



**The Effectiveness of a Gamified Project-Based Learning Model
in Enhancing Engagement and Motivation in Early Childhood
STEAM Education**



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Abstrak

Pembelajaran anak usia dini idealnya berlandaskan prinsip belajar melalui bermain yang menekankan keterlibatan aktif dan pengalaman langsung anak. Namun, praktik pembelajaran di PAUD masih didominasi pendekatan konvensional dan berpusat pada guru, sehingga berdampak pada rendahnya minat, motivasi, dan keterlibatan belajar anak. Penelitian ini bertujuan untuk mengembangkan model pembelajaran proyek berbasis gamifikasi bermuatan STEAM (Science, Technology, Engineering, Art, and Mathematics) serta menguji efektivitasnya dalam meningkatkan motivasi dan keterlibatan belajar anak. Penelitian menggunakan metode Research and Development (R&D) dengan prosedur ADDIE yang meliputi tahap analysis, design, development, implementation, dan evaluation. Subjek uji coba adalah anak kelompok B di TK PKK 4, Kabupaten Pasuruan. Teknik pengumpulan data meliputi observasi, wawancara, dan dokumentasi. Kelayakan model dinilai melalui validasi ahli materi, ahli desain pembelajaran, dan ahli media. Uji efektivitas dilakukan menggunakan desain pre-eksperimental dengan analisis peningkatan skor melalui N-Gain dari hasil pretest dan posttest motivasi serta keterlibatan belajar anak. Hasil penelitian menunjukkan bahwa model pembelajaran STEAM berbasis gamifikasi dinyatakan valid dan layak digunakan, dengan persentase validasi ahli materi sebesar 79,4% (valid) dan ahli desain pembelajaran sebesar 96,6% (sangat valid), serta perbaikan desain media berdasarkan masukan ahli. Penerapan elemen gamifikasi berupa misi, poin, tantangan, dan lencana terbukti mampu meningkatkan minat dan partisipasi aktif anak dalam pembelajaran. Nilai N-Gain sebesar 0,5 menunjukkan peningkatan motivasi dan keterlibatan belajar anak pada kategori sedang. Dengan demikian, model pembelajaran STEAM berbasis gamifikasi efektif dalam meningkatkan motivasi dan keterlibatan belajar anak usia dini.

Abstract

Early childhood learning should be grounded in the principle of learning through play, which emphasizes active engagement and direct experience. However, learning practices in early childhood education institutions are still dominated by conventional, teacher-centered approaches, resulting in low levels of children's interest, motivation, and learning engagement. This study aims to develop a gamification-based project learning model incorporating STEAM (Science, Technology, Engineering, Art, and Mathematics) and to test its effectiveness in increasing children's motivation and engagement in learning.. This research employed a Research and Development (R&D) method using the ADDIE procedure, which includes the stages of analysis, design, development, implementation, and evaluation. The research subjects were Group B children at TK PKK 4, Pasuruan Regency. Data were collected through observation, interviews, and documentation. The feasibility of the learning model was evaluated through validation by subject matter experts, instructional design experts, and media experts. The effectiveness of the model was tested using a pre-experimental design by analyzing the improvement scores through N-Gain based on pretest and posttest results of children's motivation and learning engagement. The results showed that the gamification-based STEAM learning model was valid and feasible for use, with subject matter expert validation reaching 79.4% (valid) and instructional design expert validation reaching 96.6% (very valid), along with media design revisions based on expert feedback. The implementation of gamification elements such as missions, points, challenges, and badges effectively increased children's interest and active participation in learning activities. The N-Gain score of 0.5 indicated a moderate improvement in children's motivation and learning engagement. Therefore, the gamification-based STEAM learning model is effective in enhancing motivation and learning engagement in early childhood education.



