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Message from the Editor-in-Chief

Dear Colleagues,

In today's rapidly evolving world of information and communication technologies, the field of education is directly influenced by this transformation. Innovative approaches in education, the integration of instructional technologies, artificial intelligence applications, and digital pedagogy continue to offer rich avenues for researchers. As TOJET, we remain committed to shedding light on this transformation by presenting up-to-date, high-quality, and original studies to our valued academic community.

In our July 2025 issue, we are pleased to share seven valuable articles prepared with interdisciplinary approaches.

The first article, authored by Ana Ester Garcia de Paiva Pinheiro and Ana Regina Mizrahy Cuperschmid, titled "Integrating Augmented Reality and Artificial Intelligence in Assembly Tasks: A Review of Strategies, Tools, and Challenges," comprehensively examines the integration of augmented reality and artificial intelligence into assembly processes, evaluating current applications and industry challenges.

The second article, prepared by Prof. Dr. İbrahim Yaşar Kazu, Aslan Kaplan, and Murat Kuvvetli, is titled "Thematic Content Analysis for Curriculum Literacy in Education." This study demonstrates how thematic content analysis can be applied in the context of curriculum literacy in education, with practical examples.

The third article, authored by Cheng-Ta Lin and Yen-Hsun Chen, titled "Through Project-based Learning to Discuss the Relations of Knowledge Absorptive Capacity, Listening, and Multiple Intelligence Acquisition," discusses the relationships among knowledge absorptive capacity, listening skills, and multiple intelligence acquisition within the framework of project-based learning.

The fourth article, written by Dr. Emel Yılmaz, titled "Cultural Identity and Ideology in Children's Media: A Comparative Analysis of Caillou and Nasreddin Hoca," addresses cultural identity and ideology in children's media from a comparative perspective.

The fifth article, by Hon Keung YAU and Choi Ho Man, titled "Evaluating Student Perceptions of Smart E-assessment Systems in Hong Kong Higher Education," examines students' perceptions of smart e-assessment systems in Hong Kong higher education institutions.

The sixth article, prepared by Min Jou, Tzu-Hsuan Kuo, Yu-Chun Chiang, Yungwei Hao, and Chun-Chiang Huang, titled "Integrating Generative AI in Teacher Education: A Qualitative Exploration of TPACK Growth and Critical Reflection," explores how the use of generative AI contributes to TPACK development and critical reflection processes in teacher education through a qualitative lens.

Our seventh and final article, authored by Yanchao Yang, Zhe Shi, Yilin Wang, and Yang Lu, titled "Exploring Applications of ChatGPT to Improve Spoken Chinese Self-efficacy of International Students: Theoretical Rationales, Limitations, and Recommendations," evaluates the potential of ChatGPT to enhance international students' spoken Chinese self-efficacy, along with its theoretical foundations, limitations, and practical recommendations.

As TOJET, we sincerely thank all our distinguished authors for their valuable contributions, our editorial board and reviewers for their diligent work during the peer-review process, and our readers for their continued support. We look forward to meeting you again in our future issues.

Call for Papers:
TOJET welcomes academic studies in the field of educational technology. Submitted articles may address topics such as the use of technology in classrooms, the impact of technology on learning, and the perspectives of students, teachers, administrators, and the community on educational technology. Such studies will enhance the quality of theoretical and practical approaches in educational technology.

Article Submission Criteria:
Submitted articles must be original, unpublished, and not under consideration by another publication.

Articles may cover a wide range of topics, including assessment, attitudes and beliefs, curriculum design, equity, applied research, learning theories, sociocultural issues, and educational practices for special populations.

Warm regards,

Prof. Dr. Aytekin İŞMAN
Sakarya University
Prof. Dr. Teresa Franklin
Ohio University
Prof. Dr. Jerry WILLIS
Louisiana State University
Editor-in-Chief

The Turkish Online Journal of Educational Technology (TOJET)
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Editorial Board

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Cultural Identity and Ideology in Children's Media: A Comparative Analysis of Caillou and Nasreddin Hoca

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Abstract
This study aims to conduct a comparative analysis of the role of children's media in the construction of cultural and economic identity through two characters: *Caillou***,** a Canadian production, and *Nasreddin Hoca Zaman Yolcusu***,** a Turkish production. Based on the premise that media serves not only as a source of entertainment but also as a significant medium for the transmission of ideological and cultural codes, the study establishes a theoretical framework grounded in the concepts of representation, semiotics, cultural capital, and simulation theory. The significance of this research lies in its examination of how media content shapes children's value systems, perceptions of identity, and understanding of social roles within a cultural context. The findings suggest that while the character of *Caillou* reflects individualism and consumer culture, *Nasreddin Hoca* foregrounds collectivist values, historical consciousness, and representations of local culture. Within this framework, the study reveals that media content exerts a profound and formative influence on children's cognitive, cultural, and social development. Especially during early childhood, media functions as a key source in shaping children's symbolic world. Therefore, the production of media content that reflects cultural diversity, promotes critical thinking, and supports multidimensional identity development is of vital importance. This study also aims to raise awareness among families, educators, and media producers in the context of media literacy.
Keywords: Children's Media, Cultural Identity, Semiotics, Caillou, Nasreddin Hoca

Introduction

In today's world, television and digital media platforms stand at the forefront of mass communication tools that define the era we live in, serving as the most effective and widespread instruments of cultural production. In developed countries, television is increasingly seen as a key source of information, with its importance in information dissemination growing day by day. As Fiske (1995: 45) states, "Television is part of the movement that realizes social change and constructs ideological values." Media has transcended its role as a mere provider of information and entertainment, becoming a powerful space of socialization where ideological, cultural, and economic codes are conveyed, especially to children.

Among mass media tools, television plays a central role in shaping children's social and cultural identities. Preschool-aged children are capable of identifying with animated characters (Oruç, Tecim & Özyürek, 2011). Especially during early childhood, the programs they watch act as decisive agents in identity formation, and the characters, settings, and narratives presented in media content directly influence how children perceive and understand the world.

The concept of "identity construction" refers to the process through which individuals build and shape their identities, including how they see themselves, how they are perceived by others, and how they position themselves within social contexts. Research has shown that identity is not an innate or purely individual characteristic, but rather a product of social environments. Individuals tend to construct their identities in relation to the characteristics of the social settings they find themselves in (Zhao et al., 2008: 1831).

The primary aim of this study is to conduct a comparative analysis of how children acquire economic and cultural identities through media content by examining two children's characters produced in different cultural contexts: the Canadian character *Caillou* and the Turkish character *Nasreddin Hoca Zaman Yolcusu*. While *Caillou* presents a modern representation that focuses on the construction of a consumer identity, reflecting Western-centric individualism and consumer culture (Eşitti, 2016: 127), *Nasreddin Hoca* serves as a vehicle for transmitting traditional values, cultural codes, and social norms, representing collectivist culture (Avcı, C. 2020: 559).

This study aims to offer a multi-layered analytical perspective situated at the intersection of cultural studies and media theories. It draws upon Stuart Hall's theory of representation (2017), Roland Barthes' semiotic analysis (2016a), Pierre Bourdieu's concept of cultural capital (2015), and Jean Baudrillard's theory of simulation (2014)

as its theoretical framework. As Hall (2005a: 104–105) argues, media content does not merely transmit messages; it also creates a space of ideological negotiation through the ways in which these messages are interpreted. This analysis seeks to deconstruct the discursive structures and cultural codes communicated by both characters. In this context, the study focuses on two key research questions:

1.How are economic and cultural identity representations conveyed to children in the programs *Caillou* and *Nasreddin Hoca Zaman Yolcusu*? What kinds of representations are developed in *Caillou* regarding the construction of a child consumer identity?

2.What cultural values and ideological orientations are emphasized in these representational forms? How is cultural identity constructed and language used in *Nasreddin Hoca Zaman Yolcusu*?

The significance of this research lies in its focus on media's impact on children not only at the behavioral level but also in terms of cultural identity formation. According to Koç (2006:226), referencing Bandura, cartoon characters have become prominent models in children's learning processes. Fictional characters are often more influential than real ones (Bandura, 1963: 3-11). Considering that a significant portion of the symbolic resources children use to make sense of the world are presented through media, the structural and semiotic analysis of children's programs becomes imperative.

The limitations of this study are that it focuses solely on specific programs in which the two characters are represented and analyzes selected scenes. Furthermore, the analysis is confined to visual and narrative elements, excluding empirical audience-based data on how children perceive these contents. Nevertheless, it is believed that a textual-level analysis of representation can make a valuable contribution to understanding the ideological structure of media content.

The research employs both semiotic analysis and critical discourse analysis as its methodology. This dual approach aims to reveal how individual consumption practices are legitimized through media, and how traditional values are symbolized. Based on the assumption that characters in children's programs are not merely entertainment elements but also media actors involved in the construction of children's cultural identities and consumer consciousness, this study seeks to offer a comprehensive understanding of the cultural, ideological, and economic impacts of media content on children's identity development.

2.Theoretical Framework

2.1. Stuart Hall – Theory of Representation and Meaning-Making in the Media

Stuart Hall's theory of representation argues that media content does not merely reflect reality; rather, it reconstructs reality through cultural and ideological codes. According to Hall (2005b: 104-105), representation is a process in which objects, people, and events are re-produced within specific linguistic or visual systems. In this process, the media presents various aspects of social life from a particular perspective, thereby guiding the audience in the production of meaning.

The process of meaning-making depends on the representation of things through language (Gökgül, 2022: 66). Hall bases the relationship between culture, language, and representation on the idea that culture is fundamentally concerned with "shared meanings." Therefore, language is essential to meaning and culture; it is always seen as a primary source of cultural values and meanings. Hall links the meaning-generating capacity of language to its function as a representational system. Language is one of the "tools" through which thoughts, ideas, and emotions are represented within a culture whether through sounds, written words, electronically produced images, musical notes, or even objects (Hall, 2017: 7). By discussing three different theories on how language is used to represent the world, Hall seeks to explore how the concept of representation enables the relationship between meaning and culture through language (Hall, 2017: 35–36).

Among these theoretical approaches, Hall is known to primarily adopt the "constructivist approach." It is significant to note that this approach plays a key role in the development of his renowned encoding/decoding model. Situated firmly within the critical paradigm, the encoding/decoding model offers a new perspective on the audience's position by challenging the notion that audiences are passive recipients of media messages (Turner, 2016: 107–108).

Children's television and digital media content carry significant ideological functions within this representational process. When considered in the context of Hall's encoding/decoding model (2017: 7), the characters and narratives presented in children's programming become structures through which particular value systems and lifestyles are encoded. For instance, *Caillou* represents the core elements of Western modernity, such as individual rights, freedom, and the capacity for personal choice. In contrast, *Nasreddin Hoca: The Time Traveler* offers a representational strategy rooted in traditional values, collective memory, and historical continuity. In this context,

representation is not merely the transmission of an image, but also the determinant of the ideological framework within which that image acquires meaning. In line with Hall's perspective, children, while learning to perceive the world through media, are simultaneously guided toward specific identity constructs.

2.2. Roland Barthes – Semiotic Analysis

Roland Barthes's semiotic theory offers a powerful framework for analyzing the multilayered processes of meaning production in cultural products particularly in media content. Barthes (1979: 88) conceptualizes signs on two levels: the denotative level, which refers to the literal or primary meaning of a sign; and the connotative level, which encompasses the secondary meanings attributed to that sign within a specific cultural context. As Barthes moved from linguistic analysis to semiotic analysis, he employed signifying systems such as denotation, connotation, and metalanguage. Each of these meaning systems is composed of a signifier (expression) and a signified (content). The first order of signification consisting of the signifier, the signified, and the sign yields denotation. Denotation occupies the primary position in the hierarchy of meaning and refers to the immediately perceptible content. The connotative level, in turn, takes the sign from the first order and repurposes it as a signifier in a new system of meaning.

Visual elements in children's programming such as character designs, setting choices, and use of color extend beyond simply presenting information. These elements carry codes that idealize specific lifestyles. For example, the home environment depicted in *Caillou* is presented as simple and safe; yet, simultaneously, it functions as a symbol of middle-class domestic life. In this context, children are not merely watching the daily routines of a character, but are also subtly encouraged to perceive that lifestyle as "natural" and "desirable." In contrast, *Nasreddin Hoca: The Time Traveler*, through its portrayal of traditional clothing, historical cityscapes, and oral narrative structures, symbolically reconstructs cultural memory.

In Barthes's framework, such signs do not merely reflect the past; they also serve as ideological propositions that shape how today's children are expected to see and interpret the past. In *Mythologies*, Barthes presents a model for decoding ideologies embedded in cultural forms. As Gottdiener (2005: 32) explains, "All ideologies are also hierarchical symbolic systems that code both objects and socially privileged practices within a system of prestige relations." Therefore, Barthes's concept enables a renewed examination of the relationship between ideology and cultural distinctions.

In this study, the selected media samples will be analyzed using Roland Barthes's (1979) semiotic model. Characters, colors, settings, and discourses employed in the programs will be treated as meaningful sign systems and examined accordingly.

2.3.Pierre Bourdieu – Cultural Capital and Symbolic Violence

Pierre Bourdieu's theory of cultural capital provides an important theoretical framework for understanding the role of children's media in reproducing class-based and cultural inequalities. Bourdieu defines cultural capital in relation to symbolic resources such as a person's level of education, language use, aesthetic preferences and patterns of behavior. According to Bourdieu, capital is described as a form of energy used within social and cultural relations. The concepts of capital and field are closely connected. Social relations within fields such as education, religion and modes of speech are contexts in which capital is reproduced and circulated through exchange processes (Göker, 2014: 278).

Bourdieu's concept of symbolic violence is particularly useful for explaining the media's power to legitimize certain lifestyles. When some ways of life are presented by the media as natural, correct or ideal, while other lifestyles are implicitly excluded, this reflects the reproduction of symbolic violence through media.

In his book *On Television*, Bourdieu clarifies one dimension of symbolic violence. Appearing on a television program often means giving up one's autonomy. This loss of autonomy can involve restrictions on speaking time, limitations on the subject matter and the imposition of specific topics. In this way, television becomes a mechanism that enables and sustains symbolic violence (Bourdieu, 1997: 21). Media content encodes which forms of capital are considered valuable, shaping children according to certain social norms.

2.4. Jean Baudrillard – Simulation Theory and the Transformation of Reality in Media

Baudrillard emphasizes that consumption is not merely an individual act but an active social behavior, a form of coercion, a moral system, and an institution. He argues that consumption functions as a social value system that integrates and regulates individuals, playing a significant role in the formation of personality and identity (Baudrillard, 2014: 95). From Baudrillard's perspective, simulation corresponds to hyperreality, where reality is produced through models without an original or base reality. Simulation short-circuits reality by reproducing it

through signs (Turan, 2011: 171). Simply put, simulation is the act of presenting something that does not exist as if it were real (Adanır, 2008: 13).

Jean Baudrillard's simulation theory explains how, in the media age, reality transforms into spectacle and how copies of reality replace reality itself. According to Baudrillard, in the postmodern media environment, the boundary between the real and its representation becomes blurred; media content ceases to be a mere representation of reality and instead creates hyperrealities that replace it (Hollinger, 2005: 197).

The episodes of Caillou, which always end positively, along with its sterile living conditions and controlled social interactions, present an idealized simulation of childhood. The challenges, contradictions, and conflicts of real life are almost entirely absent from this content. In this sense, the program offers children a "model reality" that is difficult to attain.

Similarly, Nasreddin Hoca: The Time Traveler does not reflect historical reality exactly but rather constructs a nostalgic and mythological past. In this program, the past becomes a tool that legitimizes contemporary values, and cultural identities are reproduced through a simulated history. Baudrillard's theory serves as a critical framework for understanding how these alternative realities produced by media take shape in the minds of children.

3. Methodology

This study is structured using a qualitative research approach aimed at understanding the cultural, ideological, and economic representations in media content targeted at children (Yıldırım and Şimşek, 2011). The methodology combines media ethnographic perspectives with semiotic analysis and critical discourse analysis (Şah, 2020: 220-222).

The primary rationale for choosing a qualitative analysis method lies in the fact that media content directed at children encompasses multilayered structures not only at the content level but also in terms of reproducing social structures, transmitting cultural norms, and processes of identity formation. Within this framework, the study aims to analyze the meanings carried by visual and narrative elements from the perspective of cultural studies.

3.1. Theoretical and Methodological Foundation

The analytical methods employed in this study are as follows:

Semiotic analysis: Within the framework of Roland Barthes' (1979) two-level theory of meaning, visuals and discourses were analyzed at both the denotative (literal meaning) and connotative (cultural/ideological meaning) levels.

