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Synchronous and Asynchronous E-Learning: The Impact of Educational Technologies on Students' Academic Achievement

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Abstract. This paper examines the impact of synchronous and asynchronous e-learning and the educational technologies supporting these modes on students' academic achievement in higher education. The study identifies the pedagogical and technological factors influencing learning effectiveness and proposes an analytical framework integrating learning modalities, technological affordances, instructional design, and individual learner characteristics. The main features of synchronous and asynchronous e-learning, corresponding teaching strategies, pedagogical objectives, and technological conditions determining their educational effectiveness are analyzed. Recent empirical studies conducted by international and Ukrainian researchers, including systematic reviews, meta-analyses, and comparative studies of online learning in higher education, are examined to identify relationships among educational technologies, learning modalities, student engagement, cognitive load, and measurable academic achievement. The analysis highlights the potential of synchronous technologies to facilitate direct interaction, social presence, real-time communication, collaborative learning activities, and immediate feedback. The advantages of asynchronous technologies are also examined, including greater learning flexibility, learner autonomy, self-paced learning, repeated access to educational resources, and enhanced opportunities for reflection and self-regulated learning. These characteristics are evaluated in relation to their potential influence on academic achievement when technological tools are appropriately aligned with learning objectives and students' educational needs. The study establishes that the effectiveness of synchronous and asynchronous e-learning depends on the quality of instructional design, the purposeful selection of educational technologies, the organization of learning activities, assessment strategies, teacher support, and students' digital competence. Particular attention is paid to technology-supported formative assessment, timely feedback, interactive learning resources, and collaborative activities as important factors contributing to improved academic achievement. The challenges associated with unstable Internet connectivity, unequal access to digital devices, technological barriers, excessive cognitive load, limited opportunities for social interaction, and difficulties in maintaining student motivation and engagement are also addressed. Based on theoretical analysis and the systematization of existing research findings, the study examines blended learning approaches that purposefully integrate synchronous and asynchronous elements to provide more balanced learning experiences and support more consistent academic outcomes. The potential benefits of combining the immediacy and interactivity of synchronous communication with the flexibility and opportunities for deeper reflection offered by asynchronous learning are discussed. The practical significance of the study lies in the development of recommendations for educators, course designers, and higher education institutions concerning the purposeful integration of educational technologies, accessibility and equal learning opportunities, technology-supported assessment, and data-informed improvements to online courses. The paper emphasizes that the use of educational technologies alone does not guarantee improved academic achievement. Their effectiveness depends on pedagogically justified integration, high-quality instructional design, and the alignment of technological tools with learning objectives, assessment procedures, and students' educational needs.

Key words: synchronous learning; asynchronous learning; student engagement; learning outcomes; cognitive load; assessment strategies.

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Синхронне та асинхронне електронне навчання: вплив освітніх технологій на академічні результати студентів

