analytically. Therefore, the focus of this theme is to explore teachers' managerial practices in learning as a factor that contributes to the improvement of critical thinking skills and student learning outcomes.

Teachers are aware of the importance of learning strategies that not only transfer information, but also stimulate students' way of thinking. One of the biology teachers stated, "I did design learning activities that, from the beginning, were able to arouse students' curiosity. For example, I open the class with a scenario of pollution cases in local river ecosystems. Then I ask open-ended questions such as 'What are the long-term impacts on the food chain?' or 'What if the role of decomposers is disrupted?' Questions like these encourage students not just to memorize, but to start analyzing, structuring arguments, and criticizing each other's answers." This was also emphasized by other teachers, "In practice, I combine group discussions and presentations so that they challenge each other's ideas. It makes them more open and reflective".

Through the results of the interview above, teachers play an active role in managing learning strategies in a planned and reflective manner. The use of trigger questions and case studies in learning is part of a cognitive management strategy that aims to direct students to think at the level of analysis and evaluation. The combination of group discussions and presentations also demonstrates the effective management of learning interactions, encouraging students to test each other's ideas and develop their arguments. These practices reflect the principles of effective learning management, specifically the presence of teacher awareness in creating a challenging yet structured learning environment. This approach aligns with the research focus, which emphasizes that improving learning outcomes is inseparable from teachers' success in designing learning strategies that foster students' critical thinking skills, particularly in the context of complex and applicable ecosystem materials. Departing from this, the form of learning strategies found is presented in Figure 1.

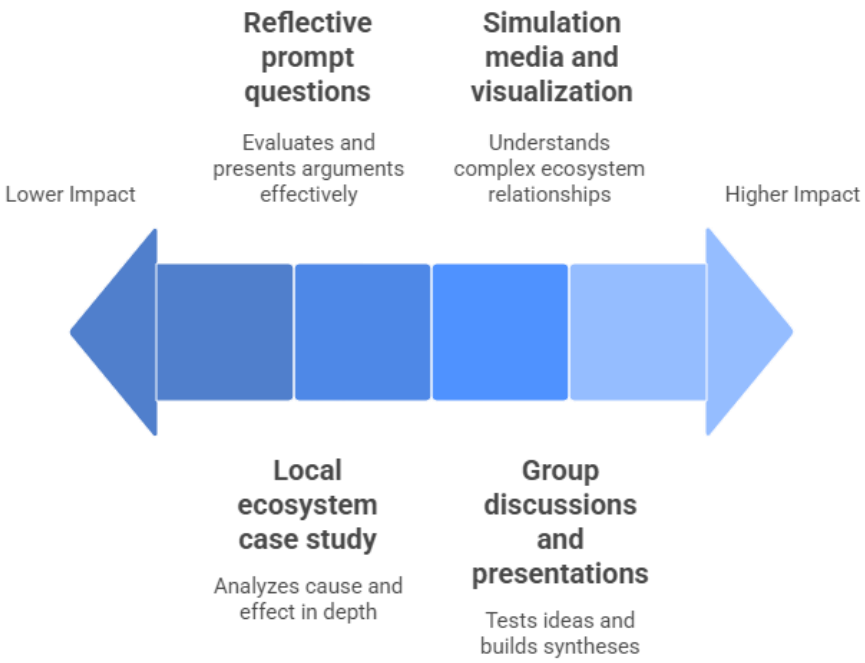

Figure 1. Teacher learning strategies ranked by student critical thinking impact

Based on the description of the findings above, the management of learning strategies by teachers is an integral part of learning management, which directly contributes to the improvement of students' critical thinking skills. Teachers who consciously design and implement strategies based on reflection, analysis, and interaction can create challenging and productive learning spaces. The application of case studies, discussions, and visual media becomes an effective managerial instrument to encourage students to think at a higher cognitive level. On the other hand, limited training and administrative burden are still obstacles to overall implementation. Therefore, these findings make an important contribution to strengthening the role of teachers as classroom managers and strategies, and emphasize that improving student learning outcomes is closely related to learning management that supports critical thinking.