Discourse analysis: Following Stuart Hall's (2005b) theory of representation, media discourses were evaluated as ideological processes of meaning production.

Cultural capital and simulation approaches: Based on Pierre Bourdieu's (1997) conceptualization of cultural capital and Jean Baudrillard's (2014) theory of simulation, the cultural codes carried by the programs and the idealized media realities were discussed. This methodological framework is supported by both international literature and Turkish academic studies.

3.2. Semiotic Analysis Process

The analysis was conducted in three main stages:

Descriptive Coding: Scenes, characters, color usage, spatial arrangements, and objects in the programs were descriptively coded (for example, Caillou's room, Nasreddin Hoca's costume).

Structural Coding: The place and function of these elements within the narrative coherence were analyzed. Each element's representation of cultural practices or ideological orientations was examined.

Ideological Coding: Visual and discursive elements were interpreted within the frameworks of Bourdieu's cultural capital and Baudrillard's simulation theories to reveal the socio-cultural contexts of the represented identities.

These stages enabled an in-depth analysis of the programs not only as content but also in terms of the meaning systems they carry.

3.3. Sample

In this study, a total of 20 episodes featuring two selected children's characters were examined using purposive sampling. The selected samples are as follows:

Caillou (PBS Kids / WildBrain - YouTube): From the 2022–2023 broadcast period, 10 episodes between the 1st and 10th episodes were viewed, and 5 episodes were analyzed. Themes such as consumption practices, individualism, and family interactions were prioritized(İşman et al., 2016; Kavut, 2018).

Nasreddin Hoca Zaman Yolcusu (TRT Çocuk, Turkey): From the 2021–2022 period, 10 episodes between the 1st and 10th episodes were viewed, and 5 episodes were analyzed. Scenes were selected based on historical memory, collective values, and indigenous cultural symbols (Türkman, 2008).

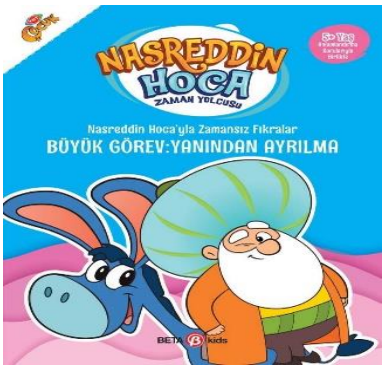
The episodes included in the analysis were subjected to scene-based thematic coding supported by visual analysis. The coding process enabled a structured examination of the economic and cultural identity representations presented in the media content (Şimşek and Şeker, 2012: 112). Furthermore, the combined use of Turkish and international literature allowed for greater theoretical diversity and a broader perspective on cultural contexts.

4. Findings and Discussion

In this section of the study, the ways in which economic and cultural identity representations presented to children in the programs Caillou and Nasreddin Hoca Zaman Yolcusu are constructed have been analyzed through direct quotations from scenes and the language use of the characters.

The analyzed scenes related to the Caillou character were obtained from episodes (2022–2023) published on WildBrain's official YouTube channel (2023). The animated series Nasreddin Hoca Zaman Yolcusu was viewed and analyzed via the TRT Çocuk platform (2019). It is noted that the series has been ongoing since 2019 and first aired on June 4, 2019.

Picture 1: Caillou



Picture 2: Nasreddin Hoca

4.1. Construction of the Individual Consumer Identity and Discourse Analysis in *Caillou*

When the findings are analyzed, it becomes evident that the character of Caillou is represented through themes of individualism, freedom, and consumer-oriented identity aimed at children. In the analyzed episodes, Caillou frequently emphasizes his personal desires in everyday conversations and openly expresses his needs.

For example, in Episode 3 titled *Caillou Doesn't Like Vegetables*, Caillou responds to his mother by saying, "I don't like vegetables; I want chocolate cookies." These lines directly convey the theme of freedom in connection with the construction of a consumer identity to the child audience.

In Episode 4 titled *Games to play*, Caillou plays a memory game with his grandmother's friend, Mrs. Murphy. She says, "I have a special deck of cards I use when my grandson visits. This game is called the memory game." When Caillou wins the game, Mrs. Murphy adds, "Whenever my grandson wins, I always give him one of these," and gives Caillou a piece of candy. This exchange reflects how individual demand and consumer identity are reinforced at an early age.

In Episode 5, titled *Caillou and His New Shoes*, Caillou's mother says, "Your feet no longer fit into your shoes. Let's go buy new ones right away." Caillou replies, "I want shoes like Sara's." These expressions highlight Caillou's use of simple and emotionally direct language. His ability to clearly articulate his desires and needs supports the development of a sense of "rights" and "entitlement" in the child viewer. Such discourse illustrates how consumer identity and social comparison are internalized from an early age.

In Episode 6, titled *Caillou at the Beach*, the structure of language and discourse emphasizes Caillou's right to self-expression. Family members are usually portrayed as responding to his requests gently and supportively. For example, his mother says, "We'll come back tomorrow to build another castle." This statement shows how individual freedom and a child-centered perspective are reflected in the media content.

In Episode 7, titled *Caillou at Daycare*, it is narrated that "Caillou was having so much fun playing that he didn't even hear his parents calling him." This type of narration reinforces the idea that toys or personal belongings function as tools for happiness and social acceptance.

4.2. Construction of Cultural Identity and Language Use in *Nasreddin Hoca Zaman Yolcusu*

In the animated series *Nasreddin Hoca Zaman Yolcusu*, Nasreddin Hoca does not speak from the past; instead, he enters the present and continues his roles as a humorist, moral teacher, advisor, and social critic. He performs these roles within the physical settings, social issues, and cultural conditions of contemporary life (Avcı, 2020, p. 565). For instance, in Episode 1 titled *Nasreddin Hoca on the Trail*, Hoca says: "Look at those mountains and hills, how beautifully the sheep and lambs are running, I miss the smell of fresh grass and the sound of bleating it reminds me of my homeland." These lines directly convey social and cultural values to children through narrative.

In Episode 2, titled *The Lion Tamer*, Nasreddin Hoca speaks to children at a zoo and says: "Unbelievable! What's a lion doing in the middle of the city? They've caged the monkeys too… Since when do lions belong in cages? Look at these modern folks they put animals in cages, cages in forests, and leave themselves stuck in the middle of noise and chaos." These statements use humor to deliver moral lessons directly to young viewers.

The character of Nasreddin Hoca is built around a discourse structure that emphasizes social solidarity, wisdom, and traditional values. In Episode 8, titled *Lost*, he remarks: "If this were back home, we'd have found it in two steps how are we supposed to find a donkey in this huge city?" This line conveys themes of communal living and cooperation directly to children. Nasreddin Hoca's style of speaking is witty, rich in humor, and often includes repeated formulas, helping children both enjoy and learn from his speech.

For example, in Episode 9 titled *Nasreddin Hoca's Lost Treasure*, the following dialogue takes place:
Nasreddin Hoca: "Your pot died..."
Neighbor: "What are you saying, Hoca? Pots don't die!"
Nasreddin Hoca: "You believed the pot could give birth, but not that it could die?"
These lines directly transmit traditional folk tales to children in a playful, memorable manner.

In Episode 10, also titled *The Lion Tamer*, Nasreddin Hoca's speech remains educational and guiding. He encourages listeners to reflect, be patient, and embrace cooperation: "Since I'm part of this game, I must save Kerim." This line represents the construction of collective identity and conveys the theme

5. Discussion and Conclusion

This study has explored how children's media constructs representations of economic and cultural identity models by analyzing the characters *Caillou* and *Nasreddin Hoca Zaman Yolcusu*. The analyses reveal that *Caillou* symbolizes Western-centered individualism, consumer culture, and the values of personal freedom, whereas *Nasreddin Hoca* embodies collectivist cultural norms, historical consciousness, and communal solidarity. These findings align with previous studies that highlight how cultural representations are coded and transmitted to children through media, particularly along the individualism–collectivism axis (Avcı, 2020; Türkmen, 2008; Yıldız, 2018). The differing linguistic and discursive practices employed in the two programs mediate the internalization and learning of cultural identity models through media exposure (Yılar & Kakşa, 2020: 534).

The data shows that *Nasreddin Hoca* uses a narrative structure enriched with proverbs, wisdom, and historical references to promote collective values, reinforcing solidarity and cultural memory. This reflects a form of "updating tradition" within the framework of contemporary media. Conversely, *Caillou* utilizes a discourse that emphasizes individual needs and emotions, aligning with consumer culture and a more individualistic worldview. As Hall and Gay (1996: 70-72) suggest, identity development is shaped through its relation to others and is continually produced through the interplay of personal attributes, social connections, and cultural interactions. The linguistic and discursive forms that children encounter in these media texts play a crucial role in their identity formation. *Caillou's* individualistic and consumption-oriented discourse helps develop children's sense of personal rights and consumer awareness, while *Nasreddin Hoca's* instructive and culturally embedded discourse supports the formation of historical belonging and social connectedness. This supports Stuart Hall's theory of media representation and meaning-making, which underscores the ideological function of encoding and decoding processes in media (Hall, 2017: 7).

As Roland Barthes (2014: 150) highlights in his semiotic analysis, the values represented by these characters are not merely surface-level entertainment but symbolic structures embedded with deep cultural and ideological codes. The design of space and the behavior of characters play a critical role in reinforcing cultural norms in children's perceptions.

Furthermore, Pierre Bourdieu's (1997: 21) concepts of cultural capital and symbolic violence provide meaningful insight into how specific lifestyles are normalized and alternative identities marginalized through media. According to the findings, *Caillou* grows up in a pedagogically supportive family environment, surrounded by books, and his personal preferences are respected all indicative of a high cultural capital profile. In contrast, *Nasreddin Hoca* is depicted as a character shaped by collective consciousness, historical context, and public interest, rather than individual freedoms.

Jean Baudrillard's (1983: 3) theory of simulation shows how the hyperrealities presented in such programs shape children's perceptions of reality. In particular, *Caillou's* idealized lifestyle can significantly influence children's expectations and social relationships when compared to real-life experiences.

In conclusion, the ideological function of children's media in the development of economic and cultural identity is closely tied not only to structural content features but also to the forms of language and narration used. Considering that media characters shape children's social and cultural worlds and play a role in identity construction, it is essential to promote cultural diversity and ideological awareness in children's media production. This is crucial for enabling children to critically and healthily explore diverse identity models.

Media producers should adopt a more conscious approach to enhancing cultural representation in children's content and support multidimensional identity development. Moreover, it is important that these contents remain connected to children's real-life experiences and contribute to the development of media literacy. In doing so, children may develop pluralistic, multicultural, and critical identity perspectives beyond the singular identity and value models imposed through media.

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Evaluating Student Perceptions of Smart E-assessment Systems in Hong Kong Higher Education

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Abstract
This study explores Hong Kong higher education students' perceptions of E-assessment systems, focusing on factors shaping acceptance of E-examinations over traditional formats. Quantitative analysis of 107 respondents reveals significant positive correlations between diverse pre-exam guidance (e.g., tutorials) and key system features (e.g., usability, user friendly), and between these features and effective E-examination feedback (e.g., instants feedback) and identity monitoring techniques (e.g., webcam surveillance). E-examinations' advantages also correlate with enhanced monitoring identity. Prior experience boosts guidance value. These findings urge institutions to refine E-assessment with robust guidance, intuitive design, and reliable monitoring to enhance engagement, integrity, and satisfaction. Limited sample diversity suggests broader demographic studies. Results inform E-assessment optimization across contexts.
Keywords: E-assessment; Importance of diverse guidance; Key E-assessment system features; E-exams versus traditional exams; E-exam feedback; Monitoring techniques.

1. Introduction

Educational assessment has dramatically evolved from traditional pen-and-paper methods to technology-driven approaches, thanks to advancements in digital technology. This shift has led to more dynamic and interactive assessment formats. As institutions increasingly adopt e-assessment systems, it is essential to understand their impact on student engagement and learning. Technology integration allows for rapid, automated results and immediate feedback, significantly enhancing the evaluation process (Kiryakova, 2021).

Numerous studies have explored students' perceptions of E-assessment, highlighting a range of insights and experiences (Crisp et al., 2016; Iahad et al., 2004; Khan et al., 2021; Kumar & Owston, 2015; Kundu & Bej, 2021; Kiryakova, 2021; Pham, 2022; Rostaminezhad, 2019). However, there is a notable gap in research regarding Hong Kong higher education students' perceptions of e-assessment systems. Given that the e-learning landscape has changed significantly over the past decade, it is essential to conduct a study on E-assessment in today's higher education context.The research will address the following questions:

1. How do demographic differences and personal characteristics, such as university or institution, major, year of study, and prior experience, affect students' perceptions of E-assessment in higher education?
2. What are the students' perceptions regarding the importance of providing various types of guidance before E-examinations?
3. What are the students' perceptions regarding the essential features of an effective E-assessment system?
4. What are the students' perceptions regarding the feedback students prefer to receive from E-examinations?
5. What are the students' perceptions regarding E-examinations compare to traditional examinations?
6. What are the students' perceptions regarding techniques used for monitoring and verifying identity during E-examinations?
7. What are the students' perceptions regarding the idea of E-examinations becoming a standard format in higher education, and what features do they feel are missing from current E-assessment systems?

To narrow the research's focus, the study will also compare perceptions based on various factors, such as differences between fields of study(Major), year of study, and prior experience with e-assessments. This focused strategy will offer helpful insights into how these factors influence the way students view e-assessment systems.

2. Literature

2.1 Definition and Purpose of Educational Assessment

Educational assessment systematically collects data on students' knowledge, skills, and attitudes to enhance teaching and learning by evaluating instructional methods, identifying program weaknesses, and monitoring progress (Institute of Education Sciences, 2023). By analyzing student performance data, educators can evaluate how effectively their teaching methods meet set learning goals, enabling continuous improvement and tailored education for students. (Baleni, Z., 2015; Owan, V. et al., 2023; Osiesi, M., 2020; Hernández, R., 2012). Assessments engage students by fostering ownership, encouraging goal-setting, and promoting active participation, while regular feedback highlights strengths and areas for improvement, boosting confidence and enriching the learning experience (Amangeldina, G. & Dudovich, D., 2022; Magdalena, I. et al., 2023; Osiesi, M., 2020; Hernández, R., 2012; Zhou, M., 2023).

Technology enhances assessments with engaging tools like online quizzes, simulations, and multimedia presentations, providing immediate feedback that allows students to adjust their learning strategies in real time (Rostaminezhad, 2019; Pham, 2022; Duterte, J., 2024; Ejjami, R., 2024). Formative assessments, integrated throughout the learning process, enable teachers to adapt their methods to meet diverse student needs, as Sadler, D. (1989) emphasizes. This shift transforms assessments into dynamic tools for improving teaching and creating responsive learning environments (Sortwell, A. et al., 2024; Lee, H. et al., 2020).

2.2 Types of Assessments

Various assessments are used to achieve educational goals, each serving distinct purposes in the learning process.

1. Diagnostic Assessments

Diagnostic assessments identify students' existing skills and areas of need before teaching starts (Fan, T. et al., 2021).

2. Formative Assessments

Ongoing feedback from these assessments helps teachers and students adjust learning strategies in real-time (Cañadas, L., 2021; Lee, H. et al., 2020).

3. Interim Assessments

Interim assessments track student progress and inform teaching adjustments throughout the year (Wang, C., 2021; Perie, M. et al., 2009).

4. Summative Assessments

These final evaluations assess students' overall achievement and mastery of course objectives at the end of a term (Kibble, J., 2017; Kusumoriny, L., 2024).

Assessments serve distinct purposes for various stakeholders in education (Bulut, O. et al., 2024; Kusumoriny, L., 2024; Sri, S. et al., 2024). Students gain insights into their learning progress, identifying strengths and areas for improvement, which helps them make informed decisions about their learning plans (Bulut, O. et al., 2024; Kusumoriny, L., 2024; Sri, S. et al., 2024; Ifenthaler, D. et al., 2022; Harris, L. et al., 2022; Shin, N. et al., 2010). Educators use assessments to evaluate group and individual needs, adapt teaching strategies, and provide targeted support, fostering deeper learning (Kusumoriny, L., 2024; Constantinou, P., 2017; Graue, M., 1993).

Administrators leverage assessment data to evaluate instructional programs, allocate resources, and align school plans with student needs (Sievertsen, H., 2022; Omoeva, C. et al., 2021). At the state level, assessments measure the effectiveness of interventions and ensure students meet standards in key subjects like mathematics and literacy (Goertz, M., & Duffy, M., 2001; Institute of Education Sciences, 2023). A balanced assessment system enhances student learning and refines teaching practices (Turdieva, R., 2024; Kusumoriny, L., 2024; Din, A. et al., 2023; Muhammad, I. et al., 2024).