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Анотація. У цій статті досліджується вплив синхронного та асинхронного електронного навчання, а також освітніх технологій, що забезпечують реалізацію цих форматів, на академічну успішність студентів закладів вищої освіти. Визначаються педагогічні та технологічні чинники ефективності навчання й пропонується аналітична модель, що інтегрує формати навчання, технологічні можливості, проєктування освітнього процесу та індивідуальні характеристики здобувачів освіти. Проаналізовано основні характеристики синхронного й асинхронного електронного навчання, відповідні стратегії викладання, педагогічні цілі та технологічні умови, що визначають ефективність цих форматів. Визначено результати сучасних емпіричних досліджень закордонних та вітчизняних науковців, зокрема систематичних оглядів, метааналізів і порівняльних характеристик онлайн-навчання у вищій освіті, присвячених взаємозв'язку між освітніми технологіями, форматом навчання, залученістю студентів, когнітивним навантаженням і вимірюваними показниками академічної успішності. Висвітлено можливості синхронних технологій щодо забезпечення безпосередньої взаємодії, соціальної присутності, спілкування в режимі реального часу, спільної навчальної діяльності та оперативного зворотного зв'язку. Охарактеризовано переваги асинхронних технологій, зокрема гнучкість навчання, автономію здобувачів освіти, можливість самостійно визначати темп опрацювання матеріалу, багаторазово звертатися до навчальних ресурсів, а також ширші можливості для рефлексії та саморегульованого навчання. Оцінено зазначені характеристики, які суттєво впливають на академічну успішність за умови узгодження технологічних інструментів із навчальними цілями та потребами студентів. Визначено, що ефективність синхронного й асинхронного електронного навчання залежить від якості проєктування освітнього процесу, доцільності вибору технологій, організації навчальної діяльності, стратегій оцінювання, підтримки з боку викладача та рівня цифрової компетентності студентів. Особливу увагу приділено формувальному оцінюванню з використанням цифрових технологій, своєчасному зворотному зв'язку, інтерактивним ресурсам і спільній навчальній діяльності, які розглядаються як важливі чинники підвищення академічної успішності. Окреслено проблеми, пов'язані з нестабільним інтернет-з'єднанням, нерівним доступом до цифрових пристроїв, технологічними бар'єрами, надмірним когнітивним навантаженням, обмеженими можливостями соціальної взаємодії, а також труднощами підтримання мотивації та залученості студентів до навчання. На основі теоретичного аналізу й систематизації даних проаналізовано підходи до змішаного навчання, які передбачають цілеспрямоване поєднання синхронних та асинхронних елементів для забезпечення збалансованого навчального досвіду й досягнення стабільніших результатів навчання. Розглянуто можливості поєднання безпосередності та інтерактивності синхронної комунікації з гнучкістю й глибиною рефлексії, характерними для асинхронного навчання. Практичне значення дослідження полягає в розробленні рекомендацій для викладачів, авторів курсів, закладів вищої освіти щодо цілеспрямованої інтеграції технологій в освітній процес, забезпечення доступності та рівних можливостей навчання, використання технологічно підтримуваного оцінювання й удосконалення онлайн-курсів на основі даних про результати навчання. У статті наголошується, що використання освітніх технологій саме по собі не гарантує підвищення академічної успішності. Ефективність залежить від педагогічно обґрунтованої інтеграції, якісного проєктування освітнього процесу та узгодженості технологічних засобів із навчальними цілями, процедурами оцінювання й освітніми потребами студентів.

Ключові слова: синхронне навчання; асинхронне навчання; залучення студентів; результати навчання; когнітивне навантаження; стратегії оцінювання.

I Introduction

Digital transformation has become an integral feature of contemporary higher education. The development of learning management systems (LMS), videoconferencing platforms, cloud-based services, multimedia resources, mobile technologies, and interactive assessment tools has expanded the possibilities for organizing learning beyond the traditional classroom. As a result, electronic learning is no longer limited to the emergency response to the contemporary realities but has increasingly become part of institutional strategies for flexible, blended, and distance education.

One of the central distinctions in electronic learning concerns the temporal organization of interaction. Synchronous learning requires teachers and students to participate in an educational activity at the same time, typically through:

– videoconferencing platforms,

– real-time chats,

– interactive whiteboards,
– polling systems,
– other communication technologies.

Asynchronous learning, in contrast, allows learners to access instructional materials, complete assignments, communicate, and undertake assessment activities without being required to participate at the same time as their instructors or peers.

The distinction is pedagogically important because the two modes create different conditions for student participation.

Synchronous environments facilitate:
– immediate communication,
– rapid clarification of questions,
– social presence,
– real-time collaboration.

Asynchronous environments provide:
– flexibility,
– learner control,
– repeated access to materials,
– opportunities to regulate the pace of learning.

Another important issue concerns the role of educational technologies. In discussions of digital education, technology is sometimes treated as an independent factor capable of improving learning simply through its presence. It is also essential to conceptualize educational technologies as mediating instruments within a pedagogical system rather than as independent determinants of academic achievement.