The Managerial Role of School Principals in Creating an Academic Climate for Critical Thinking

The managerial role of a principal includes responsibility for designing, directing, and evaluating various operational and academic aspects of the school. In this context, school principals play a strategic role in creating an academic environment that fosters the development of students' critical thinking skills. This is achieved through policy-making, learning supervision, teacher empowerment, and the management of training programs and learning innovations. This theme is important because it demonstrates that the achievement of student learning outcomes, particularly in the area of critical thinking, is not solely determined by teachers in the classroom, but also by the principal's leadership in creating a conducive learning environment. By fostering a collaborative, open, and reflection-based school culture, school principals can play a key role in managing education quality, focusing on the development of students' critical thinking.

According to the interview results, the principal emphasized the importance of creating a learning environment that encourages students to think actively. He stated:

"One of the things we emphasized in the weekly teacher meeting is the importance of creating a learning atmosphere that not only focuses on cognitive achievement, but also encourages students to get used to thinking analytically. I encourage teachers to present every material, including routine ones such as ecosystems, with an approach that sparks students' curiosity. For example, we often discuss how to insert open-ended questions or actual case studies that can get students not only to answer, but also to ask again."

Other teachers also emphasized this:

"On the curriculum side, we have indeed programmed routine training for teachers, especially those related to the implementation of HOTS-based learning. In the training, teachers received not only material but also the opportunity to create problem-based lesson plans and LKPD, as well as participate in classroom simulations. After the training, we also assist when teachers start to implement these strategies in the classroom, and we evaluate them together in a reflection forum."

The description indicates that school leaders have a strong awareness of the importance of critical thinking as a crucial foundation for achieving high-quality learning outcomes. The principal does not stop at providing normative direction, but follows up on it through the consistent management of training, supervision, and learning evaluation. Routine forums such as teacher meetings are used as a managerial vehicle to encourage innovation in teaching strategies. In addition, the monitoring of learning tools, including lesson plans, emphasizes that school management positions itself as a director of instructional quality. This pattern reflects the practice of management based on academic vision, where the principal plays the role of an instructional leader who initiates a reflective learning environment while fostering a culture of critical thinking. Thus, the role of the principal is crucial in forming a school culture that supports the development of students' reasoning powers, as well as ensuring that every effort made has a real impact on improving the quality of learning outcomes.

Table 1. Principals' Managerial Strategies in Building an Academic Climate for Critical Thinking

Dimensions of Managerial Strategy	Principal-Specific Initiatives	Implementation Mechanism
Instructional Leadership	Encourage teachers to design problem-based learning	Classroom supervision based on the critical thinking skills rubric
	Establishing HOTS indicators in school assessments	Integration of HOTS indicators in daily and summative scoresheets
System and Program Support	Providing regular training in innovative learning for teachers	Monthly workshop with facilitators from LPTK and supervisors
	Forming a learning tool development team	Cross-subject teacher collaboration in the development of lesson plans
Strengthening the School's Academic Culture	Compile an academic calendar that includes open discussion sessions for students to participate in.	Session "critical thinking student forum" facilitated by the student council and supervisors
	Embedding critical thinking values in school discipline and vision	Integration of analytical, reflective, and solutive principles in the school's vision-mission document

Building a critical thinking academic climate is a managerial strategy for school principals, as outlined in Table 1, which is implemented through three key dimensions.

First, in the aspect of instructional leadership, the principal encourages teachers to integrate problem-based learning and HOTS indicators in assessment. The rubric-based supervision mechanism and the integration of HOTS in the assessment instrument ensure that critical thinking skills are systematically measured. Second, through system and program support, school principals facilitate routine training with resource persons from LPTK and supervisors, and also form a team to develop cross-subject learning tools. This enhances the capacity of teachers and fosters collaborative innovations in lesson planning. Third, strengthening the school's academic culture is achieved through the preparation of an academic calendar that includes a forum for students to develop critical thinking skills and integrate analytical, reflective, and problem-solving values into the school's rules, visions, and missions. Thus, this strategy confirms that the leadership of school principals plays a crucial role in institutionalizing a culture of critical thinking as a whole.