2.3 E-assessment: Definition and Characteristics

E-assessment refers to any type of assessment that is constructed, delivered, and marked using technology, typically through a tailor-made assessment platform. E-assessment encompasses a wide range of practices that integrate technology into various stages of the assessing process, from creation to delivery, marking, and feedback (Jordan, S., 2013; Mo, D. et al., 2022; Kundu, A. & Bej, T., 2021). In the majority of cases, E-assessment is the complete end-to-end process on a computer or digital device, but it may also be used to refer to some components, such as on-screen marking or test construction (Gibson, 2020).

E-assessment has also been referred to traditionally as computer-based testing, online assessment, or computer-based assessment, and the phrases are interchanged (Heil, J. & Ifenthaler, D., 2023). The E-assessment can be utilized both for summative and formative assessments, and therefore an effective tool for educational institutions (Mate, K. & Weidenhofer, J., 2022). Formative e-assessments provide ongoing feedback during the learning process, enabling students and educators to make timely adjustments, while summative e-assessments evaluate student learning at the conclusion of an instructional unit (Serutla, L. et al., 2024).

One significant aspect of e-assessment is its distinction from traditional assessment methods, such as pen-and-paper tests. While both approaches aim to evaluate learning outcomes, the implementation differs significantly. In e-assessment, technology facilitates not only the delivery of assessments but also the collection and analysis of data, allowing for innovative question formats and immediate feedback (Heil, J. & Ifenthaler, D., 2023). This shift in methodology can enhance the overall assessment experience for both students and educators (Mate, K. & Weidenhofer, J., 2022).

E-assessment offers several key characteristics that enhance the assessment experience. Firstly, it provides immediate feedback to students, helping them understand their performance in real-time (Heil, J. & Ifenthaler, D., 2023; Mate, K. & Weidenhofer, J., 2022). This prompt feedback loop encourages reflection and allows learners to make necessary adjustments to their study strategies. Additionally, e-assessment facilitates efficient data collection and analysis, providing educators with valuable insights into student performance trends and learning outcomes (Heil, J. & Ifenthaler, D., 2023; Mate, K. & Weidenhofer, J., 2022).

Another important aspect of e-assessment is its scalability (Isaías, P. et al., 2023; Isaías, P. et al., 2024). Educational institutions can administer assessments to large groups of students simultaneously, streamlining logistics and resource management (Heil, J. & Ifenthaler, D., 2023; Ristov, S. et al., 2014; Masagazi, J. et al., 2024). E-assessment platforms often support diverse question formats, including multiple-choice, short-answer, and essay questions, which cater to various learning styles and assessment objectives (Isaías, P. et al., 2023; Isaías, P. et al., 2024).

Moreover, e-assessment enhances accessibility for students with disabilities or those requiring accommodations. Many platforms offer features such as text-to-speech, adjustable font sizes, and alternative input methods, ensuring equitable access to assessment opportunities (Kumar, K. & Owston, R., 2015; Mate, K., & Weidenhofer, J., 2022). Security is another significant advantage of e-assessment. With content stored digitally, the risk of loss is minimal, and access can be controlled through measures such as two-factor authentication (Alnasser, F. & Elrashidi, A., 2023; Ubah, A. et al., 2022). The ability to randomize assessment content further decreases the potential for cheating, as each student can receive different questions or variations of the same test (Miguel, J. et al, 2015; Küppers, B. et al., 2020). E-assessments are usually conducted in a locked-down environment, where all other functionalities on the computer, including internet access, are disabled during the assessment (Gibson, 2020; Küppers, B. et al., 2020; Keykha, A. et al., 2025).

2.4 E-assessment format and examples

E-assessment offers diverse formats ideal for online platforms, providing benefits like automated grading and instant feedback (Heil & Ifenthaler, 2023; Karunarathne & Wijewardene, 2021; Baleni, 2015). These include matching exercises, fill-in-the-gap tasks, and interactive elements like drag-and-drop or simulations (Mate & Weidenhofer, 2022; Heil, J. & Ifenthaler, D., 2023; Crisp et al., 2016). Traditional assessments, such as essays, case studies, and discussion forums, can be adapted online to assess skills like communication and teamwork (Bayne et al., 2022; Gunning & Collins, 2018). Live or recorded presentations further enhance engagement and support varied learning styles, fostering active learning and collaboration (Mate & Weidenhofer, 2022; Hughes et al., 2024; Chen et al., 2022; Hulton & Gapper, 2020).

2.5 Development of Hypothesis

2.5.1 Prior experience in E-assessment

Students with prior experience in E-assessment may affect their perspectives on the E-assessment system and E-examinations. Research indicates that these students place a high value on institutional support (Khan et al., 2021). Their familiarity with the challenges of E-examinations leads them to appreciate guidance even more. Moreover, students have positive perceptions of specific features like webcam proctoring and digital interfaces for answering questions when they become more familiar with E-examinations (Domínguez-Figaredo & Gil-Jaurena, 2024). This suggests that prior experience with e-assessment systems significantly influences students' views on these key features which enhance their comfort and satisfaction with the system's functionalities. Furthermore, students with prior E-assessment experience tend to have a positive overall perception of E-examinations, with a specific appreciation for immediate feedback and efficient processes (Khan et al., 2021). However, while they often feel less stressed and find E-examinations reliable, these positive perceptions can vary across different groups (Afacan Adanır et al., 2020). Thus, prior experience is essential to become an indicator for analysis in understanding student attitudes toward E-assessment. Therefore, I hypothesize:

H1: Students with prior experience in E-assessment have a greater understanding of the importance of diverse guidance before E-examinations.

H2: Students with prior experience in E-assessment hold a more positive perspective on the key features of the E-assessment system.

H3: Students with prior experience in E-assessment have a favorable view of the feedback provided during E-examinations.
H4: Prior experience with E-assessment influences students' perspectives on E-examinations compared to traditional examinations.
H5: Students with prior experience in E-assessment view monitoring techniques during E-examinations positively.

2.5.2 Major Difference in E-assessment
Each academic major has its own specific learning outcomes, which are tailored to the unique requirements and goals of the discipline. As a result, E-assessment methods may not be equally suitable for all majors. According to Saha, D., Das, S., and Acharjee, D. (2023), E-examinations may be particularly challenging for majors that emphasize practical skills and hands-on learning experiences. In these fields, such as engineering, medicine, or the arts, the reliance on E-assessment formats may limit the effectiveness of evaluating students' true competencies. Furthermore, it is likely that the administrative tools used in e-assessments will not be that good in showing students' real practical abilities, which, in the end, can affect the completeness of the assessment. Therefore, it is essential to analyze the differences in majors to determine how they affect Hong Kong students' perspectives on E-assessment. Thus, I hypothesize:
H6: Students from different Majors perceive the Identity Monitoring Techniques in E-Examinations differently.

2.5.3 Study Year Difference in E-assessment
Students from different academic years may have different points of view about E-assessment. According to Khan et al. (2021), early-year students tend to focus on monitoring issues, while later-year students prioritize practicality. Early-year students may resist monitoring due to a lack of familiarity, whereas later-year students embrace it for its efficiency. Similarly, Iahad et al. (2004) suggest that students in later years generally have a more positive perspective on E-examinations feedback, which can also extend to their views on monitoring. Therefore, it is essential to analyze the differences in study years to determine how they affect Hong Kong students' perspectives on E-assessment. Thus, I hypothesize:
H7: Students from different Study Year perceive E-Examinations Feedback differently.
H8: Students from different Study Year perceive Identity Monitoring Techniques in E-Examinations differently.

2.5.4 Diverse Guidance before E-examinations and Key Features of E-assessment system
The study demonstrates a positive relationship between the importance of diverse guidance before E-exams and the key features of E-assessment systems (Mo, Tang, Wu, & Tang, 2022). This relationship exists because guidance reduces uncertainty, develops skills, facilitates adaptation to new technology, and aligns with the digital context. Thus, I hypothesize:
H9: There is a positive relationship between Diverse Guidance and Key Features
2.5.5 Key Features of E-assessment system and E-Examinations Feedback
On the other hand, the positive relationship between Key Features of E-assessment system and E-Examinations Feedback indicates that the more effectively these features function, the more valuable students find the feedback for their learning process (Iahad, Dafoulas, Kalaitzakis, & Macaulay, 2004). Thus, I hypothesize:
H10: There is a positive relationship between Key Features and E-Examinations Feedback

2.5.6 Key Features of E-assessment system and Monitoring Techniques in E-examinations
The features enhance monitoring by improving security, efficiency, and adaptability, as demonstrated by the benefits for administrators and the outcomes of system design. This relationship exists because these features facilitate proactive oversight, reduce instances of cheating, and ensure consistent monitoring during large-scale assessments, aligning with the demands of modern digital education (Saha, Das, & Acharjee, 2023). Thus, I hypothesize:
H11: There is a positive relationship between Key Features and Monitoring Techniques
2.5.7 E-Examinations vs. Traditional Examinations and Monitoring Techniques in E-examinations
The monitoring techniques are significant factors affecting respondents' attitudes toward the comparison of E-examinations and traditional examinations. Effective monitoring enhances security, efficiency, and adaptability in the examination process, ultimately influencing students' views on the reliability and integrity of the assessment (Khan et al., 2021). Thus, I hypothesize:
H12: There is a positive relationship between E-Examinations vs. Traditional Examinations and Monitoring Techniques

3. Research methodology

3.1 Research Design

This study applies a quantitative research design to comprehensively examine the perceptions of Hong Kong higher education students regarding E-assessment systems. The research uses a structured questionnaire to measure the variability of students' attitudes, preferences, and concerns towards e-assessment. The quantitative methodology used is one of the easiest ways to obtain numerical data for the purposes of statistical analysis giving insights into trends and patterns in student perceptions. This approach is particularly effective in capturing a broad variety of opinions across different demographic groups, which strengthens the trustworthiness and accuracy of the results.

3.2 Participants

The target population for this study consists of students enrolled in higher education institutions across Hong Kong, encompassing undergraduate, postgraduate, master's, and doctoral students. Specifically, the survey focuses on non-exchange students from various universities and colleges to ensure a representative sample of the local student body. The inclusion of students from diverse fields of study enriches the data and allows for a comparative analysis of perceptions based on academic discipline and level of study. A convenience sampling method was utilized to recruit participants, leveraging online forums and Canvas discussions to reach a broad audience efficiently. This method not only facilitates easier access to participants but also ensures a timely collection of data.

3.3 Questionnaire Development

The survey comprises 37 questions divided into three categories to capture participants' perspectives on e-assessment systems:

Demographic Information (4 multiple choice questions): Collects data on educational institution, field of study, study year, and e-assessment experience to analyze perception trends across groups.

Perceptions of E-assessment (31 Likert scale questions): Participants rate agreement on e-assessment aspects, including pre-exam guidance, system features, feedback, traditional exam comparisons, identity verification, and comfort, allowing nuanced insights.

Open-ended Questions (2 questions): Enables free expression on standardizing online exams and desired e-assessment features, enriching quantitative data with qualitative insights.

3.4 Data Collection

A pilot test was conducted with 10 students who were my friends from various universities and institutions in Hong Kong before the full distribution of the survey to all students. In this pilot study, the participants were asked to complete a questionnaire in order to determine if they could understand it on their own. They were then asked to provide their feedback on the questionnaire once it had been collected. It was concluded that all of them could understand it. The questionnaire's length and complexity were also moderate.

Data were collected using an online survey platform, which guarantees anonymity and confidentiality for all participants. The questionnaire was distributed through online forums for higher education students and shared among friends to ensure broad reach and effective engagement. The survey remained open for a specified period, providing ample time for responses. Participants were informed about the study's purpose and methodology, promoting transparency throughout the process. They were reassured that their responses would be kept confidential and utilized solely for research purposes, thereby fostering trust and encouraging honest feedback.

3.5 Data Analysis

Data will be analyzed using SPSS, with descriptive statistics (means, standard deviations, frequencies) summarizing demographic and Likert-scale responses to identify perception trends. Open-ended responses will be qualitatively analyzed for themes, enabling a mixed-methods approach. Factor analysis will validate scales by assessing one-dimensionality, factor loadings (>0.3, Fornell & Larcker, 1981), and corrected item-total correlations (>0.2, Kline, 2015), removing items below thresholds. Scale reliability will be tested using Cronbach's alpha (>0.7, or >0.5 for scales with <10 items; Fornell & Larcker, 1981; Pallant, 2010). Independent t-tests and one-way ANOVA will compare group means (e.g., by gender, experience, study year), and Pearson correlations will explore factor relationships.

3.6 Ethical Considerations

Informed consent was obtained from all participants, who were informed about the study's purpose, question types, and time commitment, ensuring transparency and trust. They were assured of their right to withdraw anytime without consequences. Data were anonymized to protect identities, using secure handling and confidentiality protocols to uphold ethical standards, safeguard privacy, and enhance research credibility.

3.7 Validation of Measurement Scale

Item 22, being nominal data, is excluded from Component Analysis, Factor Analysis, and Reliability Analysis due to its categorical nature, which complicates meaningful correlation calculations.

3.7.1 Factor Analysis

As mentioned, a factor loading of 0.3 is considered acceptable (Fornell & Larcker, 1981), while a corrected item-total correlation of 0.2 is used to verify the items (Kline, 2015). The values of factor loading of each Item are larger than 0.3. However, the value of Corrected Item-Total Correlation of Item27 is less than 0.2. Thus, it should be deleted. After removing Item27, all items' Corrected Item-Total Correlation values are greater than 0.2 and all items' Factor Loading values are larger than 0.3. Thus, the scale is reliable, and all items have large variances for factor analysis.

3.7.2 Component Analysis

Table 1: Component Analysis for each factor

Construct	Components Extracted	Variance Explained (Component 1, Component 2)
Diverse Guidance	1	56.33%
Key Features	2	48.31%, 14.95%
E-exam Feedback	1	50.73%
E-exams vs. Traditional exam	1	40.46%
Monitoring Techniques	2	39.61%, 17.21%

Principal Component Analysis (PCA) validated the survey's measurement scales by identifying underlying components for each construct. One component was extracted for Importance of Diverse Guidance (56.33% variance), E-Examinations Feedback (50.73%), and E-Examinations vs. Traditional Examinations (40.46%). Two components were extracted for Key Features (48.31% and 14.95% variance) and Identity Monitoring Techniques (39.61% and 17.21% variance). Component 1 was prioritized for each construct due to higher variance explained, confirming scale suitability for further analysis

3.7.3 Reliability Analysis

Table 2: Reliability Statistics for each factor

Item	Cronbach's Alpha	N of Items	Notes
Importance of Diverse Guidance	0.604	3	All correlations >0.2
Key Features of E-Assessment System	0.832	8	All correlations >0.2
E-Examinations Feedback	0.826	5 (originally 6)	Item 21 deleted (alpha improved from 0.787)
E-Exams vs. Traditional Exams	0.61	5(originally 6)	All correlations >0.2; Item 27 excluded earlier (Section 3.7.1)
Identity Monitoring Techniques	0.735	6(originally 7)	Item 29 deleted (alpha improved from 0.732)

Reliability analysis confirmed internal consistency using Cronbach's alpha (>0.5 for scales with <10 items; Pallant, 2010), with values ranging from 0.604 to 0.826 (Table X). Items 21 and 29 were removed from Feedback and Monitoring Techniques to improve alpha to 0.826 and 0.735, respectively, ensuring scale reliability for further analyses.

4. Results and Discussion

4.1 Introduction

This section discusses the data analysis results. It begins with demographic statistics of respondents, providing background on university/institutions, major, study year, and prior E-assessment experience for subgroup allocation. Next, descriptive statistics are summarized, followed by independent samples t-tests comparing factors by prior experience, one-way ANOVA assessing differences by university/institutions, major, and study year, and Pearson correlations analyzing relationships between Diverse Guidance and Key Features, Key Features and E-Examinations Feedback, Key Features and Monitoring Techniques, and E-Examinations vs. Traditional Examinations and Monitoring Techniques. The discussion follows, addressing each analysis in order.