Researchers and educational practitioners continue to examine the effectiveness of different instructional modes in supporting students' learning, enhancing their active participation, and improving academic outcomes across various disciplines and learner groups. Recent findings from meta-analyses, randomized controlled trials, and large-scale empirical studies provide a more comprehensive understanding of these issues and indicate that blended instructional approaches may offer significant advantages. In particular, pedagogically designed combinations of synchronous and asynchronous learning activities can create more flexible and effective learning environments by integrating real-time interaction with opportunities for self-paced study, reflection, and independent learning.

The sources were selected according to established criteria of methodological rigor, prioritizing meta-analyses, randomized controlled trials, large-scale cohort studies, and empirically grounded investigations undertaken in higher education and professional training contexts. The review focuses on recent research examining the implementation, effectiveness, and educational outcomes of different distance-learning formats. Particular attention is given to studies by Zeng, Tan, Hooshyar, Hung, Wu, Ratan, Zhou, Hart, Dubyna, Bratanych, as well as to a range of empirical investigations addressing the effects of synchronous and asynchronous learning modalities on student engagement, cognitive load, and academic performance [21], [18], [7], [8], [19], [14], [22], [5], [4,] [1].

The purpose of this study is to synthesize and compare recent international evidence on synchronous and asynchronous e-learning in higher education and to explain how learning modality, educational technologies, instructional design, and learner characteristics are associated with academic achievement and related learning outcomes.

Specifically, the study examines the pedagogical functions of digital tools, the roles of interaction and feedback, and the contribution of learner autonomy and self-regulation. It also identifies conditions under which synchronous and asynchronous activities can be purposefully combined and derives practical recommendations for designing flexible, inclusive, and pedagogically coherent e-learning environments. Because the study is an analytical literature review, it interprets previously published evidence rather than testing a new intervention or estimating an original pooled effect size.

The scientific novelty of this study lies in the integrated analytical examination of synchronous and asynchronous e-learning as complementary instructional modalities and in the systematization of the factors through which educational technologies may be associated with students' academic achievement in higher education. Unlike approaches that compare online learning formats primarily in terms of their overall

effectiveness, this study considers the relationship between learning modality, pedagogical design, interaction, feedback, learner autonomy, and self-regulated learning. Particular attention is paid to the distinction between the technological characteristics of digital learning environments and the pedagogical conditions under which these technologies are used.

This study employs an analytical literature review approach to examine published research on synchronous and asynchronous e-learning and their relationships with students' academic achievement in higher education. The methodological framework combines:

– comparative analysis,
– thematic synthesis,
– critical evaluation of empirical evidence,
– conceptual generalization.

These methods are used to identify recurring findings, examine differences between instructional modalities, and interpret the pedagogical and learner-related factors associated with educational outcomes.

Comparative analysis was used to examine the characteristics and pedagogical functions of synchronous and asynchronous learning. Thematic synthesis was applied to organize the evidence into interconnected analytical categories, including interaction and social presence, flexibility and learner control, instructional design, feedback mechanisms, and academic achievement. Critical evaluation was used to interpret the consistency and limitations of reported findings, taking into account differences in research designs, learning contexts, student populations, and outcome measures. Conceptual generalization was then used to formulate conclusions about the conditions under which synchronous and asynchronous activities may complement one another in higher education.

The study is based exclusively on the analysis and interpretation of previously published research. It does not involve the collection of original participant data, the implementation of a new educational intervention, or the calculation of an original pooled effect size. Accordingly, the conclusions are presented as an analytical synthesis of the available evidence. The methodological approach is intended to provide a transparent basis for comparing learning modalities and developing evidence-informed recommendations for the pedagogical integration of educational technologies.

II Materials and Methods

The ongoing advancement of digital technologies has fundamentally transformed the higher education landscape, accelerating the adoption of synchronous and asynchronous e-learning modes. Each modality offers distinct pedagogical affordances for:

– facilitating teacher–student interaction,
– delivering instructional content,
– fostering learner autonomy,
– supporting the assessment of academic performance.

