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# Comparative Analysis of Synchronous and Asynchronous Learning Modes in Online Education: Effectiveness, Student Engagement, and Learning Outcomes

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**Abstract.** The article discusses the primary tactics, approaches, and goals of both synchronous and asynchronous e-learning modes from a practical and scientific standpoint. The empirical evidence and recent reviews comparing synchronous and asynchronous modes of online learning in higher education are provided. The fundamental issues with modern ICT, along with the distinctions between synchronous and asynchronous e-communication techniques, are identified. The synchronous and asynchronous e-learning modes, used by institutions of higher education to resolve problems that come up on a student's current road to self-improvement, are presented. Recent meta-analytic and randomized studies, where both modes can produce positive learning gains, are described. The differences and complementarities in instructional effectiveness, student engagement (behavioral, emotional), cognitive load and measurable learning outcomes are examined. The synchronous and asynchronous online learning environments that are necessary to deliver remote education are discussed. Different synchronous and asynchronous modalities of engagement are highlighted. The comparison of both formats with asynchronous mode, which typically offers greater flexibility and reflective depth, while synchronous one increases immediacy, social presence, and lower certain aspects of cognitive load in some contexts, is given. The article argues that blended or bichronous approaches – deliberate, pedagogically guided combinations of synchronous and asynchronous elements – deliver the most consistent benefits across outcome domains. The thoughtful blends of synchronous and asynchronous designs that embed flexible scheduling, psychosocial support, and low-bandwidth options, which best support continuity, safety, and learning outcomes, are proposed. The case study findings about the value of asynchronous learning settings for improving proficiency are assessed. A study of the distant learning strategy is provided. Emphasis on the top resources and technologies for both synchronous and asynchronous online learning is placed. The fundamental steps for implementing distance learning technologies in educational institutions are developed. Students' preferences for the methods employed in remote learning are taken into consideration. The fundamental difficulties that both synchronous and asynchronous forms of distance learning present to educators, organizations, and learners are discussed. Techniques along with digital learning tools for delivering and improving the quality of education that can contribute to successful distance teaching and learning are suggested. Recommendations for course designers and institutions for purposeful alignment of mode with learning tasks, accessibility and equity safeguards, and data-driven iterative design, are focused on.

**Key words:** synchronous learning; asynchronous learning; student engagement; learning outcomes; cognitive load; bichronous.

## Порівняльний аналіз синхронних та асинхронних форм навчання в онлайн-освіті: ефективність, залучення студентів та результати навчання

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**Анотація.** У статті розглядаються основні тактики, підходи та цілі синхронних і асинхронних режимів електронного навчання з практичної та наукової точок зору. Подано емпіричні дані та сучасні огляди, що

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порівнюють синхронні та асинхронні форми онлайн-навчання у закладах вищої освіти. Визначено основні проблеми сучасних інформаційно-комунікаційних технологій, а також відмінності між синхронними й асинхронними методами електронної комунікації. Представлено особливості застосування синхронного та асинхронного електронного навчання у закладах вищої освіти для розв'язання проблем, які виникають на шляху саморозвитку студентів. Описано результати нещодавніх мета-аналітичних і вибіркового досліджень, які свідчать, що обидва режими можуть забезпечувати позитивні навчальні результати. Проаналізовано відмінності та взаємодоповнюваність у навчальній ефективності, залучення студентів (поведінковій, емоційній), когнітивному навантаженні та вимірюваних результатах навчання. Розглянуто онлайн-навчальне середовище, необхідне для забезпечення дистанційної освіти, а також різні форми синхронної та асинхронної взаємодії. Порівняно обидва формати, зазначено, що асинхронний режим зазвичай забезпечує більшу гнучкість і глибину рефлексії, тоді як синхронний підвищує відчуття присутності, соціальну взаємодію та знижує певні аспекти когнітивного навантаження в окремих контекстах. У статті стверджується, що змішані або біохронні підходи – це свідомо спроектовані педагогічні комбінації синхронних та асинхронних елементів – забезпечують найбільш послідовні переваги в усіх напрямках навчальних результатів. Запропоновано продумані поєднання синхронного та асинхронного дизайну, які включають гнучке планування, психосоціальну підтримку та опції з низьким використанням пропускну здатності мережі, що найкраще сприяють безперервності, безпеці та якості навчання. Оцінено результати кейс-дослідження щодо цінності асинхронного навчання для підвищення рівня компетентності. Подано аналіз стратегії дистанційного навчання, акцентовано увагу на найкращих ресурсах і технологіях для синхронного та асинхронного онлайн-навчання. Розроблено основні етапи впровадження технологій дистанційного навчання у закладах освіти. Враховано переваги студентів щодо методів, застосовуваних у дистанційному навчанні. Обговорено основні труднощі, які створюють синхронні та асинхронні форми дистанційного навчання для викладачів, організацій і здобувачів освіти. Запропоновано методики та цифрові інструменти навчання, що можуть підвищити якість освітнього процесу та сприяти успішному дистанційному навчанню. Основна увага приділяється рекомендаціям для розробників курсів та закладів освіти щодо цілеспрямованого узгодження форматів навчання із завданнями, забезпечення доступності та рівності, а також використання підходів до навчального дизайну, заснованих на даних.