4.2 Demographic Information of Respondents

119 questionnaires were collected, and 107 questionnaires were useful. Respondents come from various universities and institutions. There are 28 CityU students with 26.2%, 9 CUHK students with 8.4%, 3 EdUHK students with 2.8%, 8 HKBU students with 7.5%, 3 HKCC students with 2.8%, 1 HKMU student with 0.9%, 1 HKSYU student with 0.9%, 14 HKU students with 13.1%, 1 HKU SPACE student with 0.9%, 4 HKUST students with 3.7%, 1 HSU student with 0.9%, 4 IVE students with 3.7%, 4 Ling U students with 3.7%, 2 MU students with 1.9%, 2 NY students with 1.9%, 20 PolyU students with 18.7%, 1 SFU student with 0.9%, 1 YCCECE student with 0.9%. Among respondents, about 11.2% of respondents are postgraduate or master, 19.6% of respondents are year1, 16.8% of respondents are year2, 16.8% of respondents are year3, 35.5% of respondents are year4 or above. 30.8% of respondents study in Art/Social Science/Education, 16.8% of respondents study in Business, 18.7% of respondents study in Engineering, 9.3% of respondents study in Pharmacy/Medicine, 9.3% of respondents study in Creative Media/Computer Science/Information Systems, 12.1% of respondents study in Science, 2.8% of respondents study in Law. About 87.9% of respondents have experience with E-assessments. Only 12.1% of respondents do not have experience with E-assessments. The background information is demonstrated below.

Table 3: Percentage of Respondents' Studying University/Institution

University/Institutions

	Frequency	Percent	Valid Percent	Cumulative Percent
CityU	28	26.2	26.2	26.2
CUHK	9	8.4	8.4	34.6
EdUHK	3	2.8	2.8	37.4
HKBU	8	7.5	7.5	44.9
HKCC	3	2.8	2.8	47.7
HKMU	1	.9	.9	48.6
HKSYU	1	.9	.9	49.5
HKU	14	13.1	13.1	62.6
HKU SPACE	1	.9	.9	63.6
HKUST	4	3.7	3.7	67.3
HSU	1	.9	.9	68.2
IVE/VTC	4	3.7	3.7	72.0
Ling U	4	3.7	3.7	75.7
MU	2	1.9	1.9	77.6
NY	2	1.9	1.9	79.4
PolyU	20	18.7	18.7	98.1
SFU	1	.9	.9	99.1
YCCECE	1	.9	.9	100.0
Total	107	100.0	100.0	

Table 4: Percentage of Respondents' Studying Major

Major

	Frequency	Percent	Valid Percent	Cumulative Percent
Art/Social Science/Education	33	30.8	30.8	30.8
Business	18	16.8	16.8	47.7
Engineering	20	18.7	18.7	66.4
Pharmacy/Medicine	10	9.3	9.3	75.7

	Creative Media/Computer Science/Information Systems	10	9.3	9.3	85.0
	Science	13	12.1	12.1	97.2
	Law	3	2.8	2.8	100.0
	Total	107	100.0	100.0	

Table 5: Percentage of Respondents' Study Year

Study_Year

		Frequency	Percent	Valid Percent	Cumulative Percent
	Postgraduate/Master	12	11.2	11.2	11.2
	Year1	21	19.6	19.6	30.8
	Year2	18	16.8	16.8	47.7
	Year3	18	16.8	16.8	64.5
	Year4 or above	38	35.5	35.5	100.0
	Total	107	100.0	100.0	

Table 6: Percentage of Respondents' prior experience of E-assessments

Prior experience of E-assessments

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	13	12.1	12.1	12.1
	Yes	94	87.9	87.9	100.0
	Total	107	100.0	100.0	

4.3 Descriptive Statistics

The items are 5-point Likert-scale questions (1=Strongly agree to 5=Strongly disagree).

4.3.1 The significance of offering various types of guidance before the E-examinations

The overall mean of Importance of Diverse Guidance Before E-Examinations is around 2.35. It means that the respondents rated this factor positively. From the five-point scale, point 2 denoted "Agree", meaning the respondents tend to agree that giving diverse guidance before the E-examinations is important.

4.3.2 The essential features of an E-assessment system

The overall mean of Key Features of an E-Assessment System is around 1.68. It means that the respondents rated this factor positively. From the five-point scale, point 2 denoted "Agree", meaning the respondents tend to agree that some features mentioned in the questionnaire are important.

4.3.3 The feedback from the E-examinations

The overall mean of E-Examinations Feedback is around 2.21. It means that the respondents rated this factor positively. From the five-point scale, point 2 denoted "Agree", meaning the respondents tend to agree that feedback after examination is important. The mean of item 17 is the lowest and close to 2, which is "I believe that students should receive a detailed explanation of the incorrect answers". This revealed that higher education students prefer having solutions or model answers after examinations.

4.3.4 E-examinations compared to traditional examinations

The overall mean of E-Examinations vs. Traditional Examinations is around 2.87. This means that the respondents rated this factor slightly positively. From the five-point scale, point 3 denoted "Neutral", meaning the respondents slightly agree that the performance on E-examinations. The mean of item 28 is the lowest and close to 2, which is "I believe that students should receive a detailed explanation of the incorrect answers". This revealed that the duration of E-examinations is appropriate, and higher education students can manage E-examinations similarly to traditional examinations.

Item 22 is “How do you rate the comfort level of E-examinations compared to traditional examinations” with five answers “E-exams are far less comfortable than traditional exams”, “E-exams are less comfortable than traditional exams”, “Both are similar in comfort”, “E-exams are more comfortable than traditional exams”, “E-exams are far more comfortable than traditional exams”. The majority of respondents selected option 3, which states that 'Both are similar in comfort.' The mean value for Item 22 is also 3, suggesting that most higher education students do not have a preference for either E-examinations or traditional examinations based on comfort, as they find them to be equally comfortable.

4.3.5 Techniques for monitoring and verifying identity in E-examinations

According to Table 43, the overall mean of Identity Monitoring Techniques in E-Examinations is around 2.73. This means that the respondents rated this factor slightly positively. From the five-point scale, point 3 denoted “Neutral”, meaning the respondents slightly agree on the methods of identity monitoring in E-examinations.

4.3.6 Open-ended questions

The questionnaire includes two open-ended questions aimed at capturing higher education students' perspectives on E-assessment. Item 36 seeks to determine whether students support the idea of E-examinations replacing traditional exams, while Item 37 explores the features that students believe would be beneficial in an E-assessment system.

The responses to Item 36 reveal a noticeable split among students. Out of 107 total replies, 30 students were in favor of E-examinations, appreciating the flexibility, convenience, and cost savings they offer, especially for those who might struggle to attend in-person assessments. On the other hand, 61 students expressed concerns, citing issues like the potential for cheating, technical glitches, and the challenges of effectively monitoring students during online tests. Many also felt that certain subjects require in-person exams due to their hands-on nature. Furthermore, 16 respondents took a neutral stance, suggesting that a combination of online and traditional exams could work well, depending on personal preferences and the specific needs of different courses.

From the Item37 results, respondents shared important ideas for improving future E-assessment systems. Many expressed a desire for more flexible exam timing, allowing students to choose when to take their tests. There was also a call for better communication tools to enable monitored interactions during exams. Improved monitoring features, like screen observation and behavior checks, were seen as essential for fairness. Quick feedback on answers, insights into classmates' responses, and clear explanations would greatly help students. Suggestions include using technology like handwriting and voice recognition, as well as AI for grading longer answers. To prevent cheating, automated checks and screen-locking at the end of exams were considered vital. Meanwhile, support for special learning needs and a question bank for revision were emphasized.

4.4 Independent Sample T-test

The Independent Samples T-test assesses significant differences between two groups, using Levene’s Test for Equality of Variances and the t-test for Equality of Means. Levene’s Test indicates equal variances if the significance level exceeds 0.05 (use equal variance results) or unequal variances if ≤0.05 (use unequal variance results). The t-test shows a significant mean difference if the 2-tailed significance is ≤0.05; otherwise, no difference exists.

4.4.1 Comparison of Importance of Diverse Guidance Before E-Examinations between prior experience

The significance value from Levene’s Test is 0.366, which is greater than 0.05. This suggests that the variances between respondents who have experienced E-assessment and those who have not are equal. As a result, the assumption of equal variances will proceed. The significance value (1-tailed) from the 't-test for Equality of Means' is 0.049, also below 0.05. This means there is statistically significant difference in the perceived importance of diverse guidance before E-examinations based on prior experience. Based on the results, the hypothesis **H1: Students with prior experience in E-assessment have a greater understanding of the importance of diverse guidance before E-examinations** is *supported*.

4.4.2 Comparison of Key Features of an E-Assessment System between prior experience

The significance value from Levene’s Test is 0.597, which is greater than 0.05. This suggests that the variances between respondents who have experienced E-assessment and those who have not are equal. As a result, assumption of equal variances will be proceed. The significance value (1-tailed) from the 't-test for Equality of Means' is 0.261, also above 0.05. This means there is no statistically significant difference in the perceived key features of an E-assessment system based on prior experience. Based on the results, the hypothesis **H2: Students with prior experience in E-assessment hold a more positive perspective on the key features of the E-assessment system** is *rejected*.

4.4.3 Comparison of E-Examinations Feedback between prior experience

The significance value from Levene's Test is 0.646, which is greater than 0.05. This suggests that the variances between respondents who have experienced E-assessment and those who have not are equal. As a result, assumption of equal variances will be proceed. The significance value (1-tailed) from the 't-test for Equality of Means' is 0.369, also above 0.05. This means there is no statistically significant difference in the perceived E-Examinations Feedback based on prior experience. Based on the results, the hypothesis **H3: Students with prior experience in E-assessment have a favorable view of the feedback provided during E-examinations** is *rejected*.

4.4.4 Comparison of E-Examinations vs. Traditional Examinations between prior experience

The significance value from Levene's Test is 0.262, which is greater than 0.05. This suggests that the variances between respondents who have experienced E-assessment and those who have not are equal. As a result, the assumption of equal variances will proceed. The significance value (2-tailed) from the 't-test for Equality of Means' is 0.566, also above 0.05. This means there is no statistically significant difference in the perceived E-Examinations vs. Traditional Examinations based on prior experience. Based on the results, the hypothesis **H4: Prior experience with E-assessment influences students' perspectives on E-examinations compared to traditional examinations** is *rejected*.

4.4.5 Comparison of Identity Monitoring Techniques in E-Examinations between prior experience

The significance value from Levene's Test is 0.614, which is greater than 0.05. This suggests that the variances between respondents who have experienced E-assessment and those who have not are equal. As a result, assumption of equal variances will be proceed. The significance value (1-tailed) from the 't-test for Equality of Means,' it is 0.098, also above 0.05. This means there is no statistically significant difference in the perceived E-Examinations vs. Traditional Examinations based on prior experience. Based on the results, the hypothesis **H5: Students with prior experience in E-assessment view monitoring techniques during E-examinations positively** is *rejected*.

4.5 One-way ANOVA

One-way ANOVA tests for significant mean differences among two or more independent groups. A significance level ≤ 0.05 indicates differences, while >0.05 shows none. Post-hoc tests identify specific group differences, with pairwise significance ≤ 0.05 indicating a difference and >0.05 showing no difference.

4.5.1 Comparison of Students' Perceptions on Identity Monitoring Techniques in E-Examinations between Major

The significance level for ANOVA is 0.375 ($F = 1.088$, $p > 0.05$). This denotes that there are no significant differences in the selection of Identity Monitoring Techniques in E-Examinations among the Majors. Furthermore, Table 58 shows that all significance levels from the post-hoc test exceed 0.05, further confirming that there are no significant differences between Majors regarding the Identity Monitoring Techniques in E-Examinations. Based on the results, the hypothesis **H6: Students from different Majors perceive the Identity Monitoring Techniques in E-Examinations differently** is *rejected*.

4.5.2 Comparison of Students' Perceptions on E-Examinations Feedback between Study Year

Table 60 demonstrates that the significance level for ANOVA is 0.113 ($F = 1.921$, $p > 0.05$). This denotes that there are no significant differences in the selection of E-Examinations Feedback among the Study Year. Furthermore, Table 61 shows that all significance levels from the post-hoc test exceed 0.05, further confirming that there are no significant differences between Study Year regarding the E-Examinations Feedback. Based on the results, the hypothesis **H7: Students from different Study Year perceive E-Examinations Feedback differently** is *rejected*.

4.5.3 Comparison of Students' Perceptions on Identity Monitoring Techniques in E-Examinations between Study Year

Table 63 demonstrates that the significance level for ANOVA is 0.881 ($F = 0.295$, $p > 0.05$). This denotes that there are no significant differences in the selection of Identity Monitoring Techniques in E-Examinations among the Study Year. Furthermore, Table 64 shows that all significance levels from the post-hoc test exceed 0.05, further confirming that there are no significant differences between Study Year regarding the Identity Monitoring Techniques in E-Examinations. Based on the results, the hypothesis **H8: Students from different Study Year perceive Identity Monitoring Techniques in E-Examinations differently** is *rejected*.

4.6 Pearson Correlation

Pearson Correlation measures the direction and strength of the relationship between two variables, with a positive coefficient (r) indicating both increase together and a negative (r) indicating one increases as the other decreases. The coefficient ranges from -1 to +1, with values near ±1 showing a strong relationship and near 0 a weak one. A 2-tailed significance <0.05 indicates a statistically significant correlation; >0.05 suggests none.

4.6.1 Relationship between Diverse Guidance and Key Features

The relationship between Diverse Guidance and Key Features, showing a Pearson correlation coefficient of 0.435 ($p = 0.001$, which is below 0.01). This result points to a positive and significant influence of Diverse Guidance on Key Features.

A coefficient of +0.435 indicates a meaningful connection between these two variables. As noted by Field (2017), a correlation value between 0.3 and 0.5 reflects a medium to large correlation. This suggests that there is a moderate positive correlation between Diverse Guidance and Key Features. Therefore, our hypothesis **H9: There is a positive relationship between Diverse Guidance and Key Features**, is *supported*.

4.6.2 Relationship between Key Features and E-Examinations Feedback

Table 66 highlights the relationship between Key Features and E-Examinations Feedback, showing a Pearson correlation coefficient of 0.390 ($p = 0.001$, which is below 0.01). This result points to a positive and significant influence of Key Features on E-Examinations Feedback.

A coefficient of +0.390 indicates a meaningful connection between these two variables. As noted by Field (2017), a correlation value between 0.3 and 0.5 reflects a medium to large correlation. This suggests that there's a moderate positive correlation between Key Features and E-Examinations Feedback. Therefore, our hypothesis **H10: There is a positive relationship between Key Features and E-Examinations Feedback**, is *supported*.

4.6.3 Relationship between Key Features and Monitoring Techniques

Table 67 highlights the relationship between Key Features and Monitoring Techniques, showing a Pearson correlation coefficient of 0.383 ($p = 0.001$, which is below 0.01). This result points to a positive and significant influence of Key Features on Monitoring Techniques.

A coefficient of +0.383 indicates a meaningful connection between these two variables. As noted by Field (2017), a correlation value between 0.3 and 0.5 reflects a medium to large correlation. This suggests that there is a moderate positive correlation between Key Features and Monitoring Techniques. Therefore, our hypothesis **H11: There is a positive relationship between Key Features and Monitoring Techniques**, is *supported*.

4.6.4 Relationship between E-Examinations vs. Traditional Examinations and Monitoring Techniques

Table 68 highlights the relationship between E-Examinations vs. Traditional Examinations and Monitoring Techniques, showing a Pearson correlation coefficient of 0.323 ($p = 0.001$, which is below 0.01). This result points to a positive and significant influence of E-Examinations vs. Traditional Examinations on Monitoring Techniques. A coefficient of +0.323 indicates a meaningful connection between these two variables. As noted by Field (2017), a correlation value between 0.3 and 0.5 reflects a medium to large correlation. This suggests that there is a moderate positive correlation between E-Examinations vs. Traditional Examinations and Monitoring Techniques. Therefore, our hypothesis **H12: There is a positive relationship between E-Examinations vs. Traditional Examinations and Monitoring Techniques**, is *supported*.

4.7 Discussion

4.7.1 Discussion of Prior Experience Comparison

The t-test p-value in Section 4.4.1 ($p=0.049$) indicates a significant difference between students with and without prior E-examination experience in rating diverse guidance, supporting hypothesis H1. Khan et al. (2021) suggest that experienced students recognize E-examination challenges, preferring guidance, while novices may underestimate difficulties, explaining the preference for varied support among the former.

Section 4.4.2 shows a t-test p-value of 0.261 (>0.05), indicating no significant difference in key features ratings between students with and without prior E-examination experience, rejecting hypothesis H2. Although previous research notes experienced students often view features like webcam proctoring positively (Domínguez-Figaredo & Gil-Jaurena, 2024), this study's broader "key features" scope may explain the lack of difference, suggesting prior experience has little impact on perceptions.

Section 4.4.3 shows a t-test p-value of 0.369 (>0.05), indicating no significant difference in E-examinations feedback ratings between students with and without prior experience, rejecting hypothesis H3. Despite previous

research noting experienced students value immediate feedback (Khan et al., 2021), this study finds no difference, possibly due to standardized feedback formats in Hong Kong, where students practice past exams and receive consistent solutions, and a universal emphasis on immediate feedback.