Nevertheless, the effectiveness of these modes cannot be explained solely by the temporal configuration of learning interactions. Instead, learning outcomes are shaped by the interplay between instructional design, pedagogical strategies, learner characteristics, and the purposeful integration of educational technologies within the learning environment.

The assumption that one mode is inherently more effective than the other is not supported consistently by recent research. A meta-analysis by Zeng and Luo examined evidence from 14 studies involving 1,098 participants in synchronous learning conditions and 804 participants in asynchronous conditions. The authors specifically investigated whether either format produced stronger academic effects and whether the results varied according to educational level and disciplinary context.

More recent empirical research further illustrates the complexity of this relationship. Hung et al., for example, compared synchronous and asynchronous online instruction in medical education. Both approaches supported learning, but the study did not demonstrate a straightforward superiority of one modality in terms of learning outcomes. Cognitive load and student experience also differed between the two conditions.

At the same time, Zeng and Xin's research involving 306 university students found higher levels of learning engagement and persistence in synchronous than in asynchronous online learning. Their analysis further showed that autonomous academic motivation was positively associated with engagement and persistence,

while time-management skills moderated the relationship between motivation and persistence in the synchronous condition. These findings suggest that the effectiveness of a particular learning mode depends on a combination of variables rather than on temporal synchronicity alone [21], [8], [20].

Another important issue concerns the role of educational technologies. In discussions of digital education, technology is sometimes treated as an independent factor capable of improving learning simply through its presence. Such an assumption is problematic. The same technological tool may produce different outcomes depending on how:

– it is incorporated into instructional design,
– what learning objective it serves,
– how much guidance students receive,
– how actively learners interact with the content.

This point is strongly supported by Wu's meta-analysis of 60 peer-reviewed empirical studies. The analysis found a statistically significant positive overall effect of digital technology on deep learning. However, the effect varied considerably across studies. The strongest outcomes were associated with systematic implementation, appropriate instructional guidance, and integration with collaborative learning. It is more appropriate to conceptualize educational technologies as mediating instruments within a pedagogical system rather than as independent determinants of academic achievement [19].

Recent research also emphasizes the importance of social presence. Ratan et al., based on survey data from 322 undergraduate students, found that social presence was higher in synchronous classes and that synchronous learning was associated with greater perceived learning and enjoyment. The authors also found that instructor social presence was particularly important for perceived course gains. These findings are particularly relevant for higher education, where successful learning requires not only access to information but also:

– interaction,
– feedback,
– academic support,
– the development of learner autonomy.

Consequently, the central research problem is not whether synchronous or asynchronous learning is universally more effective, but how different technological and pedagogical configurations of these two modes influence students' academic outcomes [14].

Recent Ukrainian research provides an important complementary perspective on the relationship between distance-learning modalities, educational technologies, and students' academic achievement. Moroz and Olkhovetskyi (2024) examined motivational and self-regulatory factors associated with students' academic success in distance-learning contexts. Their findings highlight the importance of intrinsic motivation, self-regulation resources, and students' interpretations of academic success and failure. This research supports the view that the effectiveness of online learning depends not only on the technological format but also on learners' motivational and regulatory characteristics [12].

The assessment of academic achievement in technology-mediated learning is another important issue addressed by Ukrainian researchers. Dubyna et al. (2022) examined approaches to evaluating students' performance during distance learning and emphasized the need to adapt assessment practices to the conditions of online education. Their work is relevant to the present study because assessment methods determine how learning outcomes are measured and how students receive information about their progress. In online environments, assessment should therefore be considered an integral component of instructional design rather than merely a final measure of achievement. Shapran (2024) analyzed the characteristics and challenges of distance learning in contemporary higher education, focusing on the use of information, communication, and psychological-pedagogical technologies. This research provides a Ukrainian higher-education perspective on the role of digital tools in organizing and individualizing the learning process. It also reinforces the need to consider institutional and contextual conditions when evaluating the educational value of technology-enhanced instruction [4], [16].