**Ключові слова:** синхронне навчання; асинхронне навчання; залучення студентів; результати навчання; когнітивне навантаження; біохронне навчання.

## *I Introduction*

The rapid expansion of online education – accelerated by the COVID-19 pandemic – has intensified attention to the relative merits of synchronous and asynchronous instructional modes. As a result of the stringent quarantine measures, the educational system underwent a rapid transition from traditional face-to-face instruction to remote learning. This context prompted educators to integrate innovative ICT-based pedagogical strategies, thereby promoting effective collaboration among all stakeholders involved in the educational process. Synchronous learning (live video lectures, real-time discussion, live labs) replicates aspects of in-person classes and supports immediacy of interaction; asynchronous learning (recorded lectures, discussion boards, self-paced modules) prioritizes flexibility and reflection.

Scholars and educational practitioners continue to investigate which instructional mode optimally supports learning, fosters student engagement, and produces superior outcomes across different disciplines and learner profiles. Emerging evidence from meta-analyses, randomized controlled trials, and large-scale empirical investigations provides nuanced insights into these questions, highlighting the potential advantages of integrative or hybrid instructional designs that strategically combine synchronous and asynchronous elements.

Sources were prioritized for methodological rigor (meta-analysis, randomized controlled trials, large cohort studies) and relevance to higher education or professional training contexts. Contemporary researchers are currently examining the implementation and effectiveness of various forms of distance learning, namely: Zeng, Luo, Alfares, Banit, Martin, Sistek-Chandler, Alzahrani, Kotun, Hung, Pagoto, Radomskyi and multiple empirical reports exploring modality effects on engagement and cognitive load [18], [1], [8], [23], [17], [2], [14].

The paper is targeted at conducting a comparative analysis of synchronous and asynchronous learning modes in online education in order to evaluate their relative effectiveness, impact on student engagement, and influence on learning outcomes. The research aims to identify the pedagogical, technological, and psychological factors that determine the success of each e-learning mode and to explore how their integration can optimize the quality and accessibility of higher education. By examining empirical evidence and recent practices, the study seeks to provide a data-driven foundation for educators and institutions to design balanced, inclusive, and sustainable online learning environments that enhance both academic performance and learner satisfaction.

## **II Materials and Methods**

The research material is based on the writings of both domestic and international academicians in such areas as synchronous and asynchronous distance learning theory and practice.

The primary research methodologies employed include:

- theoretical approaches, such as the analysis of research literature on synchronous and asynchronous formats;
- empirical methods (encompassing surveys, assessments, interviews, pedagogical observations);
- experimental pedagogical studies.

The transition to online education has been promoted by rapid developments in digital technologies, coupled with contemporary pedagogical frameworks that emphasize learner-centered approaches and adaptable instructional environments. These frameworks support flexibility in content delivery, pacing, and modes of interaction, thereby facilitating greater student engagement, personalized learning pathways, and improved learning outcomes across diverse disciplines. The integration of synchronous and asynchronous modalities further enhances the ability of educational institutions to respond to individual learner needs, technological constraints, and contextual challenges, such as those arising from disruptions to traditional face-to-face instruction.