Based on the results of the above research, the principal plays a crucial role in creating an academic climate that fosters students' critical thinking through a systematic managerial approach. Efforts such as teacher training, lesson plan evaluation, and strengthening a reflective culture are key strategies in ensuring that critical thinking values are integrated into all learning practices. The presence of academic symbols in the school environment, along with a designated space for reflection, strengthens the learning atmosphere that encourages analysis and exploration. The role of the principal is not only administrative, but also that of a learning leader who can facilitate the transformation of students' ways of thinking by strengthening teacher capacity and fostering a positive school culture. Thus, effective education management has proven to be a crucial foundation in enhancing learning outcomes by strengthening critical thinking skills.

Learning Evaluation System as a Managerial Instrument to Improve Learning Outcomes

The learning evaluation system in the context of education management serves not only as a measuring tool for academic achievement but also as a managerial instrument to direct, control, and improve the learning process. Evaluations managed with a managerial approach include indicator planning, selection of assessment forms, analysis of learning outcomes, and follow-up based on student achievement data. In this study, the evaluation system is not only intended to provide grades, but also to comprehensively map the achievement of students' critical thinking skills. When evaluation is designed to measure students' ability to analyze, synthesize, and reflect, it functions as a driving tool to improve the quality of learning. Therefore, this theme is relevant to demonstrate how planned and critical thinking skills-oriented evaluations can be an important component of a school's managerial strategy for improving overall learning outcomes.

In an interview, the Biology teacher explained the change in his approach to conducting assessments:

"In the past, I only judged the correct answer from the question. However, I have now started using the rubric of analysis, where students are asked to explain why they chose an answer and critically assess the case. We also use it as a reflection material in the classroom."

A deputy head of curriculum also added:

"We encourage teachers to not only focus on the grades, but also to make descriptions of students' critical thinking achievements, which are included in the report card. This helps us map out which classes need further intervention."

The two interviews above illustrate a significant shift in the practice of learning evaluation, from traditional functions as cognitive measuring tools to diagnostic instruments that emphasize critical thinking. Teachers no longer stop at assessing final results, but instead start using analysis-based rubrics to evaluate students' thinking processes more comprehensively. Thus, evaluation becomes an integral part of reflective learning strategies that encourage students to develop reasoning skills. At the same time, school management systematically manages the results of evaluations using a data-driven approach, laying the foundation for academic decision-making, such as the provision of remediation, special mentoring, and reassignment. This pattern suggests that evaluation is not merely a selection mechanism, but rather a means of enhancing the quality of learning. Therefore, an evaluation system managed by management plays an important role in ensuring that educational interventions are more targeted and oriented towards achieving meaningful learning outcomes.

Building on this, it is evident that a learning evaluation system designed and managed by a manager can significantly contribute to improving student learning outcomes. Evaluations based on critical thinking skills enable teachers and school management not only to quantify students' academic achievement but also to gain a deeper understanding of their cognitive processes. The use of evaluation results as a basis for academic decision-making, such as exceptional guidance, improvement of teaching methods, and enrichment of materials, demonstrates that evaluation has become an integral part of the learning quality management cycle. Thus, evaluation is no longer just an assessment of results, but rather part of an integrated managerial strategy to improve the quality of thinking and sustainably enhance student learning outcomes.

Discussion

The results of this study confirm that learning management plays a strategic role in improving students' critical thinking skills and learning outcomes, especially in learning ecosystem materials at the high school level. The research focused on identifying how the management of instructional strategies, principal leadership, and evaluation systems can shape students' reflective mindsets, as reflected in three main themes found in the field. The relevance of these findings is increasingly evident in the context of 21st-century learning needs, which no longer emphasize memorization but focus on the ability to analyze, evaluate, and create new knowledge. Therefore, this discussion will outline the relationship between empirical findings and education management theory, cognitive learning theory, and various valid previous studies, in order to strengthen the scientific position of the results of this research. Each theme will be critically analyzed to uncover the theoretical and practical contributions of managerial practice in critical thinking-based learning.