Section 4.4.4 shows a t-test p-value of 0.566 (>0.05), indicating no significant difference in perceptions of E-examinations versus traditional exams between students with and without prior experience, rejecting hypothesis H4. Despite previous research noting reduced stress with experience (Afacan Adanır et al., 2020), similar exam structures in Hong Kong and fading novelty may explain the uniform acceptance across groups.

Section 4.4.5 shows a t-test p-value of 0.098 (>0.05), indicating no significant difference in monitoring techniques ratings between students with and without prior E-examination experience, rejecting hypothesis H5. Despite previous research noting positive views on webcam proctoring (Domínguez-Figaredo & Gil-Jaurena, 2024), this study finds uniform perceptions, likely due to increased familiarity post-COVID-19, emphasizing fairness and reliability over individual experience.

4.7.2 Discussion of Major Comparison

Section 4.5.1 shows a one-way ANOVA significance value of 0.375 ($F = 1.088$, $p > 0.05$), indicating no significant difference in perceptions of identity monitoring techniques in E-examinations across majors, rejecting hypothesis H6. Although previous research notes that E-assessment often fails to evaluate practical skills (Saha, D., Das, S., and Acharjee, D., 2023), this study finds uniform perceptions, likely due to standardized monitoring techniques in Hong Kong's paper-based E-examinations, where practical skills are assessed separately via assignments, leading to similar student attitudes across fields.

4.7.3 Discussion of Study Year Comparison

Section 4.5.2 shows a one-way ANOVA significance value of 0.113 ($F = 1.921$, $p > 0.05$), indicating no significant difference in E-examination feedback perceptions across study years, rejecting hypothesis H7. Although previous research suggests later-year students view feedback more positively (Iahad et al., 2004), this study finds uniform perceptions, likely due to consistent exposure to E-examinations and improved feedback quality, aligning student views across academic levels.

Section 4.5.3 shows a one-way ANOVA significance value of 0.881 ($F = 0.295$, $p > 0.05$), indicating no significant difference in perceptions of monitoring techniques across study years, rejecting hypothesis H8. Although previous researches suggest later-year students view monitoring more positively (Iahad et al., 2004; Khan et al., 2021), this study finds uniform perceptions, likely due to standardized techniques post-COVID-19 and shared trust in their fairness, aligning views across academic levels.

4.7.4 Discussion of Relationship between Diverse Guidance and Key Features

Section 4.6.1 shows a Pearson correlation coefficient of 0.435 ($p < 0.001$), indicating a moderate positive correlation between Diverse Guidance and Key Features, supporting hypothesis H9. This aligns with Mo et al. (2022), who emphasize varied guidance's role in preparing students for E-examinations by reducing anxiety and enhancing familiarity with digital interfaces. Catering to diverse learning styles and providing clear instructions on system features (e.g., time management, feedback tools) boosts engagement and performance. Inadequate guidance may lead to underutilized resources, lowering scores, while effective support empowers students, underscoring its importance in E-examination success.

4.7.5 Discussion of Relationship between Key Features and E-Examinations Feedback

Section 4.6.2 reveals a Pearson correlation coefficient of 0.390 ($p < 0.001$), indicating a moderate positive correlation between Key Features and E-Examinations Feedback, supporting hypothesis H10. This aligns with Iahad et al. (2004), showing that user-friendly E-assessment systems enhance feedback accessibility, improving communication between educators and students. Khan et al. (2021) note that intuitive features increase interaction, making feedback more valued, while Domínguez-Figaredo and Gil-Jaurena (2024) highlight that streamlined design helps students focus on feedback interpretation, boosting engagement and learning outcomes by addressing strengths and weaknesses effectively.

4.7.6 Discussion of Relationship between Key Features and Monitoring Techniques

Section 4.6.3 shows a Pearson correlation coefficient of 0.383 ($p < 0.001$), indicating a moderate positive correlation between Key Features and Monitoring Techniques, supporting hypothesis H11. This aligns with Saha et al. (2023), emphasizing that user-friendly platforms enhance monitoring efficiency, reducing implementation effort for teachers and students (Domínguez-Figaredo & Gil-Jaurena, 2024; Khan et al., 2021). Minimized

technical issues improve dependability and accessibility, making the system a reliable tool for tracking student progress (Domínguez-Figaredo & Gil-Jaurena, 2024).

4.7.7 Discussion of Relationship between E-Examinations vs. Traditional Examinations and Monitoring Techniques

Section 4.6.4 shows a Pearson correlation coefficient of 0.323 ($p < 0.001$), indicating a moderate positive correlation between E-Examinations vs. Traditional Examinations and Monitoring Techniques, supporting hypothesis H12. Aligning with Khan et al. (2021), the remote nature of E-Examinations requires robust Monitoring Techniques, including authentication processes, to ensure academic integrity. Advanced tools like webcam monitoring, which do not rely on in-person invigilators (Domínguez-Figaredo & Gil-Jaurena, 2024), enhance efficiency and fairness while addressing higher cheating risks in E-Examinations (Khan et al., 2021). These innovations boost trust, emphasizing the critical role of Monitoring Techniques in E-Examinations compared to Traditional Examinations.

5. Conclusion

The questionnaire results were in line with the hypotheses H1, H9 to H12, but did not accept the hypotheses H2 to H8. The table below displays the outcome of the hypotheses.

Table 7: Results of the Hypothesizes

Hypothesis	**Results**
H1: Students with prior experience in E-assessment have a greater understanding of the importance of diverse guidance before E-examinations	*supported*
H2: Students with prior experience in E-assessment hold a more positive perspective on the key features of the E-assessment system	*rejected*
H3: Students with prior experience in E-assessment have a favorable view of the feedback provided during E-examinations	*rejected*
H4: Prior experience with E-assessment influences students' perspectives on E-examinations compared to traditional examinations	*rejected*
H5: Students with prior experience in E-assessment view monitoring techniques during E-examinations positively	*rejected*
H6: Students from different Majors perceive the Identity Monitoring Techniques in E-Examinations differently	*rejected*
H7: Students from different Study Year perceive E-Examinations Feedback differently	*rejected*
H8: Students from different Study Year perceive Identity Monitoring Techniques in E-Examinations differently	*rejected*
H9: There is a positive relationship between Diverse Guidance and Key Features	*supported*
H10: There is a positive relationship between Key Features and E-Examinations Feedback	*supported*
H11: There is a positive relationship between Key Features and Monitoring Techniques	*supported*
H12: There is a positive relationship between E-Examinations vs. Traditional Examinations and Monitoring Techniques	*supported*

5.1 Summary

This study examines Hong Kong higher education students' perceptions of e-assessment, focusing on factors influencing their preference for e-examinations versus traditional paper-based formats. A survey of 107 students assessed pre-exam guidance (e.g., tutorials, practice tests), system usability, instant feedback, and identity monitoring (e.g., webcam surveillance), comparing e-examinations to traditional assessments.

The study found that prior experience only had an impact on importance of diverse guidance before. Demographic background, such as field of study or study year, do not affect students' views in Identity Monitoring Techniques in E-Examinations and E-Examinations Feedback. There is a moderate positive correlation between Diverse Guidance and Key Features, Key Features and E-Examinations Feedback, Key Features and Monitoring Techniques, E-Examinations vs. Traditional Examinations and Monitoring Techniques. These insights guide optimizing e-assessment systems, enhancing their integration into higher education and supporting innovation.

5.2 Limitation of study

This study's findings have limitations affecting their generalizability and reliability. The sample size of 107 responses may be insufficient to detect significant effects or represent the broader population. Uneven distribution, with only CityU, HKU, and PolyU contributing over ten participants each, raises concerns about applicability. Limited demographic diversity further restricts the findings' relevance across different groups.

5.3 Recommendations for Future Research

This study on e-examination performance and monitoring techniques sets the stage for deeper e-assessment research. Future studies could analyze specific factors in greater detail. While this study examined students' perceptions based on year, major, and prior e-assessment experience, additional variables like gender, age, and GPA should be explored to assess their impact on perceptions. Furthermore, this study on students' perceptions of e-assessment in higher education could extend to secondary schools or international contexts to better understand its impact across educational settings. Additionally, given respondents' interest in AI integration, future research should explore AI's role in enhancing e-assessment effectiveness, accessibility, and personalization.

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Exploring Applications of ChatGPT to Improve Spoken Chinese Self-efficacy of International Students: Theoretical Rationales, Limitations, and Recommendations

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ABSTRACT
As China joined the World Trade Organization (WTO) and its national strength continued to grow, enthusiasm for learning Chinese has been heating up globally. Chinese language education has gradually integrated into the education systems of more countries, becoming a significant focus of attention and study. However, despite the increasing demand for learning Chinese, international students still face several challenges in learning spoken Chinese due to limitations in teaching hours and the number of teachers, especially a lack of personalized, timely targeted feedback. This paper aims to explore the feasibility of using ChatGPT to assist international students in enhancing their spoken Chinese self-efficacy based on Social Cognitive Theory. The discussion focuses on how ChatGPT can help improve students' spoken Chinese self-efficacy through creating opportunities for successful learning experiences, offering indirect learning opportunities, using verbal persuasion, and adjusting emotional and physiological states. The paper also discusses the issues related to ChatGPT, such as the timeliness of information updates, potential language and cultural biases, and inadequate handling of non-verbal communication, and offers targeted suggestions.
Keywords: ChatGPT; International Students; Spoken Chinese; Self-Efficacy; Social Cognitive Theory

INTRODUCTION
As China joined the World Trade Organization (WTO) and rapidly strengthened its national power, exchanges and collaborations between China and foreign countries have become increasingly frequent, presenting a pattern of multi-level, multi-domain cooperation. China's open-door policy has not only propelled economic development but also enhanced cultural and educational exchanges and cooperation. China's education system has progressively opened its doors to the world, offering more opportunities for learning Chinese and understanding Chinese culture globally. Under the active promotion of the Chinese government, Confucius Institutes have rapidly expanded and strengthened worldwide. As a vital platform for promoting Chinese culture, Confucius Institutes are dedicated to spreading Chinese language and culture, enhancing cultural exchanges and cooperation between China and other countries. Confucius Institutes not only provide high-quality teaching resources and learning environments for foreigners learning Chinese but also play an active role in promoting Chinese culture globally and fostering friendships and cooperation between China and other countries (Bodomo et al., 2024; Gil, 2017; Sun, 2023).

With China's rise and the advancement of its open-door policy, Chinese, as one of the most spoken languages in the world, has increasingly garnered attention and importance internationally. Chinese is not only the native language of the Chinese people but has also become a link connecting China with the world. The importance of Chinese is not only evident in cultural exchanges (Fatima & Saman, 2024) but also holds significant value in international trade (Ismail, 2010), technological innovation (Chai, 2023) among other fields. As the global influence of Chinese continues to expand, more and more people wish to master the language to better understand Chinese culture, communicate with Chinese people, and gain a competitive edge in careers related to China. Especially in the context of globalization, an increasing number of multinational corporations and institutions require employees with Chinese language skills to tap into the Chinese market and strengthen cooperation with China.

In recent years, Chinese as a foreign language education has shown a robust development trend globally. The age of learners is becoming younger, not limited to adults or university students, but increasingly extending to high schools, middle schools, elementary schools, and even kindergartens (Miller, 2021; W. Xu, 2021). More and more countries are incorporating Chinese into their national education systems, integrating Chinese language instruction into school curricula to cultivate students' cross-cultural communication skills and global competitiveness, for instance, Philippines (Jingyi & De Dios, 2024), Saudi Arabia (Alshammari, 2020) and America (S. Zhang, 2021) . This trend not only reflects the growing demand for learning Chinese but also demonstrates a strong interest in and

recognition of Chinese culture and China's development.

As language serves as the primary tool for human communication, its importance is self-evident. In language teaching, oral instruction occupies a crucial position (Алаудинова, 2022). Speaking is the most direct and commonly used form of language in daily communication, characterized by its practicality and immediate communicative impact. Therefore, teaching speaking is not only an important part of language learning but also a key element in developing students' language application abilities and enhancing their communicative skills. The ultimate goal for Chinese learners is to be able to use Chinese proficiently in communication. This includes not only simple everyday conversations but also broader and more complex communication scenarios such as academic discussions, business negotiations, and social interactions. With the ongoing process of globalization, communicative ability has become one of the main objectives of language education worldwide. In this context, as one of the most spoken languages globally, the orientation of oral proficiency testing in the overseas national education systems has become increasingly important. Among the 'listening, speaking, reading, and writing' skills, international students generally consider 'speaking' the most important (Amoah & Yeboah, 2021), because oral skills directly reflect a person's level of language application and communicative ability. However, compared to reading and writing, learning and mastering speaking skills are indeed more challenging. For international students who come to China, quickly mastering oral skills relevant to daily life and study is very urgent. Adapting to the new language environment in a short time and effectively communicating with Chinese people are their primary challenges. Thus, rapidly improving their speaking skills is crucial. This not only helps them better integrate into the Chinese living and learning environment but also enhances their learning efficiency and communication abilities.

In traditional international Chinese speaking classes, there are some noteworthy issues. Firstly, the limited class practice time makes it difficult to cover a wide range of practical topics, resulting in some topics being outdated and disconnected from everyday life. Moreover, for international students, learning spoken Chinese requires a lot of repetitive practice, and the traditional classroom model may not provide each student with sufficient practice opportunities, which restricts the improvement of their speaking abilities. Limited by teaching duration and the number of teachers, international students often cannot receive adequate personalized and timely targeted feedback during their spoken Chinese learning process. This situation presents certain challenges to the enhancement of their speaking capabilities.

In recent years, modern educational technology has been widely applied in Chinese language learning, attracting the interest of many learners. Research indicates that Chinese speaking apps (such as iChinese, aha Chinese, Fluent Conversation: Learning Chinese, etc.) are highly valued by learners, particularly impacting beginner-level Chinese learners significantly. However, these apps still have some deficiencies in content and technology. For example, current Chinese speaking software usually only provides practice for specific speaking materials and most can only offer feedback at the phonetic level. This limitation leads to these apps not being very effective. Effective spoken expression is not just about the accuracy of phonetic pronunciation but also involves grammar usage, vocabulary selection, comprehension abilities, and fluency among other aspects (Brown, 2024). However, current speaking apps often fail to provide comprehensive feedback and cannot help learners improve their speaking abilities in these areas comprehensively.

With the rise of generative artificial intelligence represented by ChatGPT, more and more people are beginning to realize the potential of this technology in the field of language learning (Li et al., 2023; X. Xu et al., 2024). It can be anticipated that generative artificial intelligence will play an increasingly important role in language learning, offering learners a more personalized and efficient learning experience. Although many scholars and educators have extensively explored the application of generative AI technologies like ChatGPT in the field of English education, these studies are primarily focused on aspects such as English listening (Xing, 2023), English writing (Fitria, 2023), reading comprehension (Xiao et al., 2023), and oral practice (Young & Shishido, 2023). However, research in the field of oral communication within international Chinese education is relatively scarce.

When predicting a person's performance on a task, self-efficacy is one of the most important factors. Self-efficacy, the confidence an individual has in their ability to accomplish a specific task (Bandura, 1977), directly influences their behavior, motivation, and performance. In the field of language learning, particularly in speaking, self-efficacy plays a crucial role (X. Zhang, 2018). A learner's confidence in their ability to express themselves fluently, understand accurately, and communicate effectively with others directly impacts their engagement and ultimate performance in language learning tasks. Learners with high self-efficacy are usually more inclined to actively participate in learning activities, brave in trying new ways of language expression, and have a stronger ability to cope with mistakes and challenges, thereby achieving better learning outcomes. Therefore, when predicting a person's performance in the oral domain of international Chinese education, it is essential to consider their level of

self-efficacy, which will provide educators with important references to develop personalized teaching strategies to help learners enhance their speaking skills and achieve better learning success.

Although research on ChatGPT in English education is relatively abundant, its application in international Chinese education is still relatively limited. Particularly in the field of Chinese speaking, there are few studies on using ChatGPT to assist international students in improving their speaking skills. Moreover, in oral learning, the self-efficacy of international students in Chinese speaking plays a crucial role in their oral performance. Therefore, the current will analyze the possibility of using ChatGPT to help foreign students enhance their Chinese speaking self-efficacy and thereby improve their speaking performance, based on social cognitive theory.