Internet-mediated learning and unrestricted digital communication are not inherently new forms of interaction; nevertheless, their critical significance and unique contributions to education have become increasingly apparent. The rapid expansion of online education in recent years has transformed the landscape of higher education, creating new opportunities and challenges for both instructors and learners. Among the various digital learning modalities, synchronous and asynchronous learning modes have emerged as central approaches, each offering distinct advantages and limitations in terms of instructional delivery, student engagement, and learning outcomes.

Synchronous learning involves real-time interaction between instructors and students, often through video conferencing or live discussions, fostering immediacy, social presence, and instant feedback. In contrast, asynchronous learning allows learners to access instructional materials at their own pace, promoting flexibility, reflective engagement, and deeper cognitive processing [4], [11].

According to Mairing, the asynchronous mode of instruction positively influences both the professional and personal development of students by encouraging active engagement with peers and instructors, enabling them to share their ideas and refine them through discussion and collaboration. The scholar stresses that students participating in asynchronous online group activities exhibit higher motivation levels and achieve deeper disciplinary understanding compared to those studying independently [9].

Zeng and Luo compared synchronous and asynchronous online formats and reported a small advantage for asynchronous formats on knowledge gains overall, though the effect size was trivial and invariant across most moderators (discipline, level). The authors also aggregated dozens of studies and reported only small average differences between synchronous and asynchronous online learning on knowledge outcomes; modality effects were often trivial relative to the influence of instructional design quality and task alignment. Other systematic reviews and syntheses likewise emphasize that design and pedagogy –not synchrony alone – drive most variance in outcomes. The scholars describe modality differences as modest – design quality and task alignment matter more than synchronicity [18].

Martin's 2021 review and other syntheses similarly found only small differences across modes when comparing controlled studies, and often indicated that hybrid or intentionally blended designs outperform mono-modal formats on average [10].

A 2024 trial by Hung et al. comparing synchronous (live WebEx) and asynchronous (YouTube lectures) delivery found that both modes produced significant learning gains and high satisfaction; cognitive load measures were lower in the synchronous condition, though effect sizes were small. The study underscores that both formats can work well when materials and assessments are properly aligned [7].

High-quality single-discipline randomized trials add nuance. For instance, a 2024 trial in education found comparable learning gains for synchronous and asynchronous delivery of the same content, while reporting lower cognitive load in the synchronous cohort – arguably because immediate instructor scaffolding reduced extraneous difficulties for live attendees. However, this advantage can vanish or reverse when connectivity

problems, large enrollment, or instructor inexperience affect live sessions. Overall, recent studies suggest both modes can be effective when well-designed [2].

Understanding the comparative effectiveness of these modes is critical for designing evidence-based online curricula that optimize learning outcomes across diverse contexts. Recent meta-analyses and empirical studies indicate that neither mode is universally superior; rather, the effectiveness depends on factors such as learner characteristics, disciplinary content, technological infrastructure, and the integration of pedagogical supports. As higher education increasingly embraces blended and bichronous designs, which combine synchronous and asynchronous elements, there is a growing need to examine how these modalities interact to enhance student engagement, reduce cognitive load, and improve measurable learning outcomes [3], [15].

Other randomized non-inferiority trials (e.g., lifestyle intervention delivery via synchronous vs asynchronous remote modalities) have shown comparable outcomes for many practical objectives, indicating that well-designed asynchronous interventions can be as effective as live formats for knowledge and behavior change.

### **III Results**

A variety of contemporary theoretical research methodologies and procedures were employed in order to accomplish the goal, validate the hypothesis, and complete the study tasks.

Through data interpretation, literature review, analysis, synthesis, induction, deduction, systematization, comparison, and generalization, qualitative methods provide an efficient research approach that enabled us to create scientific sources, identify the key components and characteristics of distance learning, and support the benefits and drawbacks.

This paper provides a comparative analysis of synchronous and asynchronous online learning, evaluating their effectiveness, student engagement, and learning outcomes. By synthesizing recent research findings, it aims to offer practical and theoretical insights to inform instructional design, policy-making, and institutional strategies for online education.

We concentrated on Sumy National Agrarian University students in this study. This emphasis was put in place to test our theory SL and ASL should be incorporated into the curriculum.