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INTRODUCTION

Early childhood education theoretically emphasizes the principle of learning through play, which requires active engagement, direct experience, and a supportive learning environment (Parker et al., 2022; Pramono et al., 2017). This principle aligns with constructivist perspectives and experiential learning theories that position children as active agents in the learning process (Kertati et al., 2023). However, in practice, the

implementation of learning in early childhood education settings still reveals a gap between ideal concepts and classroom realities. Learning tends to remain conventional, teacher-centered, and heavily reliant on worksheets and textbooks, thereby limiting opportunities for children's exploration. Such conditions have implications for low levels of learning motivation and engagement among children, as reflected in behaviors such as boredom, lack of focus, and incomplete participation in learning activities. In fact, learning engagement is a crucial prerequisite for meaningful learning, especially in early childhood, where learning occurs through direct interaction with the environment (Wang et al., 2019; Zuhriyah et al., 2025)

Previous studies have shown that gamification and STEAM-based learning approaches hold significant potential for enhancing student motivation and engagement. Gamification is understood as the application of game elements in non-game contexts to encourage participation and motivation (Mahbubi, 2025; Schott, 2025; Srimuliyani, 2023). Meanwhile, STEAM learning emphasizes the integration of science, technology, engineering, arts, and mathematics through exploratory and contextual activities relevant to children's daily lives. Research findings indicate that gamification increases enthusiasm and engagement, while STEAM contributes to the development of creativity and critical thinking skills (Isnaningrum & Marlioni, 2025; Jasmaniah et al., 2025). However, most existing studies focus on primary to higher education levels or examine these approaches separately. Research integrating gamification within STEAM learning in early childhood education contexts remains relatively limited.

The novelty of this study lies in the development of a gamified project-based learning model integrated with STEAM, designed systematically and contextually in accordance with the characteristics of early childhood learners. This model utilizes project-based activities as the core of learning, incorporates game elements (gamification), and integrates STEAM components (Science, Technology, Engineering, Art, and Mathematics) into each stage of the learning process, thereby creating active, enjoyable, and meaningful learning experiences for young children.

Unlike previous studies that tend to focus on a single approach, this research not only develops an instructional model and its accompanying guidebook but also empirically tests its effectiveness. The findings indicate improvements in children's motivation and learning engagement following the implementation of the model, encompassing cognitive,

emotional, and behavioral aspects. Therefore, this study contributes to the development of innovative learning models in early childhood education.

Based on the identified problems and research gaps, this study aims to examine the effectiveness of the developed learning model. The primary issue addressed relates to the low levels of motivation and engagement in early childhood STEAM learning that has not yet been integrated with appropriate motivational strategies. Accordingly, the research question is formulated as follows: How effective is a gamified project-based STEAM learning model in enhancing engagement and learning motivation among early childhood learners? This question serves as the central focus in evaluating the model's effectiveness in addressing learning challenges in early childhood education.

This study is grounded in the argument that integrating gamification into STEAM learning can enhance motivation and engagement among young learners (Isnaningrum & Marliani, 2025; Jasmaniah et al., 2025; Purba et al., 2024). Gamification provides clear goals, progressive challenges, and immediate feedback that foster emotional engagement, while STEAM offers meaningful learning experiences through exploration and creative production (Dinihari et al., 2024). The findings demonstrate that children become more enthusiastic, actively participate, and show greater focus in completing learning activities after the implementation of the model. Thus, the gamified project-based STEAM learning model has strong potential as an effective alternative strategy to improve the quality of early childhood education, particularly in enhancing learning motivation and engagement.

LITERATURE REVIEWS

Over the past decade, research has increasingly emphasized early childhood learning approaches that prioritize active engagement, hands-on experiences, and learning through play. Within this context, STEAM (Science, Technology, Engineering, Arts, and Mathematics) has emerged as an integrative approach that encourages children to explore, solve problems, and create contextually meaningful products. The literature indicates that STEAM in early childhood education contributes significantly to the development of critical thinking, creativity, and problem-solving skills (Isnaningrum & Marliani, 2025; Mansoer et al., 2025; Suryaningsih, 2024).

STEAM learning in early childhood is commonly implemented through a project-based learning model. Project-Based Learning (PjBL) is an instructional approach

grounded in constructivist principles, problem-solving, inquiry, integrated learning, and reflection. It emphasizes a balance between theoretical understanding and practical application, allowing learners to design and implement projects individually or collaboratively to produce tangible outcomes (Sari & Zulfah, 2017). However, several studies reveal that the implementation of STEAM still faces challenges, including limited teacher understanding, lack of methodological variation, and low levels of children's engagement in exploratory activities. These conditions suggest that the effectiveness of STEAM depends not only on content but also on pedagogical strategies that can optimally motivate and engage learners.