The role of interaction and feedback is further illustrated by Bratanych and Myroshnychenko (2022), who investigated formative feedback in synchronous distance learning for English for Specific Purposes at a non-language university under martial law in Ukraine. Their study demonstrates the relevance of pedagogical and

technical conditions for implementing feedback in synchronous online instruction. This finding complements international research on interaction and social presence by drawing attention to feedback as a practical mechanism for supporting learning and monitoring students' progress in challenging educational circumstances [1].

Taken together, these studies contribute complementary evidence concerning learner motivation and self-regulation, assessment practices, the pedagogical use of digital technologies, and formative feedback. Within the analytical framework of the present study, these findings are considered alongside international research to examine how learning modality, instructional design, and learner characteristics may be associated with academic achievement. The studies are not treated as directly interchangeable, since they differ in educational context, research focus, and outcome measures.

III Results

The analysis of recent scholarly literature revealed that the effectiveness of synchronous and asynchronous e-learning is determined by a combination of technological, pedagogical, and learner-related factors rather than by the learning modality itself. The reviewed studies demonstrated that both synchronous and asynchronous formats can support students' academic achievement when educational technologies are appropriately aligned with instructional objectives, learning activities, and assessment strategies.

The comparative analysis identified several distinctive characteristics of the two learning modes. Synchronous e-learning was generally associated with greater opportunities for real-time interaction, immediate instructor feedback, collaborative problem-solving, and the development of social presence. Videoconferencing platforms, interactive digital whiteboards, real-time polling systems, and online communication tools enabled instructors to provide immediate clarification and monitor students' participation during learning activities. These technological affordances were particularly relevant to activities requiring discussion, oral communication, collaborative decision-making, and immediate formative feedback.

However, synchronous learning has limitations. It requires students and teachers to be available simultaneously and is therefore more dependent on stable Internet access and appropriate technical equipment.

Asynchronous e-learning, by contrast, demonstrated particular advantages in terms of temporal flexibility, learner autonomy, individualized pacing, and repeated access to instructional materials. Learning management systems, recorded lectures, electronic resources, discussion forums, online assignments, and asynchronous assessment tools enabled students to organize their learning according to their individual schedules and revisit learning materials when necessary. The reviewed evidence suggests that these characteristics may be especially beneficial for students who demonstrate a high level of self-regulation, motivation, and time-management skills. The most important is temporal flexibility. Students can access materials at a time comfortable with their individual circumstances. The second advantage is self-paced learning. Students can pause, replay, reread, or revisit learning materials. The third advantage is learner autonomy. Students have greater control over the organization of their learning activities. Thus, asynchronous learning may be particularly effective when students possess sufficient self-regulatory competence and when the course provides clear structure, deadlines, feedback, and assessment.

The analysis further indicated that the relationship between educational technologies and academic achievement is mediated by the quality of pedagogical integration. The mere availability of digital tools did not consistently result in improved academic performance. More favorable learning outcomes were observed when technological resources were incorporated into clearly structured instructional activities, accompanied by appropriate teacher guidance, and combined with active learning, collaboration, formative assessment, and timely feedback. A comparison of the reviewed studies also revealed that students' academic achievement should be considered together with complementary indicators of learning effectiveness. Student engagement, persistence, motivation, perceived learning, cognitive involvement, and social presence were frequently associated with the effectiveness of synchronous and asynchronous learning environments. In particular, synchronous interaction tended to strengthen students' sense of participation and social connectedness, whereas asynchronous learning provided greater opportunities for independent learning and self-paced engagement. Table 1 provides a comparative analysis of the reviewed studies, highlighting their findings regarding students' academic achievement.