Sumy National Agrarian University has been professionally developing highly skilled individuals in the agrarian sector of the national economy for over 40 years. The university offers bachelor's and master's degrees to its alumni. English, German, and French are studied by students in all of the institution's disciplines. They receive instruction in Business Foreign Language, Professional Foreign Language, and English as Optional Subject. The goal of learning a foreign language is to develop the communication skills required for professional and situational oral and writing communication.

The primary goals of the aforementioned disciplines are to learn how to use foreign languages practically in a variety of speaking activities, including a wide range of subjects necessary for professional requirements; to get up-to-date knowledge on specialized subjects from overseas sources; and many other things.

The university goal is to produce highly skilled and competitive individuals with extensive professional knowledge, ongoing computer training throughout their studies, and fluency in foreign languages. The options available to students are distance learning, part-time, and full-time. The university was compelled to establish an online learning environment and use distance learning due to strict quarantine regulations.

This research establishes the present synchronous and asynchronous e-learning/teaching methods and assesses how well a/synchronous environments contribute to improved English language learning at Sumy National Agrarian University (SNAU).

Two groups of SNAU students participated in this study:

- those who study English as Optional Subject (EOS)
- those who learn Professional Foreign Language (PFL).

About three months in the spring of 2025 and two months in the fall of 2025 were spent observing performance and communication. In EOS and PFL, there were 100 and 50 active students, respectively. The two primary research methodologies proposed to be used are empirical (questioning, testing, discussion, pedagogical observation, and pedagogical experiment) and theoretical (analysis of scientific literature on distance learning). This research is qualitative. The opinions of the students were used to gather a lot of data.

In addition to their traditional classroom instruction, the group of EOS students was given a variety of individual and online learning assignments. This comprised the initial individual tasks, such as quizzes, e-lectures, and films of research and laboratory experiments from the university blended educational resources and distant learning platform.

Through the university distance learning platform, another group of students (PFL students) worked on the case techniques prior preparations. The students were required to study a problem and identify logical solutions and ways to make it better including the further discussion.

Since the closed-form surveys were straightforward, easy for both respondent groups to complete, and pertinent to the study goal, the students were requested to fill them out in order to provide feedback regarding the SL and ASL processes.

The purpose of this study was to answer the following research question: "Name three positive and three negative characteristics of both synchronous and a/synchronous modes" in order to assess the advantages and disadvantages of a/synchronous mode.

The most popular benefits of synchronous learning that students cited were as follows:

- 1) instant input from groupmates and the teacher (65%);
- 2) the opportunity to actively participate in the course in a classroom model setting (35%).

These findings indicate that young people are receptive to novel learning approaches that make education engaging and, consequently, more motivating. Positive acceptance is always sparked by modifications to the educational process that involve unconventional and engaging learning methods.

The following set illustrates a few drawbacks of the synchronous mode that the students brought to light, namely:

- 1) technology accessibility (45%);
- 2) planned time (35%);
- 3) reliance on unforeseen circumstances (25%).

The statistics show that the experiment proceeded correctly, demonstrating that the participants are aware of the setting in which they are studying. They may approach the work with the right mindset, exercising responsibility and self-organization to the fullest.

Beneficial asynchronous mode moments highlighted by the educational process participants are:

- 1) chance to obtain the necessary information whenever you want (54%);
- 2) more time to consider the assigned task (30%);
- 3) freedom to express thoughts more freely than in face-to-face spoken conversation (16%).

This study also confirms earlier studies in this area that found that e-learning improves students' motivation and responsibility. Students emphasized the asynchronous mode shortcomings:

- 1) delayed responses and feedback, such as emails (53%);
- 2) problems with comprehending complicated subjects (rules, tasks, assessments) (47%).

In response to these results, less than half (35%) of the participants reported some difficulties with the SL and ASL system when compared to the traditional one, while 65% of the respondents reported no difficulties.

Hence, students' answers to the question of whether learning English is better done synchronously or asynchronously are therefore quite intriguing: 75% of participants stated that they prefer synchronous communication, while 25% of students said that they prefer asynchronous communication.

According to these findings, 75% of the students are willing to speak with or see the teacher and want to engage in direct interaction, much like they would in traditional classroom settings. 25% percent of the responders, however, are prepared to work without prompt guidance and input from peers and teachers. According to students' perceptions, it is simpler to build speaking skills through synchronous sessions, and they also have a strong desire for it. At the same time, they expressed satisfaction with the asynchronous mode when handling the written compositions.