THEORETICAL FOUNDATION

SOCIAL COGNITIVE THEORY

Social Cognitive Theory, proposed by American psychologist Albert Bandura (Bandura, 1986), is a foundational social psychology theory that views learning and behavior as inherently social. This implies that the interactions between individuals, their environments, and the interplay between the individual and the environment are crucial for understanding their learning and behavioral outcomes, hence the concept of 'triadic reciprocal determinism' was introduced. The theory considers environmental factors, behaviors, and personal factors as relatively independent yet interactively influencing theoretical entities. Environmental factors refer to the external environment surrounding the individual, including physical, social, and cultural settings. Specifically, the physical environment includes virtual or real learning environments, such as online or offline learning settings; the cultural environment includes cultural values, social norms, and language usage; the social environment includes factors such as peer pressure. These environmental factors impact an individual's cognitive processes and behavioral performance. Personal factors include individual cognition, emotions, motivation, personality, etc. These personal aspects influence how individuals perceive, understand, and respond to their environments.

SELF-EFFICACY

Self-efficacy is an individual's estimation and judgment of whether they can successfully complete a particular behavior. This concept was first introduced by psychologist Albert Bandura in 1977, who defined self-efficacy as an individual's confidence in their ability to execute the skills necessary to accomplish specific tasks. Bandura et al. (Bandura et al., 1999) conducted extensive research on the factors influencing self-efficacy, pointing out that it can be developed through the following four pathways: (1) Mastery experiences: Building confidence and self-efficacy through one's own successful experiences. Successful experiences can enhance an individual's confidence, making them believe they have the ability to complete tasks; (2) Vicarious experiences: Enhancing one's self-efficacy by observing the successful experiences of others. When individuals see others similar to themselves successfully complete a task, they may believe they have the same capabilities, thereby boosting their self-efficacy; (3) Verbal persuasion: Verbal encouragement and persuasion from others can help individuals build confidence and self-efficacy in their abilities. When others express trust and support and provide encouragement, individuals may feel more confident to take on challenges; (4) Effects of physiological and affective states: An individual's emotional and physiological states can also affect their self-efficacy. When individuals feel relaxed, happy, and positive, their self-efficacy may be enhanced; conversely, when they feel tense, anxious, and negative, their self-efficacy may decrease.

CHINESE PROFICIENCY GRADING STANDARDS FOR INTERNATIONAL CHINESE LANGUAGE EDUCATION

The *Chinese Proficiency Grading Standards for International Chinese Language Education* (GF0025-2021) (hereafter referred to as *Standards*) is a language standard developed by the Center for Language Education and Cooperation under the Ministry of Education of the People's Republic of China. It was released in March 2021 and officially implemented from July 1, 2021. The *Standards* classifies learners' Chinese proficiency into 'three levels and nine grades,' and construct a 'four-dimensional benchmark' consisting of *syllables, Chinese characters, vocabulary, and grammar*. It forms three evaluation dimensions based on *communicative competence, topic task content, and language quantitative indicators*, employing *listening, speaking, reading, writing, and translating* as five language skills to accurately determine learners' Chinese proficiency.

Specifically, *speaking* is divided into three levels and nine grades, examining elements such as syllables, vocabulary, grammar, communication, impromptu speeches, debates, discourse expression, opinion expression, logic, content, pronunciation, intonation, rhetoric, and intercultural content. For example, at the ninth grade, the

The *Standards* specify that learners at this level should be proficient in using advanced language quantitative indicators of syllables, vocabulary, and grammar to competently handle topic expressions and communication tasks. They are expected to have a strong ability in discourse expression and flexible language use. Learners should

be capable of expressing their thoughts and insights completely, accurately, and fluently, with content that is rich and logically structured. Additionally, their pronunciation should be precise and their intonation natural. They should also be adept at using rhetorical techniques to enhance the effectiveness of their oral expressions, thereby demonstrating robust intercultural communication skills.

CHATGPT

ChatGPT is a natural language processing model developed by OpenAI, one of the artificial intelligence models trained on a large-scale language dataset. It can generate responses based on patterns and statistical rules observed during its pre-training phase and interact based on the context of the conversation, truly communicating like a human. It can even complete tasks such as writing papers, emails, scripts, copy, translations, and code. ChatGPT can understand and generate human-like text, making it widely used in fields such as translation (Cao & Liu, 2024; Gao et al., 2024; Sahari et al., 2023), scientific research (Khlaif et al., 2023, 2023), English teaching (Kostka & Toncelli, 2023; Lou, 2023; Z. Zhang, 2024).

THEORETICAL RATIONALE

This section explored in detail the feasibility of using ChatGPT to enhance the spoken Chinese self-efficacy of international students from four aspects: providing successful experiences, offering indirect learning opportunities, engaging in verbal persuasion, and adjusting emotional and physiological states.

CREATING OPPORTUNITIES FOR SUCCESSFUL LEARNING EXPERIENCES

ChatGPT can offer feedback and guidance, helping students identify and correct language errors, and advising them on the accuracy and fluency of their spoken expressions. By promptly detecting and pointing out mistakes, students can understand their shortcomings and improve their spoken Chinese abilities with the help of ChatGPT.

Firstly, as an artificial intelligence-assisted tool, ChatGPT has significant advantages in providing timely feedback. Through interactions with ChatGPT, students can instantly understand their performance, and this real-time feedback is crucial for improvements in their spoken practice. ChatGPT's analytical capabilities can also help students comprehensively understand their level of language expression and identify specific areas needing improvement, allowing them to target their oral practice effectively and thus continuously accumulate successful experiences.

Secondly, ChatGPT can provide not only general feedback but also personalized and targeted feedback based on the student's oral task performance. By analyzing students' spoken expressions, ChatGPT can accurately identify language problems and offer improvement suggestions tailored to their individual needs. This personalized feedback not only helps students gain a deeper understanding of their language level but also stimulates their motivation to learn, encouraging them to practice speaking more diligently and thus gain more successful experiences.

Additionally, ChatGPT can provide personalized learning content, study plans, and practice materials based on the students' needs and proficiency levels. Through interaction with ChatGPT, students can choose learning materials and practice content that suit their learning goals and progress, thus more effectively enhancing their spoken Chinese abilities. This personalized learning experience not only helps students systematically train their speaking skills but also allows them to accumulate more successful experiences in oral practice, thereby improving their spoken Chinese self-efficacy.

OFFERING INDIRECT LEARNING OPPORTUNITIES

As an intelligent language model, ChatGPT can not only provide an experience of conversing with learners but also simulate real spoken language interactions, allowing learners to immerse themselves in a simulated language environment. By dialoguing with ChatGPT, learners can observe spoken expressions in simulated scenarios, and accumulate a wealth of Chinese speaking techniques, vocabulary usage, and grammatical structures. This real-time communication experience helps learners intuitively understand the essentials of oral communication and enhance their ability to respond in actual spoken interactions.

Observing ChatGPT's simulated spoken expressions, learners can also perceive and empathize with others' experiences and apply them to their own speaking practice. By imitating and learning from the spoken materials generated by ChatGPT, learners can gradually develop their own style and techniques of spoken expression, continually improving and perfecting these in practice. This indirect method of learning not only boosts learners' confidence in their speaking abilities but also enhances their communicative skills, enabling them to use spoken Chinese more fluently in daily life and learning.

Furthermore, learners can also observe language skills by watching interactions between their classmates and ChatGPT, or from their own conversations with ChatGPT. By sharing and discussing their experiences interacting with ChatGPT, learners can inspire each other and explore techniques and strategies for spoken expression, thereby collectively enhancing their spoken efficacy. This collaborative learning method not only promotes interaction and cooperation among learners but also deepens their understanding and mastery of spoken expression, offering them more inspiration and assistance in their language learning.

USING VERBAL PERSUASION

Apart from making targeted assessments of learners' spoken expression, thinking logic, and grammar, ChatGPT can also simulate human-like interactions by expressing timely support and encouragement to learners, thereby helping international students build confidence in their Chinese speaking abilities.

Firstly, ChatGPT can promptly offer encouragement and recognition to international students, showing support and affirmation for their efforts in learning. By praising and acknowledging their achievements in learning spoken Chinese, students feel that their efforts are worthwhile and recognized, which in turn enhances their self-efficacy in spoken Chinese. For example, if international students perform well during oral practice with ChatGPT, it can encourage and praise their progress and efforts, making them feel that their achievements are acknowledged and valued.

Secondly, ChatGPT can provide motivation and support when students face difficulties or challenges. It encourages students to actively confront challenges in spoken Chinese, reinforcing their belief that they can overcome difficulties. This positive verbal persuasion can inspire students to bravely face challenges in learning, boosting their spoken Chinese self-efficacy, and thereby improving their spoken Chinese performance. For instance, when students encounter difficulties in oral practice, ChatGPT can convey encouraging messages, tell them to believe in their abilities, and offer advice and support to help them overcome obstacles and make progress.

In summary, by simulating human interactions, ChatGPT can offer a more comprehensive and personalized learning experience to international students by offering timely encouragement and support, helping students build confidence and enhance their self-efficacy in spoken Chinese.

ADJUSTING EMOTIONAL AND PHYSIOLOGICAL STATES

In situations of public scoring, students may feel pressure from teachers and peers, leading to anxiety and tension, which can affect their learning performance. ChatGPT, however, can provide private scoring. This private scoring is visible only to the user and not accessible to others, allowing students to learn and express themselves more relaxedly, reducing the interference of external pressures, and helping to improve learning outcomes. Thus, ChatGPT can offer a private learning environment that helps international students reduce anxiety and tension, allowing them to conduct self-assessment and reflection without external pressure or influence, thereby boosting their confidence in spoken Chinese.

Furthermore, private scoring can help students more objectively evaluate their learning progress, as they do not have to worry about others' judgments or criticism, thereby freely exploring and trying new ways of spoken expression. Through private scoring, students can learn and practice in a safe and relaxed environment, fully utilizing their potential and improving the efficiency and quality of learning.

Additionally, ChatGPT can adjust the rigor of scoring based on students' progress and needs, making the evaluation more aligned with students' actual levels and learning goals, thus more effectively stimulating their interest and motivation to learn. The characteristics of private scoring allow students to fully tap into their potential in a low-pressure and high-efficiency learning environment, thereby better enhancing their confidence and performance in spoken Chinese.

LIMITATIONS AND SUGGESTED SUGGESTIONS

Although utilizing ChatGPT can help international students enhance their spoken Chinese self-efficacy, we must also acknowledge its limitations.

Firstly, ChatGPT's responses are based on its pre-trained datasets, which may lead to outdated or inaccurate information, and knowledge of specific fields or the latest developments may not be updated timely. Especially in a rapidly changing social and technological environment, ChatGPT might not keep up with the latest trends, affecting its accuracy and reliability on certain topics. To address this issue, we need to continually update ChatGPT's dataset and enhance the supplementation and updating of specific domain knowledge to ensure it can

provide accurate and timely information and responses.

Secondly, ChatGPT's responses may be influenced by language and cultural biases. In some cases, ChatGPT may not accurately understand or correctly respond to questions related to specific languages or cultures. Due to differences between languages and cultures, misunderstandings or errors might occur, affecting the understanding of and response to certain topics or expressions. Therefore, we need to be aware of these language and cultural biases when using ChatGPT and avoid relying on it as the sole tool for oral language learning.

Additionally, non-verbal communication plays a crucial role in oral interactions, such as body language, facial expressions, and tone changes. Since ChatGPT is based on text interactions, it cannot handle or respond to non-verbal communication, which may limit the ability to practice the comprehensiveness of spoken interactions. Thus, we need to combine other learning methods and tools, such as oral coaching and role-playing, to comprehensively enhance students' oral communication skills and compensate for ChatGPT's shortcomings in non-verbal communication.

In summary, while ChatGPT has certain advantages in enhancing spoken Chinese self-efficacy, we must also recognize its limitations and take appropriate measures to address and compensate for them, in order to achieve more comprehensive and effective oral language learning goals.

Therefore, international students can enhance their spoken self-efficacy by integrating a variety of other learning resources. For example, they can actively participate in real spoken interaction activities, converse with Chinese people, or join language exchange groups or programs to gain more authentic and extensive Chinese spoken practice experience.

At the same time, when learning spoken Chinese, international students should extensively engage with different linguistic and cultural resources. They can read Chinese literature, watch Chinese movies or documentaries, and participate in cross-cultural exchange activities to enhance their understanding of Chinese civilization from multiple perspectives and avoid the influence of language and cultural biases.

Additionally, although ChatGPT is a useful tool, the importance of human involvement and participation in the oral learning process still needs to be emphasized. The human role is crucial, especially in providing real-time information and discussing topics, where ChatGPT cannot replace human interaction. It is recommended to introduce other resources in oral practice, such as news reports and discussion on social media platforms, so that students can stay informed and discuss current topics and events in a timely manner.

Lastly, international students can utilize video and audio resources to observe and learn non-verbal communication skills. This allows them to directly observe non-verbal elements such as body language, facial expressions, and tone changes, thus enhancing their communication abilities.

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Integrating Augmented Reality and Artificial Intelligence in Assembly Tasks: A Review of Strategies, Tools, and Challenges

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Abstract
The integration of Augmented Reality (AR) and Artificial Intelligence (AI) is a growing subject in the technological field, especially when applied to benefit assembly tasks. This paper presents a Systematic Literature Review to explore the benefits, challenges, methods and tools in the utilization of AR and AI to assembly tasks applications. The study selected 27 relevant publications from the period between 2019 and January 2025 to identify strategies reported in the literature to implement AR and AI to assembly processes. The results show that the integration of these technologies was used mainly in the sectors of industry and manufacturing and the AI was employed mostly to object detection through deep learning models. This review highlights the possibility of utilization of integrating AR and AI for a diversity of fields and the necessity to implement automatic real time fault detection for error minimization and productivity enhancement.
Keywords: Extended Reality; Machine Learning; Mounting; Mixed Reality; Industry 4.0

Introduction

Despite technological advances throughout the time, such as machinery and digital manuals, instead of printed ones, the human force is still needed in many factories. Although necessary, human involvement in the process of assembly strongly influences several factors such as feasibility, working comfort, financial costs, operation safety and product quality (Santhi et al., 2015).

The incidence of human errors is mostly related to workplace conditions, environment and equipment (Saptari; Jia Xin Leau; Mohamad, 2015). The human limitations, such as cognitive load and fatigue, can impact performance, demanding technological assistance to improve efficiency, reduce mental strain and minimize errors (Stork; Schubö, 2010). Considering the increase of complexity in assembly processes, rise of decision-making challenges and product quality problem possibility, it is necessary to implement measures to optimize the assembly process such as immersive technologies that innovate assemblies and mitigate the mentioned risks (Panagou et al., 2023). This article provides a comprehensive Systematic Literature Review (SLR) and a discussion on adopted strategies reported in the literature for the integration of Augmented Reality (AR) and Artificial Intelligence (AI) applied to assembly tasks. For this purpose, the key questions that motivated this research were: (i) What was the main purpose of using AI? (ii) Which AI models were used the most? (iii) Which software and hardware were most used? (iv) How can AR and AI solutions be adapted to different assembly scenarios? (v) What were the common challenges and limitations in implementing AR and AI in assembly processes? (vi) What were the recommendations for future research or development in the application of AR and AI in assembly processes? This paper addresses techniques developed for this niche, presents recent trends and advancements in the field, and provides a comprehensive overview of contributions already made by the academic community. Further exploration into this subject can benefit AR projects aiming to adopt AI for assembly processes, given the potential that this association must facilitate these processes.

Augmented Reality integrated with Artificial Intelligence

The concept of AI can be defined as a subfield of computer science focused in enabling computers for human-performed tasks like interpretation, learning, knowledge representation, problem-solving, among others (Zhang et al., 2021). With the advancement of AI, more specialized approaches have emerged, such as machine learning, a subset of AI (Pradhan; Dinesh Kumar, 2019), and deep learning, a type of machine learning (Sasikala et al., 2021). Machine learning carries out knowledge acquisition through experience and improves its performance throughout

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the process (Sasikala et al., 2021). Within machine learning, deep learning stands out, as a branch of machine learning, assists computers learn from extensive amounts of information for tasks like image and speech recognition and object detection (Soori; Arezoo; Dastres, 2023).

AR can benefit from AI by implementing data interpretation (Uma, 2019), real-time feedback (Naqvi et al., 2024), object, voice and gesture recognition, environmental understanding, input data delivery (Ştefan et al., 2023), personalization and major interactivity (Lampropoulos, 2025). Due to these attributes, this integration can be applied to a variety of specific sectors such as training and education for healthcare professionals (Battineni et al., 2024), pharmacy (Roosan, 2023) and general medical applications (Naqvi et al., 2024; Okeh, 2024).