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Table 1. Comparative analysis of the reviewed studies

Dimension	Synchronous e-learning	Asynchronous e-learning	Role of educational technologies
Interaction	Real-time interaction	Delayed interaction	Videoconferencing, chats, forums
Feedback	Immediate	Delayed or scheduled	Interactive assessment, LMS
Flexibility	Lower	Higher	Recorded lectures, digital resources
Learner autonomy	Moderate	High	LMS, self-paced materials
Social presence	Generally higher	More limited	Video, collaborative platforms
Self-regulation	Moderate requirement	Higher requirement	LMS tracking, reminders
Collaboration	Real-time collaboration	Flexible collaborative activities	Shared documents, forums
Academic achievement	Depends on instructional design	Depends on instructional design	Strategic technology integration
Most suitable activities	Discussion, practice, problem-solving	Content acquisition, revision, independent study	Combination of digital tools

Within this framework, synchronous learning is primarily associated with interaction, social presence, immediate feedback, and collaborative learning, while asynchronous learning is associated with flexibility, autonomy, individual pacing, and repeated access to learning resources. Technical tools act as mediators that enable these pedagogical functions.

The practical application of the proposed framework is that course designers can begin with the intended learning outcome and then select the format and technology that best support it. For example, asynchronous resources can be used for preparation, repeated practice, and self-assessment, while synchronous sessions can be reserved for discussion, clarification, collaborative problem-solving, and feedback. Instructors should monitor not only grades and test scores but also participation, task completion, and evidence of self-regulation, while providing additional guidance to students who show declining engagement. These recommendations can inform the design and review of online and blended courses in different higher-education disciplines. The framework is a planning tool, not a guarantee of improved achievement; its effectiveness should be evaluated in each teaching context. The outcomes indicate that the most effective use of educational technologies is associated with a purposeful combination of synchronous and asynchronous activities. Asynchronous technologies can be effectively employed for preliminary content acquisition, independent study, revision, and formative assessment, while synchronous technologies can be used for discussion, clarification, collaborative activities, practical application, and immediate feedback. Such a complementary model allows the specific pedagogical affordances of each modality to be utilized within a coherent learning environment. Consequently, the central principle emerging from the analysis is that the question should not be whether synchronous or asynchronous learning is inherently more effective. Instead, the key question should be which format, technical tool, and pedagogical strategy are most appropriate for achieving a particular learning outcome.

Overall, the findings demonstrate that synchronous and asynchronous e-learning should not be regarded as competing instructional approaches. Rather, they represent complementary modes whose educational effectiveness depends on the appropriate selection and pedagogical integration of digital technologies. The evidence indicates that a balanced combination of both modalities may create more flexible and learner-centered educational environments while supporting academic achievement, engagement, and learning autonomy.

IV Discussion

The findings of the present study indicate that the effectiveness of synchronous and asynchronous e-learning cannot be explained solely by the temporal organization of educational interaction. Rather, academic achievement is shaped by the interaction of learning modality, pedagogical design, educational technologies,

and learner characteristics. Recent research increasingly supports this multidimensional interpretation, emphasizing that the effectiveness of online learning depends on the quality of interaction, students' self-regulation, teacher support, and the purposeful integration of digital technologies.

An important factor identified in the literature is student self-regulation. This factor is particularly significant in asynchronous learning environments, where students have greater responsibility for organizing their learning activities, managing their time, monitoring their progress, and maintaining motivation. Miao and Ma, based on data from 334 undergraduate students, demonstrated that self-regulated learning was positively associated with learning engagement in online environments. Their findings further indicated that social presence mediated relationships between self-regulation, online interaction, and student engagement. These results suggest that asynchronous learning can be highly effective when students possess sufficient self-regulatory competencies and when instructional design provides mechanisms for interaction and feedback. This conclusion is reinforced by Chen et al., who investigated online self-regulation profiles among 676 nursing students. Their findings demonstrated significant differences in engagement between students with different levels of self-regulation, with students possessing stronger self-regulatory abilities demonstrating higher levels of online learning engagement. Consequently, the flexibility provided by asynchronous learning should be accompanied by explicit pedagogical support for developing students' planning, monitoring, and self-evaluation skills [9], [2].