This study found that teachers play the role of classroom managers who consciously design high-level thinking-based learning strategies. Strategies such as case studies, reflective questions, collaborative discussions, and ecosystem visualizations reflect the application of the principles outlined in Vygotsky's theory of social constructivism (Badarnah, 2025; Cardenas Morales et al., 2025; Levin et al., 2025), which

emphasizes the importance of social interaction in the construction of knowledge. Research by Cahyani et al. (2022) shows that the use of contextual media in environmental case studies encourages students to analyze cause and effect in depth. These results are reinforced by (2019), which states that open-ended questions in science learning improve students' reflective thinking skills. Meanwhile, a study by Mayarni & Nopiyanti (2021) highlights that effective management of group discussions encourages students to synthesize ideas. The alignment between these findings and previous studies shows that adaptive and reflective learning strategy management is a crucial factor in shaping the critical thinking climate in the classroom.

The principal in this study plays the role of an instructional leader who not only manages the administration but also serves as a facilitator of academic cultural transformation. This finding aligns with studies by Agustini et al. (2025), Which Found that teacher training facilitated by school principals had an impact on changing teaching methods to be more analytical. Research by Antonio & Prudente (2023) also showed that reflection-based academic supervision improves the quality of lesson plans and the implementation of the HOTS strategy. These findings are corroborated by research (Levy-Feldman, 2025), which shows that symbolic reinforcement, such as critical thinking posters, can shape students' awareness of their thought process. Thus, school principals have proven to be strategic actors in building an academic ecosystem that encourages the birth of students' critical thinking skills.

The evaluation system, in the context of these findings, serves not only as a tool to measure learning outcomes but also as an instrument for enhancing the data-driven learning process. According to research by van der Zanden et al. (2020), the critical thinking evaluation rubric encourages students to formulate more logical arguments. Other studies by Chen & Esmaeilzadeh (2024) revealed that the qualitative description in the report card helps teachers in determining advanced learning strategies. Meanwhile, Sari et al. (2022) emphasize the importance of digital evaluation as a tool for monitoring learning progress in real-time. These three studies reinforce the finding that evaluations managed managerially through rubrics, narrative descriptions, and digital platforms can significantly improve the quality of students' thinking and learning outcomes.

Practically, this study provides an important reference for school managers and teachers in integrating learning management with a critical thinking approach. Teachers can develop more reflective instructional strategies, while principals are encouraged to create support systems, such as supervision, training, and evaluation, that are oriented towards the quality of students' thinking. For education policymakers, the results of this research can serve as a basis for formulating 21st-century competency-based school management policies. Theoretically, this study contributes to the strengthening of HOTS-based learning management models by demonstrating that critical thinking skills can be developed systematically through measurable managerial interventions. This research also expands the understanding that the effectiveness of learning outcomes is not only influenced by content but also by the underlying management process.

Overall, the discussion of the three main themes reveals that comprehensive learning management, encompassing teacher strategies, principals' leadership, and evaluation systems, makes a significant contribution to fostering critical thinking skills and enhancing student learning outcomes in ecosystem materials. The integration of the findings with previous theories and studies reinforces the argument that quality education is not only determined by the content of the curriculum, but also by the way

learning is strategically managed. This research highlights the importance of systemic and collaborative approaches in enhancing the quality of learning. In the future, further research can examine other dimensions, such as the role of school community culture and the integration of digital technology in learning management, as well as longitudinal analysis of the impact of critical thinking on long-term academic achievement.

CONCLUSION

This research confirms that effective learning management plays a central role in improving students' critical thinking skills and learning outcomes, especially in ecosystem materials at the high school level. Learning strategies designed reflexively by teachers, supported by a conducive academic climate through the leadership of the principal, as well as learning evaluations based on critical analysis, have been proven to encourage students to think more analytically, reflectively, and solutionally. A systematic managerial approach to designing learning activities, supporting teachers through training, and utilizing evaluation as a diagnostic tool directly contributes to achieving more meaningful learning outcomes. These findings indicate that improving the quality of education depends not only on the cognitive aspects of students, but also on the synergy between teachers, principals, and strategically managed evaluation systems. This research provides an important foothold for the development of a learning management model that is oriented towards sustainably strengthening critical thinking.

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