In line with these developments, gamification has become a widely discussed approach in educational research over the past decade. Gamification refers to the application of game elements—such as points, levels, challenges, and rewards—into non-game contexts to enhance motivation and learner engagement (Dinihari et al., 2024; Purba et al., 2024). Previous studies demonstrate that gamification effectively increases enthusiasm, attention, and participation across various educational levels. In early childhood contexts, gamification has been shown to create enjoyable learning environments while fostering emotional and behavioral engagement (Fauziyah et al., 2025; Moyo et al., 2025; Ocha & Laksana, 2025). Nevertheless, most studies treat gamification as a supplementary strategy rather than integrating it systematically into a comprehensive learning model, often emphasizing extrinsic rewards without sufficient pedagogical design to support intrinsic motivation. .

Literatur juga menunjukkan bahwa motivasi dan keterlibatan belajar merupakan dua konstruk utama yang menentukan kualitas pembelajaran anak usia dini. The literature further highlights that motivation and learning engagement are two key constructs determining the quality of early childhood education (Erlangga et al., 2024). Learning motivation refers to internal and external drives that encourage children to actively participate in learning activities, while engagement encompasses behavioral, emotional, and cognitive involvement. Recent studies affirm that young children learn most effectively when they are interested, emotionally involved, and physically active during the learning process (Srimuliyani, 2023). However, empirical evidence indicates that conventional, teacher-centered instruction contributes to low levels of motivation and engagement. Therefore, learning approaches that are enjoyable, challenging, and

meaningful are more effective in fostering intrinsic motivation and sustaining children's engagement (Erlangga et al., 2024).

The gamified project-based STEAM learning model is conceptualized as an instructional approach that utilizes project activities as the core of learning, integrates game elements (gamification), and embeds STEAM components (Science, Technology, Engineering, Art, and Mathematics) into each stage of the learning process. This model is designed to create active, engaging, and meaningful learning experiences for early childhood learners. It represents a development of project-based learning integrated with gamification elements and STEAM content as the foundation of learning activities. Rahmaniati (2026) supports the use of models such as Project-Based Learning, STEAM, and technology-based learning to create educational ecosystems that foster 21st-century skills. Gamification, in particular, can attract learners' interest, and its integration with project-based STEAM learning further enhances motivation and engagement..

Recent studies have begun to explore the integration of STEAM with motivational strategies, including gamification. Findings suggest that combining STEAM with gamified activities can improve the overall quality of children's learning experiences (Khuluq et al. 2023; Andhianto et al., 2024; Marwiyah, 2022). However, most research remains partial, either focusing solely on STEAM without strong motivational strategies or applying gamification without clear integration into the learning model. Moreover, studies that specifically develop and empirically test a structured gamified project-based STEAM model tailored to early childhood characteristics are still limited. This gap highlights the need for more comprehensive and sustainable instructional models..

Based on the analysis of the past decade's literature, it can be concluded that project-based learning, gamification, and STEAM each hold significant potential for enhancing motivation and engagement in early childhood education. However, their integration into a unified and systematic learning model has not been extensively explored. Therefore, the development of a gamified project-based STEAM learning model is highly relevant to address the issue of low motivation and engagement among young learners. Existing literature provides a strong theoretical foundation that integrating STEAM exploration with contextually designed gamification elements can create enjoyable, meaningful, and process-oriented learning experiences while contributing to the advancement of innovative learning practices in early childhood education.

Critically, the integration of PjBL, STEAM, and gamification in early childhood education reflects a paradigm shift from product-oriented learning toward process-oriented and meaningful learning experiences. While products remain as representations of children's work, the primary success lies in increased motivation, active engagement, basic critical thinking skills, and social collaboration. Thus, the gamified project-based STEAM model is not merely a methodological adaptation but represents a responsive instructional innovation aligned with children's developmental characteristics and the demands of 21st-century competencies.

METHOD

This study employed a Research and Development (R&D) design aimed at developing and testing the effectiveness of a gamified project-based STEAM learning model in enhancing motivation and learning engagement among early childhood learners. The development process followed the ADDIE framework, which includes five stages: analysis, design, development, implementation, and evaluation. This design was selected as the study seeks not only to examine phenomena but also to produce a valid and effective instructional model applicable in early childhood education settings.