The importance of teacher support should also be emphasized. Miao and Ma, examining 492 university students, found that teacher autonomy support was positively associated with online learning engagement, while self-efficacy and self-regulated learning played mediating roles in this relationship. This finding indicates that the effectiveness of technology-enhanced learning does not result from students' independent interaction with digital resources alone. The instructor remains an important component of the online learning environment, particularly through the provision of autonomy-supportive guidance, feedback, encouragement, and appropriately structured learning activities. The role of social presence provides another explanation for differences between synchronous and asynchronous learning. Synchronous environments allow students to communicate in real time and may therefore create stronger perceptions of immediacy, interpersonal connection, and participation. Miao and Ma demonstrated that online interaction influenced learning engagement partly through social presence. Consequently, videoconferencing, real-time discussion, collaborative digital tools, and interactive communication platforms can perform an important pedagogical function when they are used to promote meaningful interaction rather than merely transmit information [10], [9].

At the same time, asynchronous learning provides important advantages in terms of flexibility and learner autonomy. Recorded lectures, LMS-based resources, electronic materials, discussion forums, and asynchronous assessments allow students to determine the pace and timing of their learning. However, recent longitudinal research by Tedre et al. demonstrates that engagement and self-regulated learning develop dynamically over time in online learning environments. Steingruber stresses that the analysis of LMS trace data and longitudinal measures identify different behavioural patterns among students, including groups requiring targeted support to improve both engagement and self-regulation. These findins suggest that asynchronous learning environments should incorporate mechanisms for identifying students who demonstrate declining participation or insufficient self-regulatory activity [6], [17].

The findings concerning the role of technology are also consistent with recent evidence on personalized technology-enhanced learning. Hooshyar et al., in a meta-analysis of personalized technology-enhanced learning in higher education, found positive effects on both cognitive and non-cognitive learning outcomes, with the magnitude of effects influenced by delivery mode and the factors incorporated into the learning model. Reichgelt et al. emphasizes the potential benefits of combining different technological and pedagogical strategies. These findings support the argument that educational technologies should not be treated as isolated technical instruments. Their effectiveness depends on their alignment with students' needs, learning objectives, and instructional strategies [7], [15].

The relationship between technology and academic achievement is particularly evident in language education. A 2026 meta-analysis of 35 studies examining technology-enhanced second-language learning in higher education reported a significant positive effect on academic achievement ($g = 0.69$) and a significant reduction in cognitive load ($g = -0.20$). Mohammed et al. also found that technology type and intervention duration moderated the effects on academic performance. These findings are particularly relevant to higher education language courses, where synchronous technologies can support real-time communication and

interaction, whereas asynchronous technologies can facilitate vocabulary learning, listening practice, independent study, and repeated exposure to instructional materials [3], [11].

The findings also indicate that synchronous learning may be particularly advantageous when educational tasks require immediate interaction. Hung et al., comparing synchronous and asynchronous online learning among undergraduate medical students, demonstrated that both formats could support learning outcomes, while cognitive load differed between the learning conditions. Thus, the choice of modality should be determined by the cognitive and pedagogical demands of the learning task rather than by an assumption that one format is universally more effective [8].

Hence, the evidence supports a complementary synchronous–asynchronous model. Asynchronous technologies can be used for preliminary content acquisition, independent learning, revision, and formative assessment, while synchronous environments can be employed for discussion, clarification, collaborative problem-solving, oral communication, and immediate feedback. Such an approach also makes it possible to address differences in students' learning preferences, levels of self-regulation, and access to educational resources. An important implication of this interpretation is that the teacher's role becomes increasingly focused on learning design and facilitation rather than information transmission. Teachers need to select technologies according to their pedagogical affordances, establish clear expectations, provide timely feedback, monitor student engagement, and support the development of self-regulated learning skills. The evidence from Miao and Ma, Presley, and Chen et al. indicates that teacher support and self-regulation are closely connected with students' engagement in online environments [10], [13], [2].