The most frequent object detection techniques identified in this systematic review can be categorized into classical computer vision, ensemble learning and deep learning approaches. Among the computer vision methods, it is worth mentioning the Scale Invariant Feature Transform (SIFT) as a technique that extracts distinctive features from images, making them invariant to scale changes and robust for object recognition (Lowe, 2004). ORB, an alternative to SIFT, is a binary descriptor that is rotation-invariant and highly efficient, making it suitable for real-time applications such as object detection on mobile devices (Rublee et al., 2011). The RANSAC algorithm is another technique used in object detection, particularly for geometric shape recognition, as it effectively eliminates outliers and fits models with minimal data (Jenkins; Goodwin; Talafha, 2024)

Ensemble learning is another method used to enhance object detection accuracy by combining multiple models integrating multiple base learners to improve performance capabilities. The main goal behind ensemble learning is recognizing that individual models have inherent limitations and can promote errors; thus, by leveraging multiple models, the approach achieves better classification performance and robustness (Mienye; Sun, 2022).

Deep learning-based object detection models, particularly those leveraging convolutional neural networks (CNNs), have transformed the field. CNNs are extensively used for processing and analyzing images, playing a vital role in object detection (Object Detection Using Deep Learning, CNNs and Vision Transformers: A Review). You Only Look Once (YOLO) is a real-time object detection framework derived from CNN (Carcellar; Tychuaco; Yumang, 2024) that trains using complete images and optimizes detection performance in a simple and fast way (Redmon et al., 2016). Region-based CNN (R-CNN) increases accuracy by applying a deep network to classify object proposals(Girshick, 2015). CenterNet proposes a low-cost solution that focuses on the geometric center of objects (Duan et al., 2019), while RetinaNet is a single-stage detector that uses deep CNNs to strengthen detection performance (Afif et al., 2020).

Modern advancements present Vision Transformer (ViT), a flexible, sequence-based approach, with big efficiency in handling a variety of input resolutions and ability to capture long-range dependencies and global context through self-attention mechanisms, being superior to the already consolidated CNNs (Elharrouss et al., 2025). Additionally, recurrent neural networks (RNNs) and variants, such as bidirectional long short-term memory (BiLSTM), have been investigated for object detection for its ability to model sequential dependencies, initially applied in text processing but with emerging uses in visual tasks (G. Liu & Guo, 2019). Finally, there are other advancements like deep neural networks (DNNs), known for their depth and width, have demonstrated strong performance across different datasets (Ciresan; Meier; Schmidhuber, 2012) and Spatio-Temporal Prompting Network (STPN), particularly useful in video-based object detection (Sun et al., 2023).

Methodology

The present SLR was carried out based on the PRISMA protocols (Tricco et al., 2018). The following databases were selected to perform the search, due to their importance within the research field: Engineering Village, Web of Science and Scopus. The search terms were segmented into three categories, Figure 1. To compose the search strings, the Boolean operators “AND” between categories and “OR” between terms were used (Fig. 1). The database search was based on journal articles that contained the selected strings within the title, abstract or keywords, in English. The selected timeframe was between January 2019 and January 2025, aiming to evaluate what is most up to date in this research area.

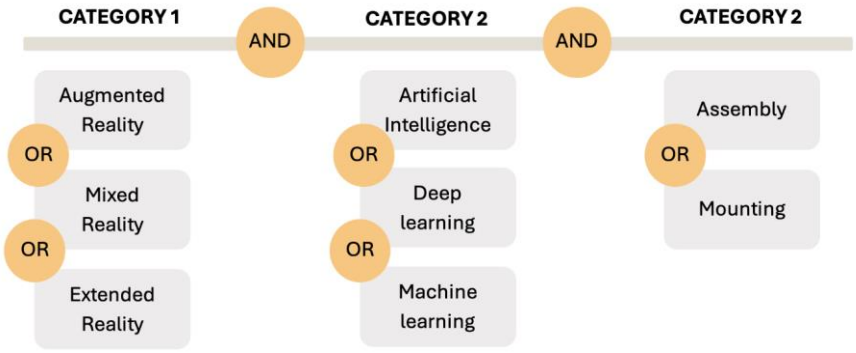

Figure 1. Selection of search strings

Inclusion and exclusion criteria

Inclusion and exclusion criteria were defined to help restrict the search to publications that addressed the subject in question. Among the inclusion criteria, the presentation of a case study dealing with AR associated with AI for assembly tasks and the descriptions of application development.

Exclusion criteria aimed to eliminate:

(i) literature review articles, to avoid duplicating or overlapping results;
(ii) off-topic articles;
(iii) articles that do not approach assembly tasks case studies, aiming specifically practical solutions;
(iv) articles that used human-robot collaboration, since including studies involving human-robot collaboration would introduce variables related to robotic assistance, which fall outside the scope of this research.

From the 192 publications obtained from the Scopus (41), Web of Science (86) and Engineering Village (65) databases, a final number of 27 publications was reached after applying the inclusion and exclusion criteria (Fig. 2). Initially, 88 duplicate articles were removed. Subsequently, it was observed that some articles lacked the search strings in the title, abstract, or keywords. This occurred because Web of Science include additional keywords in the automated search, such as *Keyword Plus*, which are generated by the Clarivate algorithm to expand search possibilities for articles (Clarivate Support, 2025). Through manual verification of the search strings, it was found that 52 articles did not meet the established criteria. It is worth noting that these articles, in addition to lacking the search strings, were found to be irrelevant to the topic upon reviewing their abstracts. All 27 resulting articles were successfully retrieved from the mentioned sources.

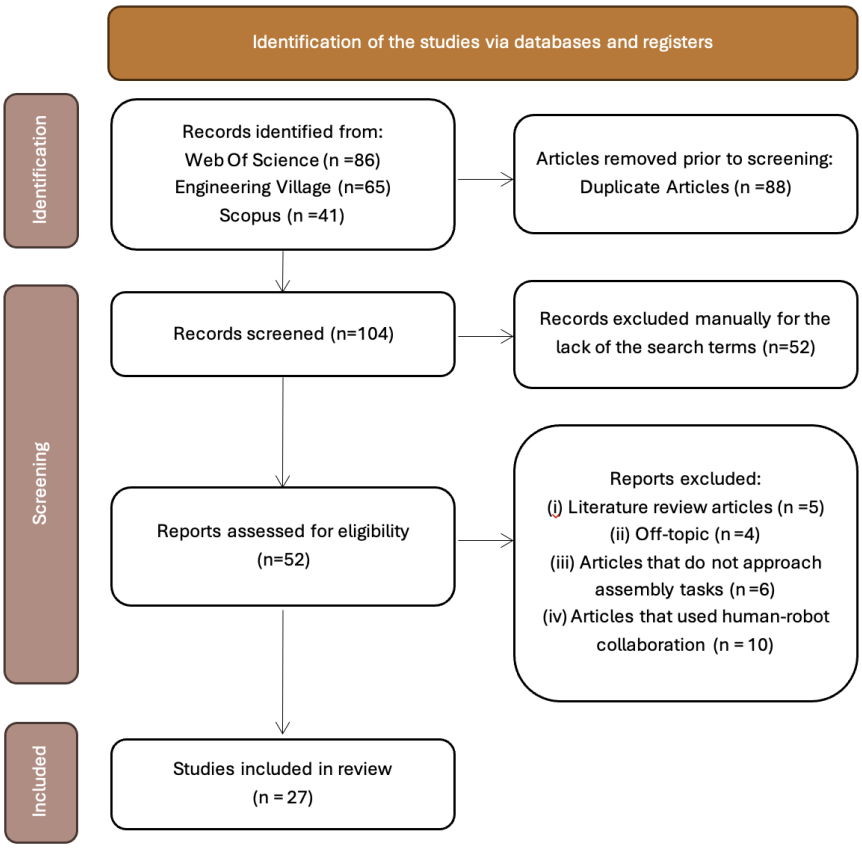

Figure 2. PRISMA flow diagram of this SLR

Furthermore, four articles were excluded as they did not align with the objectives of this study, focusing instead on topics from unrelated scientific domains, including neurology (Qin; Bulbul, 2023), livestock (Arıkan et al., 2023), labor law (Jain, 2019), and biomedicine (Mertz, 2023).

The articles which have already conducted a literature review were excluded, as the objective is to analyze the adopted strategies in articles presenting a case study using AR and AI applied to assembly tasks. The focus of this SLR is the identification, classification and of tools and methods used in the implementation of AR and AI in assembly tasks, in addition to providing an update of the period considered. It is pertinent to mention the generality of the assembly tasks addressed in this work, in contrast to the specific sectors such as construction (Hajirasouli et al., 2022), manufacture (Sahu; Young; Rai, 2021; Szajna; Kostrzewski, 2022; Lăzăroiu et al., 2024) and industry (Devagiri et al., 2022). These articles were excluded from this analysis also to avoid duplicating or overlapping results.

Six articles did not approach assembly tasks in the study (Azzam et al., 2023; Du; Kong; Zhao, 2023; Liu; Zhang; Gowda, 2023; Luo et al., 2024; Ma et al., 2024; Yue et al., 2024) and for this reason, they were excluded. Ten articles employed human-robot collaboration (Mueller et al., 2019; Wang et al., 2019; Dimitropoulos et al., 2021; ZHAO et al., 2021; Chu; Liu, 2023; Zhang et al., 2023a; Li et al., 2024a; Tolenov; Omarov, 2024; Xie et al., 2024; Zheng et al., 2024). They were excluded to ensure that the analysis remains focused on understanding the direct impact of AI and AR on human-performed tasks without confounding factors introduced by robotic interaction or automation.

Bibliometric Analysis

This section aims to analyze the bibliometric data related to the 27 resulting articles, summarized in Table 1.

Table 1. Bibliometric analysis of the studied articles.

RESEARCH	YEAR	JOURNAL	NATIONALITY
[69]	2022	INTERNATIONAL JOURNAL OF ADVANCED MANUFACTURING TECHNOLOGY	Italy
[70]	2023	INTERNATIONAL JOURNAL OF ADVANCED MANUFACTURING TECHNOLOGY	China
[71]	2020	SENSORS	South Korea
[72]	2024	BUILDINGS	China
[73]	2020	VIRTUAL REALITY AND INTELLIGENT HARDWARE	China
[74]	2021	IEEE TRANSACTIONS ON INSTRUMENTATION AND MEASUREMENT	China
[75]	2021	IEEE TRANSACTIONS ON INDUSTRIAL INFORMATICS	China
[76]	2019	SYMMETRY-BASEL	Slovakia
[77]	2023	ROBOTICS AND COMPUTER-INTEGRATED MANUFACTURING	China
[78]	2024	JOURNAL ON MULTIMODAL USER INTERFACES	India
[79]	2024	AUTOMATION IN CONSTRUCTION	Australia
[80]	2024	INTERNATIONAL JOURNAL OF HUMAN-COMPUTER INTERACTION	Switzerland
[81]	2021	JOURNAL OF AMBIENT INTELLIGENCE AND HUMANIZED COMPUTING	Singapore
[82]	2024	JOURNAL OF MANUFACTURING SYSTEMS	China
[83]	2023	ADVANCED ENGINEERING INFORMATICS	China
[84]	2022	APPLIED SCIENCES-BASEL	Italy
[85]	2024	ADVANCED ENGINEERING INFORMATICS	Taiwan
[86]	2023	IEEE TRANSACTIONS ON INDUSTRIAL INFORMATICS	China
(Filipescu et al., 2024)	2024	SENSORS	Romania
(Zhao et al., 2023)	2023	EXPERT SYSTEMS WITH APPLICATIONS	China
(Zhao et al., 2022)	2022	MEASUREMENT SCIENCE AND TECHNOLOGY	China
(Cramer et al., 2024)	2024	INTERNATIONAL JOURNAL OF COMPUTER ASSISTED RADIOLOGY AND SURGERY	Germany
(Lai et al., 2020)	2020	JOURNAL OF MANUFACTURING SYSTEMS	United States
(Aiken et al., 2024)	2024	IEEE ACCESS	Canada
(Geng et al., 2025)	2025	JOURNAL OF MANUFACTURING SYSTEMS	China
(Li; Chen, 2022)	2022	FRONTIERS IN PSYCHOLOGY	China
(Grappiolo et al., 2021b)	2021	INTERNATIONAL JOURNAL OF ADVANCED MANUFACTURING TECHNOLOGY	Netherlands

In the final selection of 27 articles considered in this study, the 14 studies were found in all the three used databases (Fig. 3).

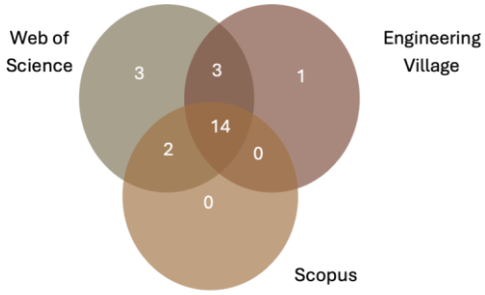

Figure 3. Articles found in each database

The selected articles were published between 2019 and September 2024, with a noticeable increase in publications from 2020 onwards (Fig. 4). Although 2020 represented a record number of publications on the topic, with a decline occurring afterwards, the numbers observed in subsequent years are still significant and constant, indicating academic interest in the topic.

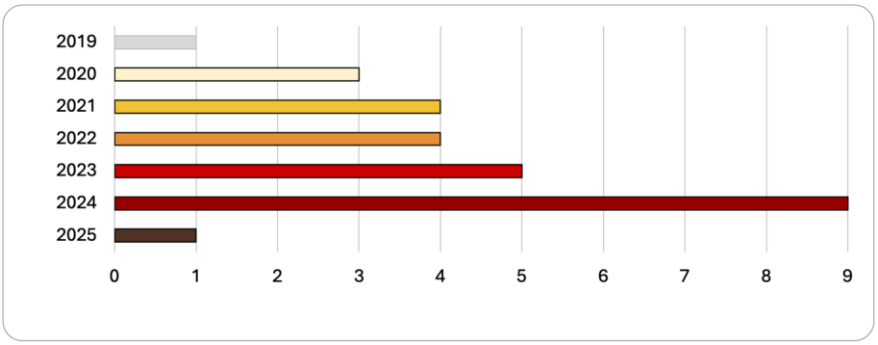

Figure 4. Publications per year.

The co-occurrence of keywords in the publications was analyzed using the VOSviewer tool. This analysis highlights the diverse range of approaches within the subject. This is illustrated by the scattered and weakly connected clusters, which are visualized in a word cloud. A total of 81 unique keywords were detected, considering author and index keywords.

To achieve a more cohesive grouping of concepts and a clearer visualization, a grouping of the keywords in the bibliography for a word cloud was made. This aimed to reduce unnecessary variations of terms related to the same concept, such as "artificial vision" and "machine vision" transforming into "computer vision". Due to many variations of assembly, the specific terms for example "cable assembly", "assembly inspection", "assembly assistant", among others, were summarized to "assembly". The same process was repeated to terms such as "augmented reality", "intelligent manufacturing", "neural networks" and "object detection". This process is useful to identify patterns and concentrate on key themes, preventing similar but slightly different terms from fragmenting the visualization. This process optimizes data representation and allows for a more straightforward and interpretable analysis (Table 2).

Table 2. Original keywords used and generalized keywords

Original keyword	Generalized keyword
AI AI surgery	artificial intelligence
Cable assembly	assembly
Assembly inspection	

Assembly assistant Assembly guidance	
Co-assembly	
Assembly elements	
Civil aircraft assembly	
Mechanical assembly	
Assembly Sequence Planning Disassembly	
AR	augmented reality
Wearable Augmented Reality Augmented Reality marker	
Artificial vision	computer vision
Machine vision	
Intelligent manufacturing workcell	Intelligent manufacturing
Recurrent neural networks	neural networks
Convolutional neural networks	
Region-based Convolutional Neural Networks (R-CNN)	
Redundant objects detection	object detection
Education 4.0/5.0	Industry 4.0

The network of connections was elaborated with the following parameters: the most frequent words are represented by larger circles and the number of connections is proportional to the line thickness (Fig. 5). The most recurrent keywords were deep learning, with 13 occurrences, followed by "augmented reality" and "assembly", both with 11 occurrences.