The study utilized both qualitative and quantitative data. Qualitative data were collected to describe learning needs, children's characteristics, and the responses of teachers and students to the implementation of the developed model. Quantitative data were used to measure children's motivation and engagement levels before and after the implementation of the gamified project-based STEAM model.

The research subjects consisted of early childhood learners at TK PKK 4 Pasuruan Regency, with classroom teachers serving as supporting informants. Additional data sources included relevant instructional documents related to the teaching and learning process.

Data collection techniques included observation, interviews, questionnaires, and documentation. Observations were conducted to assess children's learning engagement during instructional activities using structured observation guidelines. Interviews with classroom teachers were carried out to gather information on initial learning conditions, challenges encountered, and perceptions of the implemented model. Questionnaires were used to analyze learning needs and to conduct expert validation of the developed product.

Documentation included photographs of activities, lesson plans, and children's work produced during the study.

Data analysis was conducted using both descriptive and inferential techniques. Qualitative data were analyzed through data reduction, data display, and conclusion drawing to describe the development and implementation processes of the learning model. Quantitative data were analyzed by comparing pre- and post-implementation measurements of children's motivation and engagement. The effectiveness of the model was assessed using the N-Gain score to determine the extent of improvement resulting from the intervention.

The measurement of learning motivation and engagement variables was conducted using instruments developed based on indicators relevant to early childhood characteristics. Learning motivation was assessed through indicators such as children's interest in learning activities, persistence in completing tasks, and enthusiasm during the learning process. Learning engagement was measured through behavioral, emotional, and cognitive involvement in gamified STEAM activities. The instruments underwent expert validation and readability testing to ensure their suitability for early childhood developmental levels

RESULTS AND DISCUSSION

The development of the learning model was carried out through the ADDIE framework, which includes the stages of Analysis, Design, Development, Implementation, and Evaluation. The outcome of this development process is a set of instructional syntax for a gamified project-based STEAM learning model, which has been compiled into a teacher guidebook..

1. Presentation of the Developed Product

a. Analysis Stage (Needs Analysis)

This study was motivated by the low levels of motivation and learning engagement among preschool children, resulting from instructional practices that remain conventional, teacher-centered, and dominated by the use of books or worksheets. As a result, children tend to be passive, easily bored, and less able to sustain attention and concentration. This condition has led to suboptimal development of cognitive abilities, creativity, and scientific thinking, as well as low achievement of STEAM-related indicators.

In addition, gamification elements such as missions, points, and rewards have not been systematically implemented. Although the needs analysis indicates that teachers are familiar with STEAM concepts, their application remains inconsistent and has not yet incorporated gamification-based approaches. Therefore, there is a need for an innovative learning model that is more active, engaging, and exploration-based through the integration of gamification into STEAM learning. This approach is expected to enable children to learn interactively through exploration, experimentation, problem-solving, and creative expression, thereby enhancing their motivation, participation, and overall learning engagement.

b. Design Stage

This stage began with the design of instructional syntax for a gamified project-based STEAM learning model, which represents the integration of project-based learning with gamification elements. The integration of these two approaches resulted in a structured set of learning phases, as presented in Table 1.

Table 1 Syntax of the Gamified Project-Based Learning Model

No.	Gamified Project Phase	Teacher Activities	Student Activities
1	Storytelling and Mission Setting	Presents contextual stories (through puppets, images, videos, or short role-play). Problems are framed as playful challenges.	Children select and agree on the project mission with guidance through open-ended questions from the teacher.
2	Play-Based Exploration	Facilitates exploration and provides appropriate scaffolding based on children's ideas.	Children engage in experiments, observations, and small-group discussions. Children create products, artworks, or real actions based on their exploration experiences.
3	Creation and Presentation	Provides emotional support and acts as a communication facilitator.	After completion, they present their work in their own ways: storytelling, pointing, role-playing, or demonstrations.
4	Reflection and Reinforcement	Facilitates children in recounting their experiences and appreciates their efforts by providing certificates or badges. Reinforcement is based on effort	Children reflect on their experiences through simple conversations or concrete media. They express feelings, share experiences, evaluate

No.	Gamified Project Phase	Teacher Activities	Student Activities
		rather than outcomes to maintain intrinsic motivation.	preferences, and listen to their peers.