Therefore, the results of the present study suggest that the effectiveness of e-learning should be understood as the outcome of a technology–pedagogy–learner interaction. Neither synchronous nor asynchronous instruction is inherently superior. Instead, academic achievement is more likely to improve when educational technologies are purposefully selected, instructional activities are appropriately structured, students receive sufficient guidance and feedback, and opportunities for both interaction and autonomous learning are provided.

V Conclusion

The analytical synthesis of recent research demonstrates that synchronous and asynchronous e-learning should be regarded as complementary instructional modalities rather than competing alternatives. Neither modality can be considered universally superior in terms of students' academic achievement. Their educational effectiveness depends on the alignment of learning activities with educational objectives, instructional design, the pedagogical functions of digital technologies, and students' individual learning characteristics.

The comparative analysis identifies distinct pedagogical functions of each modality. Synchronous e-learning is particularly appropriate for activities requiring immediate interaction, real-time feedback, collaborative problem-solving, oral communication, and clarification of complex concepts. However, its implementation depends on simultaneous participation, reliable technological infrastructure, and appropriate management of students' cognitive and organizational demands. Asynchronous e-learning provides greater temporal flexibility, opportunities for self-paced study, repeated access to learning materials, and independent knowledge acquisition. Its effectiveness, however, requires clear learning objectives, structured learning materials, regular progress monitoring, and adequate support for students' motivation and self-regulation.

A principal finding of the study is that educational technologies do not independently guarantee improved academic achievement. Their contribution depends on how their technological affordances are integrated into the pedagogical process. Digital communication, content-delivery, assessment, and collaborative tools are most educationally meaningful when they support defined learning outcomes, active student engagement, formative assessment, and timely feedback. Consequently, technology selection should be guided by pedagogical objectives and the characteristics of the intended learning activities.

The scientific contribution of the study consists in the synthesis of existing evidence into a four-component conceptual framework linking learning modality, the pedagogical functions of educational technologies, instructional design, and learner characteristics. The framework provides an analytical basis for explaining how these components interact in technology-enhanced higher education. It also emphasizes that the relationship between educational technologies and academic achievement should be interpreted in the context of teaching strategies, assessment practices, learner engagement, and self-regulated learning. The proposed framework

represents a conceptual contribution derived from the reviewed literature and requires further empirical validation.

From a practical perspective, the findings support the purposeful integration of synchronous and asynchronous activities within a coherent learning design. Asynchronous activities can be used for preparatory study, independent work, revision, and formative assessment, while synchronous sessions can focus on discussion, collaborative problem-solving, practical application, and immediate clarification of learning difficulties. Higher education institutions should therefore develop instructional models that combine the strengths of both modalities while ensuring accessibility, appropriate teacher support, transparent assessment criteria, and continuous monitoring of learning progress.

The study has several limitations. Its conclusions are based on the analytical synthesis of previously published research. The reviewed studies differ in research design, educational context, student population, technological environment, and measures of academic achievement. Consequently, the findings do not establish a universal causal relationship between a particular learning modality and academic performance, nor do they permit a direct quantitative comparison of all instructional approaches.

Future research should empirically test the proposed conceptual framework across academic disciplines and student populations. Particular attention should be given to objectively measured academic achievement, knowledge retention, cognitive load, student engagement, and self-regulated learning. Comparative and longitudinal studies should also examine how different combinations of synchronous and asynchronous activities influence learning outcomes under varying technological and institutional conditions.

Hence, the effective integration of educational technologies in higher education requires a shift from choosing between synchronous and asynchronous delivery toward designing pedagogically coherent learning environments. The central implication of this study is that educational outcomes depend not on the technological format alone, but on the purposeful coordination of learning activities, instructional support, assessment, and learner characteristics. This approach provides a conceptual foundation for developing flexible and evidence-informed e-learning practices in contemporary higher education.

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