#### ***IV Discussion***

The research has substantially deepened our understanding of how synchronous and asynchronous modes perform in online higher-education settings. Two consistent findings emerge from recent analyses, randomized trials and large surveys:

- 1) neither mode is uniformly superior for all outcomes;

2) contextual and design factors – more than temporal format per se-explain most variance in effectiveness, engagement, and learning gains [18], [10].

The following review synthesizes contemporary evidence, highlights key moderator variables, and draws out implications for education in crisis contexts.

The research conducted offers increasingly robust evidence regarding the comparative strengths, limitations, and contextual sensitivities of synchronous and asynchronous online learning modes.

Large survey studies, presented by Fabriz et al., add nuance about perceptions: students often report higher social presence and short-term motivation in synchronous sessions, but self-reported performance differences are not consistently observed. Alfares stresses that the emergent picture is that design quality, alignment of tasks to mode, and facilitation skill determine whether synchronous or asynchronous choices translate into measurable learning advantages [5], [1].

A recent experimental study by Hung et al. compared synchronous and asynchronous delivery of a training module and found that both formats yielded significant gains in post- and retention-test scores. Importantly, students in the synchronous group experienced lower cognitive load, although the overall effect sizes were small [7].

Similarly, another randomized controlled trial (with  $N = 1,044$  participants) revealed no significant difference in knowledge outcomes between asynchronous and synchronous formats, although the asynchronous group reported higher acceptance and the synchronous group reported higher intrinsic motivation [14].

For example, Zeng & Luo found a trivial weighted effect size ( $g \approx 0.08$ ) favoring asynchronous formats across multiple studies, suggesting that the most important factors are instructional design and context. Hence, the analytic work continues to support the conclusion that modality alone is not the primary determinant of learning gains [18].

In a large survey of students ( $N = 3,056$ ) and faculty ( $N = 396$ ) during COVID-19, Fabriz et al. report that students in mostly synchronous settings reported higher social presence, but this did not translate into clear superiority in self-reported performance or satisfaction [5].

Therefore, the literature indicates that both synchronous and asynchronous learning can be effective under well-designed conditions, and that differences in learning outcomes by mode are typically small and moderated by design, discipline and student characteristics.

Engagement research provides further nuance. Behavioral engagement (e.g., attendance, discussion postings) tends to be higher in synchronous sessions where live presence and real-time interaction drive situational motivation. For example, survey work in 2022 found that 72 % of respondents reported satisfaction with synchronous learning, compared with 66 % for asynchronous formats [16].

However, the same study noted no statistically significant difference in achievement according to preferred mode.

Emotional engagement (sense of belonging, motivation) is often stronger in synchronous settings, likely because of greater social presence, immediacy, and peer/faculty interaction.

Hartina et al. describe cognitive engagement (depth of processing, reflection) as a tendency that favors asynchronous modes when tasks are structured to enable reflection, self-pacing and review of materials. Some flipped-class designs that combine asynchronous prep with synchronous discussion show higher cognitive engagement and performance [6].

In sum, engagement patterns differ by mode and task type: synchronous supports immediacy and social connection; asynchronous fosters flexibility and deeper processing – but only if well scaffolded.

Cognitive load is emerging as a key moderator of modality effectiveness. Hung et al. point out significantly lower mental load scores in synchronous learning versus asynchronous modules ( $p = 0.0005$ ) [7].

This suggests that real-time instructor support and interactive scaffolding may reduce extraneous load for learners. On the other hand, asynchronous settings offer flexibility but demand higher self-regulation, which can increase intrinsic or germane load if learners are unprepared. These findings suggest that institutions should consider cognitive-load impacts when choosing or designing modalities.

Recent literature emphasizes that modality performance is highly contingent on infrastructure, access and learner context. For example, a 2022 study, made by Nor and Wijaya, showed that 55.1 % of students preferred

asynchronous learning during the pandemic, while only 44.9 % preferred synchronous; however, no difference in academic achievement emerged between modes [13].