Table 1 illustrates four main phases in the gamified STEAM-based learning model: (1) Storytelling and Mission Setting, (2) Play-Based Exploration, (3) Creation and Presentation, and (4) Reflection and Reinforcement. Furthermore, a teacher guidebook was designed to support the implementation of the gamified project-based learning model. This guidebook contains materials on gamified STEAM learning as well as sample lesson plans or extended teaching modules..

c. Development Stage

This stage focuses on the production and refinement of instructional materials and supporting tools. Various learning resources were developed, including teaching modules, children’s activity sheets, instructional media, and simple educational games where feasible, while considering safety and ease of use for young learners. The teaching module was developed using the theme “Water.” The preparation of the lesson plan followed the 2024 guidelines for instructional planning issued by the Ministry of Education, Culture, Research, and Technology. At a minimum, the lesson plan includes learning objectives, learning activities, and assessment components (Kemendikbudristek, 2024). The gamification elements incorporated in the model include levels, badges, points or stars, challenges or missions, and rewards. At this stage, the developed materials and products were validated by experts, including early childhood education specialists, subject matter experts, instructional design experts, and educational media experts, to assess their relevance, feasibility, and effectiveness. Based on the validation results, revisions were made to improve the learning model. The next step involved conducting individual trials followed by small group trials.

d. Implementation Stage

The implementation stage involves applying the model in an actual learning context. The learning model was tested in a preschool classroom on a limited scale to observe its practical application. During this stage, observations were conducted to

examine children's motivation and engagement, their responses to gamification elements, and their developmental progress in relation to the established learning objectives.

e. Evaluation

The evaluation stage aims to assess the effectiveness and overall success of the learning model. To continuously improve both the product and instructional strategies, formative evaluation was conducted at each stage of the process (analysis, design, development, and implementation). A summative evaluation was carried out after the implementation phase to determine the extent to which the model enhanced preschool children's motivation and engagement in learning. Data from observations, interviews, and documentation were used as the basis for evaluation. The evaluation instruments included observation sheets on children's motivation and engagement, as well as pre-tests and post-tests.

2. Presentation of Trial Data Analysis

The trials were conducted after the product had been validated by experts. Data collection was based on the results of expert validation, individual trials, small group trials, and field trials in an actual classroom setting.

a. Validation Results Analysis

Product validation by the instructional design expert was conducted by a lecturer in Early Childhood Education at the Faculty of Education, Universitas Negeri Malang, namely Dr. H. Ahmad Samawi, M.Hum., on September 18, 2025. The validation result showed a score of 96.6%, indicating a very high level of validity. Validation by the subject matter expert, Dr. Yudithia Dian Putra, M.Pd., M.M., was conducted on October 29, 2025, resulting in a score of 79.4%, which falls into the valid category.

Validation by the educational media expert, Dr. Ajeng Putri Pratiwi, S.Pd., M.Pd., was conducted on November 6, 2025, yielding a score of 94%, categorized as highly valid.

The average score from all validators was 90.13%, indicating that the gamified project-based STEAM learning model falls into the "very valid" category.

b. Individual Trial Analysis

Based on the validation results, the model was declared feasible for implementation. The individual trial was conducted with two children aged 5–6 years at TK PKK 4 Dewi,

Pasuruan Regency, on December 1, 2025. This trial aimed to obtain initial insights into the model's acceptability and effectiveness. The evaluation criteria included ease of use, practicality, attractiveness, and effectiveness.

c. Small Group Trial Analysis

The model was tested on a small group of four preschool children aged 5–6 years at TK PKK 4, Pasuruan Regency. The trial was conducted on December 2, 2025, resulting in a percentage score of 95.8%, which falls into the “very good” category in terms of material and media attractiveness. The evaluated aspects included clarity of task instructions and task distribution.

d. Field Trial Analysis (Actual Classroom)

The model was implemented in a real classroom setting involving ten preschool children aged 5–6 years at TK PKK 4, Pasuruan Regency. The implementation took place on December 13, 2025, resulting in an implementation rate of 92.8%, categorized as very good

To evaluate the model's effectiveness and efficiency in improving children's motivation and engagement, observations as well as pre-tests and post-tests were conducted. The N-Gain analysis yielded a score of 0.5, categorized as moderate, indicating an improvement in children's motivation, engagement, and understanding after participating in gamified STEAM-based learning.

Based on the field implementation results, it can be concluded that the developed gamified project-based STEAM learning model falls into the “very good” category. This finding is supported by teacher interviews, which indicate that the model is easy to implement, the gamification flow is easy to understand, the model is practical for classroom use, and the activities are engaging—particularly the use of a star board, which effectively motivates children. Additionally, the model can be applied both individually and in groups, and the gamification rules are clear and easy to follow.

DISCUSSION

The findings of this study indicate that the gamified project-based STEAM learning model significantly improves preschool children's motivation and learning engagement, with the average gain score falling within the moderate category. This finding is consistent

with contemporary studies demonstrating that gamification enhances student engagement through game elements that promote goal orientation, immediate feedback, and a sense of achievement (Hellín et al., 2023; Purba et al., 2024). Even in early childhood learning contexts, the integration of gamification elements with hands-on activities has been shown to strengthen learning interest and reduce boredom, thereby increasing both emotional and behavioral engagement (Lledó et al., 2023; Wijoyo, 2025; Zakiyah et al., 2025). However, the moderate level of improvement observed in this study differs from findings in studies involving older students or higher educational levels, which tend to report stronger effects. This difference may be attributed to the developmental characteristics of young children, who require more direct experiences and intensive social support in the learning process.

The primary implication of this finding is that gamification functions as a motivational architecture that structures meaningful learning experiences, rather than merely serving as a tool for entertainment. This is in line with LuoLuo (2022) who found that gamification designed to support concrete and relevant learning experiences is more effective in fostering sustained situational interest and cognitive engagement compared to approaches that rely solely on extrinsic rewards. In the context of this study, the use of task points, group missions, and process-oriented reinforcement helped facilitate intrinsic motivation rather than motivation driven purely by external rewards, supporting findings that intrinsic motivation is a stronger predictor of long-term engagement than extrinsic motivation alone (Mahbubi, 2025).

The increase in learning engagement can also be explained by the model's ability to fulfill children's basic psychological needs, including competence, autonomy, and social connection. Chen et al., (2024) reported that learning environments structured to provide opportunities for collaborative social interaction and progressive achievement consistently influence students' behavioral and cognitive engagement. This relationship is further supported by studies indicating that learning experiences that are challenging yet achievable promote self-efficacy and a sense of competence among young learners, which in turn strengthens their participatory behavior in learning tasks ((Hikmat & Hidayat, 2025; Li et al., 2024; Zainuddin et al., 2024) Furthermore, the findings reveal that STEAM components function not merely as additional content but as a cognitive structure that enhances meaningful learning. The exploration of real-world problems, collaboration among children, and reflection on learning outcomes foster the simultaneous development

of critical thinking and creativity. This aligns with the findings of Roussou et al., (2025) yang menunjukkan bahwa pembelajaran STEAM yang terintegrasi dengan aktivitas which demonstrate that STEAM learning integrated with contextual activities improves both engagement and conceptual understanding compared to traditional approaches. In this regard, the integration of gamification and STEAM creates a learning framework that is not only engaging but also capable of stimulating higher-order thinking. This has important implications for early childhood education, which emphasizes active and meaningful learning experiences. This study also supports Huang et al., (2023), who argue that gamification can enhance students' interest in learning; therefore, its integration with project-based learning and STEAM content further strengthens students' motivation and engagement in the learning process..

CONCLUSION

This study concludes that the developed gamified project-based STEAM learning model is valid and feasible for implementation in early childhood education. The results of expert validation, as well as individual, small group, and field trials, indicate that the model falls within the “very good” category. The implementation of gamification elements integrated into the syntax of the learning model has been shown to significantly enhance the motivation and learning engagement of children aged 5–6 years across behavioral, emotional, and cognitive dimensions.

The contribution of this study lies in providing an applicable gamified project-based STEAM learning model that aligns with the developmental characteristics of young children. This model offers an alternative innovative instructional strategy for early childhood educators to create meaningful and child-centered learning experiences. Future research is recommended to examine the effectiveness of the model across broader contexts and larger sample sizes, as well as to explore the integration of digital technologies to further strengthen the implementation of gamified STEAM learning in early childhood education.

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