This underscores that when access constraints (bandwidth, time zones, caregiving responsibilities) are present, asynchronous options enhance equity without sacrificing outcomes. Moreover, studies in low-resource settings highlight that synchronous formats may only be effective if participants have reliable connectivity, devices, and stable schedules. The equity dimension is particularly relevant for contexts of disruption (e.g., war, displacement, emergencies).

A growing consensus in the literature is that blended or bichronous models – where synchronous and asynchronous components are deliberately integrated – provide the most consistent benefits. Such designs capitalize on the strengths of each mode: asynchronous for resource delivery and reflection, synchronous for interaction and feedback.

For example, Martin et al. discuss best practices for bichronous online learning, reporting improved retention and engagement when weekly rhythms combine short live sessions with asynchronous preparatory modules [11].

In practice, many studies suggest that mode matters less than the alignment of mode with learning task, evidence-based instruction, and the scaffold use of both modalities.

## ***V Conclusion***

The research finds only small, often negligible average differences between synchronous and asynchronous delivery on knowledge tests and course grades; where effects exist, they are typically task- or discipline-specific. Well-designed randomized and quasi-experimental trials reinforce this conclusion: several recent trials report comparable learning gains across modes when content, assessment and instructor facilitation are held constant.

Those trials also reveal important secondary distinctions – most notably, synchronous instruction can reduce certain measures of extraneous cognitive load by enabling immediate instructor scaffolding, whereas asynchronous instruction more reliably supports repeated review and consolidation.

Large survey studies add nuance about perceptions: students often report higher social presence and short-term motivation in synchronous sessions, but self-reported performance differences are not consistently observed. Overall, the emergent picture is that design quality, alignment of tasks to mode, and facilitation skill determine whether synchronous or asynchronous choices translate into measurable learning advantages. Synchronous reliance can disadvantage learners with limited bandwidth, caregiving responsibilities, or conflicting time zones. Asynchronous components increase accessibility but place heavier self-regulation demands on learners.

Contemporary engagement research distinguishes three dimensions – behavioral, emotional, and cognitive – and shows that synchronous and asynchronous modes tend to support different engagement profiles: behavioral engagement (attendance, live participation metrics) is typically higher in synchronous settings because real-time sessions create immediate incentives for attendance and provide opportunities for live interaction; emotional engagement (sense of belonging, motivation) often improves with synchronous contact, particularly early in a course when community building matters; cognitive engagement (depth of processing, argument elaboration) frequently benefits from asynchronous tasks that allow time for reflection, research and composed responses – provided such tasks are moderated.

Thus, engagement outcomes are not a zero-sum function of synchrony but rather reflect how instructors allocate activities to capitalize on each mode's affordances.

The study highlights the following remaining gaps, namely: longitudinal studies of retention and labor-market outcomes for cohorts educated during crises are scarce; randomized cross-disciplinary trials that control for design quality are limited; and evidence on optimal mixes of synchronous/asynchronous components in low-resource settings is still emergent.

The purposeful integration of synchronous and asynchronous elements – often labelled bichronous – yields stronger results than relying exclusively on one mode. Case studies and faculty training programs demonstrate that short, focused synchronous activities (Q&A, active learning, small-group breakout tasks) combined with curated asynchronous preparatory and consolidation materials produce high engagement and

efficient learning. Research that systematically tests bichronous schedules, pedagogical scaffolds for self-regulation, and psychosocial integration in disrupted environments would be particularly valuable.

The research indicates that mode alone does not determine success; rather, the interplay of task alignment, infrastructure, learner readiness, and pedagogical design drives effectiveness. For most institutional goals – especially under conditions of disruption – thoughtfully integrated bichronous designs that combine flexible asynchronous resources with targeted synchronous interaction and explicit supports for access and wellbeing are the most evidence-based choice.

Neither synchronous nor asynchronous modes are universally superior. Each offers distinct affordances: asynchronous formats afford flexibility and reflective depth, while synchronous formats enhance social presence and can reduce certain cognitive burdens when well facilitated. The strongest, most reliable gains come from integrated bichronous/blended designs that align mode to task, protect equity, and iterate based on data. Institutions seeking to optimize online education should therefore adopt a design-centered approach: define learning outcomes first, then select and combine modes purposefully, while investing in infrastructure and staff development.

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