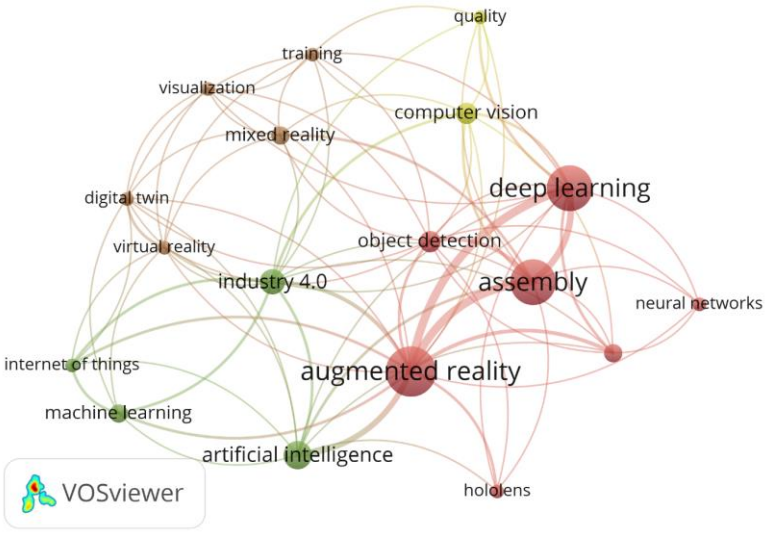

Figure 5. Keyword cloud.

The proceedings that published the most articles in the field were from International Journal of Advanced Manufacturing Technology and Journal of Manufacturing Systems with 3 publications each, while the IEEE Transactions on Industrial Informatics, Advanced Engineering Informatics and Sensors had two publications each. The remaining articles were published only once in different venues (Fig. 6).

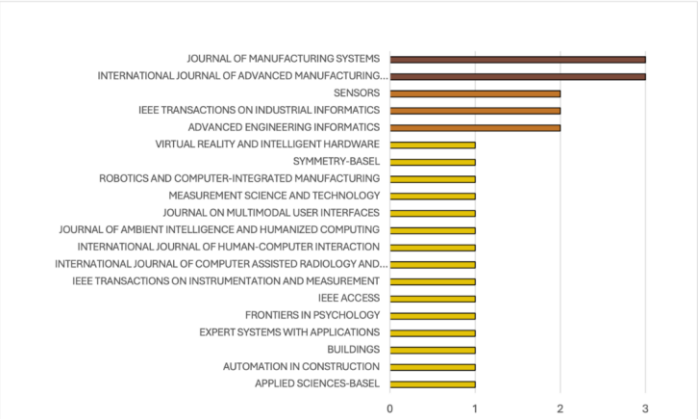

Figure 6. Publications per journal.

In the nationality segmentation analysis (Fig. 7), the research institution of the first author of each article was considered. It is evident that China accounts more than half of the selected content for this study, with 12 out of 27 articles. Following, Italy and Romania with two publications each. The analysis of publications per country serves as a geographic indication of locations where this has been more academically developed (Fig. 8).

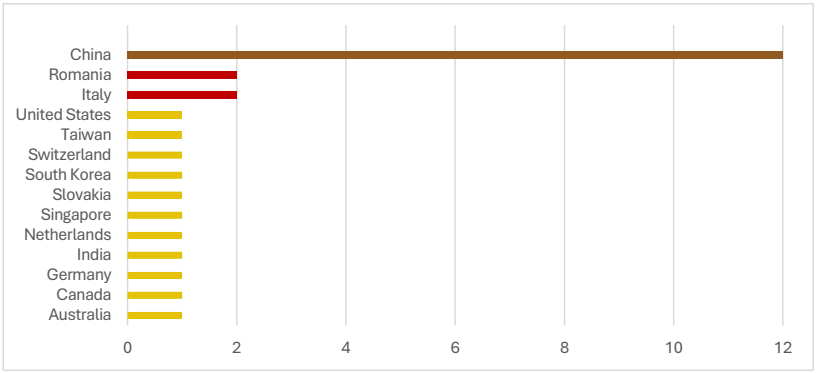

Figure 7. Publications per country.

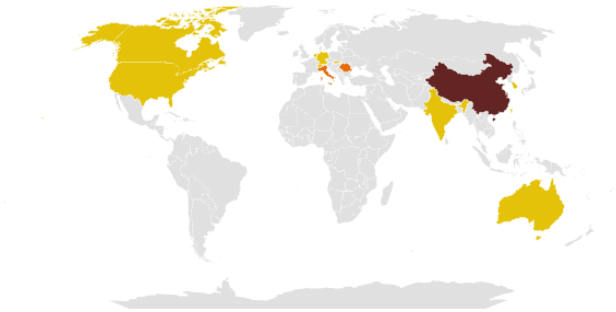

Figure 8. Locations of the publications reviewed.

Data classification

Table 3 summarizes the main analyzed topics, highlighting the key analyzed categories and their corresponding attributes. This approach enables a structured understanding of the data and facilitates further exploration of the patterns identified within the study.

Table 3. Data classification in each research.

RESEARCH	PURPOSE OF AI USAGE	IA MODEL	ASSEMBLY OBJECT	SOFTWARE	HARDWARE	ERROR DETECTION
(Generosi et al., 2022)	body tracking	CMU Deep Learning Model; Google Mediapipe Hand Tracking Model.	manufacturing work operations	-	iPhone	-
(Zhang et al., 2023b)	body tracking	YOLO	connectors of eletromechanical products	Unreal Engine;	-	✓
(Choi; Seo, 2020)	progress measurement	BAGGING METHOD	ship block	-		-
(Dzeng; Cheng; Cheng, 2024)	quality inspection	YOLO	scaffolding	Roboflow, Unity, Vuforia, MRTK	Hololens	✓
(Zheng et al., 2020)	object detection	CNN	aircraft cable	-	-	-
(Wang; Yan, 2021)	angle measurement; action recognition	YOLO; FASTER R-CNN; CNN	complex screws with a screwdriver	-	web cameras	✓
(Li; Zheng; Zheng, 2021)	object detection	RETINANET	aviation connectors	-	HiAR G200	-
(Zidek et al., 2019)	object recognition	R-CNN	standart parts (nuts, screws, washes)	Blender	Smartphone Samsung S7; Epson Moverio BT350	-
(Hu et al., 2023)	object recognition	MASK R-CNN	cable brackets	Vuforia	Iphone	-
(Raj et al., 2024)	object detection; body tracking; quality inspection	YOLO	pneumatic cylinder	Unity + MRTK + SolidWorks	Hololens	✓
(Chen et al., 2024)	vision-language understanding and generation	VIT	construction scenarios	Unity + C# Scripts;	Hololens	-
(Seeliger; Weibel; Feuerriegel, 2024)	visual navigation prediction	DNN	indoor environments	Unity + MRTK	Hololens	-
(Ho et al., 2021)	progress measurement	R-CNN	hybrid medical device	Unity; Vuforia	Iphone7; Logitech cameras; Epson Moverio	-
(Li et al., 2024b)	object detection; quality inspection	FCNs, YOLO	Non specified	Pytorch 1.7.1; OpenCV 4.5.1; Coin3D	camera monocular	-

RESEARCH	PURPOSE OF AI USAGE	IA MODEL	ASSEMBLY OBJECT	SOFTWARE	HARDWARE	ERROR DETECTION
(Wang et al., 2023)	body tracking	YOLO	aircraft component exhaust vent	Unity + MRTK	Hololens/HTC Vive	-
(De Feudis et al., 2022)	body tracking	OPEN POSE; YOLO	mechanical/industrial parts	SPSS Software	HTC Vive	-
(Chu; Chen; Chen, 2024)	object recognition	RANSAC	flange (mechanical part)	Apple ARKit	iPhone 12.	-
[86]	object detection	CENTERNET, CNN	reducer (mechanical part)	-	-	-
(Filipescu et al., 2024)		STPN	two workpieces, each consisting of five components (base, body, top and two cylinders)	SCADA and SIEMENS Tia Portal; MatLab; OpenCV; Node-RED; VNC Viewer	IFM Cameras 3D O3R222	-
(Zhao et al., 2023)	object detection	YOLO	screwdriver, cable piler, connector, etc	Unity, Visual Studio, MRTK, Open Neural Network Exchange	Hololens	-
(Zhao et al., 2022)	object detection	CENTERNET; YOLO	aircraft parts	-	-	-
(Cramer et al., 2024)	object recognition	-	surgical procedures	-	Microsoft HoloLens 2	-
(Lai et al., 2020)	object detection	FASTER R-CNN	tools, allen key, drill, screwdriver	Unity	Logitech camera	-
(Aiken et al., 2024)	object detection	YOLO; CNN	hydraulic fracturing valve	Blender-Proc2	Hololens; Matterport Pro	-
(Geng et al., 2025)	3d tracking, visual recognition, virtual-real matching, and rule reasoning are combined to complete, sequence, and locate the assembly targets	Deep Learning Recognition Model	complex electrical connectors	OpenIAI, using OpenCV, Unity, and Visual Studio	Custom made portable integrated desktop AR hardware named SNIO (Smart Nav-igator of Industrial Operations)	-
(Li; Chen, 2022)	object detection	Oriented FAST and Rotated BRIEF (ORB)	spindle	Vuforia	Hololens	-
(Grappiolo et al., 2021b)	progress measurement	RETINA NET	lumminaire	Freecad; Unity	Logitech camera	-

DISCUSSION

This section aims to focus on answering the questions established in the introduction based on the information acquired through the SLR.

What is the purpose of using AI?

Among the applications reported in the reviewed articles, it was possible to identify several uses for AI with a primary focus on object detection and recognition. Many studies implemented AI-driven object detection to identify components and parts during assembly processes (Lai et al., 2020; Zheng et al., 2020; Li; Zheng; Zheng, 2021; Zhao et al., 2022; Li et al., 2023; Aiken et al., 2024). Additionally, object recognition is employed to distinguish between different parts and tools, improving efficiency in assembly operations (Zidek et al., 2019; Hu et al., 2023; Chu; Chen; Chen, 2024; Cramer et al., 2024).

These applications allow AR systems to provide real-time guidance and error detection, ensuring accuracy and reducing the risk of assembly errors. The distinction between object detection and object recognition was identified. This separation is important in this analysis since the recognition of objects includes the classification of these objects based on their features and the detection is a task that consists of locating and identifying the objects within an image (Wang, 2016).

Beyond object detection, many articles focus on other uses for AI, such as tracking and measuring assembly progress through AI techniques. Body tracking is commonly used to observe assembler movements, enhancing ergonomics and task performance in assembly environments [69], [70], [78], [83], [84].

Progress measurement, which monitors the stages of assembly tasks, is also a crucial AI use (Choi; Seo, 2020; Grappiolo et al., 2021a; Ho et al., 2021). Additionally, AI-driven angle measurement and action recognition can give precise feedback on task execution, improving the accuracy and efficiency of manual assembly processes [74], ensuring that assembly tasks are performed in a correct and optimized way.

Some studies have explored AI applications in more functionalities, such as quality inspection, utilized in the identification of errors and ensure compliance with assembly standards [72], [78], [82]. Other studies also explored the role of AI in vision-language understanding for human-machine interaction [79] and visual navigation prediction for guiding assembly in complex environments [80]. Additionally, some researchers integrated AI-driven techniques like 3D tracking, virtual-real matching, rule reasoning, and target location to enhance precision in assembly tasks (Geng et al., 2025) (Fig. 9).

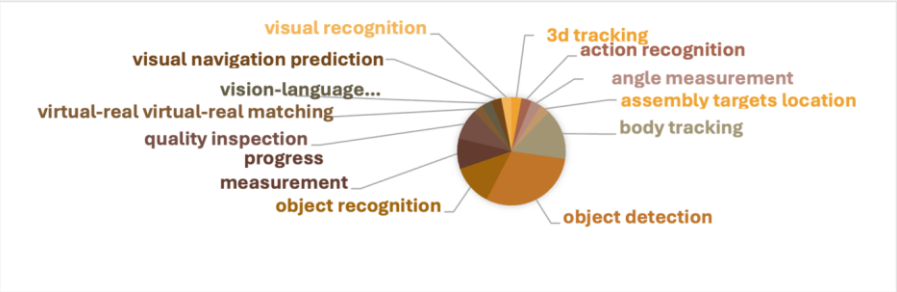

Figure 9. Purposes for AI usage.

Error analysis appears in many of the articles, often conducted by the researchers on the collected data to assess precision in the applications (Lai et al., 2020; Li et al., 2023, 2024b; Zhao et al., 2023). But one step ahead in the integration of AR and AI is the automation of the error detection, providing instant feedback for the assembler. This feature is observed in 4 of the 27 articles (Wang; Yan, 2021; Zhang et al., 2023b; Dzeng; Cheng; Cheng, 2024; Raj et al., 2024). They presented different approaches to automating error detection in assembly processes, leveraging advanced AI techniques and real-time monitoring systems.

(Zhang et al., 2023b) developed a two-stage assembly posture detection method that calculates matching errors for rotational and translational movements. Rotational errors are based on orientation discrepancies from rotation matrices, while translational errors use the intersection rate between bounding boxes estimated by the YOLO-6D network and virtual guidance models.

(Dzeng; Cheng; Cheng, 2024) trained a deep machine learning model with real images to automatically recognize deficiencies in scaffoldings, such as missing crosstie rods, lower-tie rods, and footboards. Their dataset included 4,240 images for training and over 1,000 for validation and testing, ensuring robust error detection.

(Wang; Yan, 2021) introduced a real-time angle-monitoring system for GPU assembly, designed to detect and warn operators of improper fastening angles with electric screwdrivers. The system prevents unacceptable quality errors by providing immediate feedback to the operator when deviations occur.

(Raj et al., 2024) implemented a fault detection algorithm integrated with HoloLens2, which uses hand-tracking capabilities to ensure all assembly steps are completed correctly based on the position of components, the user's thumb and index finger positions, and the distance between them, tailored to specific object sizes.

An analysis of the applications identified reveals diverse purposes for the implementation of AI in this context including object detection and recognition, body tracking, quality inspection, and fault detection. These automations optimize workflows by reducing errors, minimizing assembly time, and assisting users in the mistakes identification and recovery once they make a mistake. Collectively, these advantages contribute to the overall improvement of product quality.

Which AI models were used?

The analyzed studies utilized a variety of AI models, with object detection being the most prevalent, highlighting the CNN and its derivate YOLO. YOLO was majorly chosen due to its high-speed real-time detection capabilities for identifying assembly parts (Wang; Yan, 2021; De Feudis et al., 2022; Zhao et al., 2022, 2023; Wang et al., 2023; Zhang et al., 2023b; Aiken et al., 2024; Dzeng; Cheng; Cheng, 2024; Li et al., 2024b; Raj et al., 2024) Several studies implemented CNNs, a consolidated model for object detection and recognition, uniquely (Zheng et al., 2020) and integrated with other models as Faster R-CNN (Wang; Yan, 2021), CenterNet (Li et al., 2023) and YOLO (Aiken et al., 2024) for improved image processing.

More specialized deep learning architectures were utilized for distinct purposes, beyond object detection and recognition; for example, Fully Convolutional Networks (FCNs) are applied for semantic segmentation (Li et al., 2024b), and ViT are employed for vision-language understanding (Chen et al., 2024). These deep learning models benefit AR applications by providing more detail to the object recognition task and contextual understanding for assembly processes.

Variations of R-CNN and its derivatives were consistently utilized for object detection and segmentation tasks, such as Faster R-CNN, which improves detection speed (Lai et al., 2020; Wang; Yan, 2021), and Mask R-CNN, which adds instance segmentation capabilities (Hu et al., 2023). Other studies used RetinaNet, known for its ability to handle class imbalance through focal loss, for precise object detection (Grappiolo et al., 2021a; Li; Zheng; Zheng, 2021).

Beyond the deep learning architectures, a variety of works focused on body and pose tracking models, which are crucial for tracking worker movements and offering real-time feedback such as Google Mediapipe Hand Tracking and CMU Deep Learning Models were used for hand and body pose detection (Generosi et al., 2022). Similarly, OpenPose, which detects human body joints, is employed for body tracking in industrial assembly scenarios (De Feudis et al., 2022). Additionally, DNNs are applied for visual navigation and movement prediction in complex environments (Seeliger; Weibel; Feuerriegel, 2024), ensuring enhancement in worker interaction with AR interfaces and guaranteeing correct assembly techniques.

Other AI models emphasize geometric recognition and feature matching techniques such as RANSAC, applied for detecting geometric features (Chu; Chen; Chen, 2024) and ORB, applied for identifying objects from different angles (Li; Chen, 2022). STPN were also used for analysis of sequential assembly processes and progress tracking (Filipescu et al., 2024).

Apart from neural networks, ensemble learning was utilized by Choi & Seo (Choi; Seo, 2020) applying bagging and boosting methods to improve model accuracy and robustness. Moreover, a deep learning recognition model integrating multiple recognition techniques is employed for complex component identification by (Geng et al., 2025) in a custom implementation.

Considering the diverse AI techniques, a classification of the AI models utilized in the analyzed articles was developed (Fig. 10). This classification aims to enhance the understanding of the strategies employed in each study to integrate AI and AR for assembly tasks. Notably, YOLO emerged as the most frequently used model.

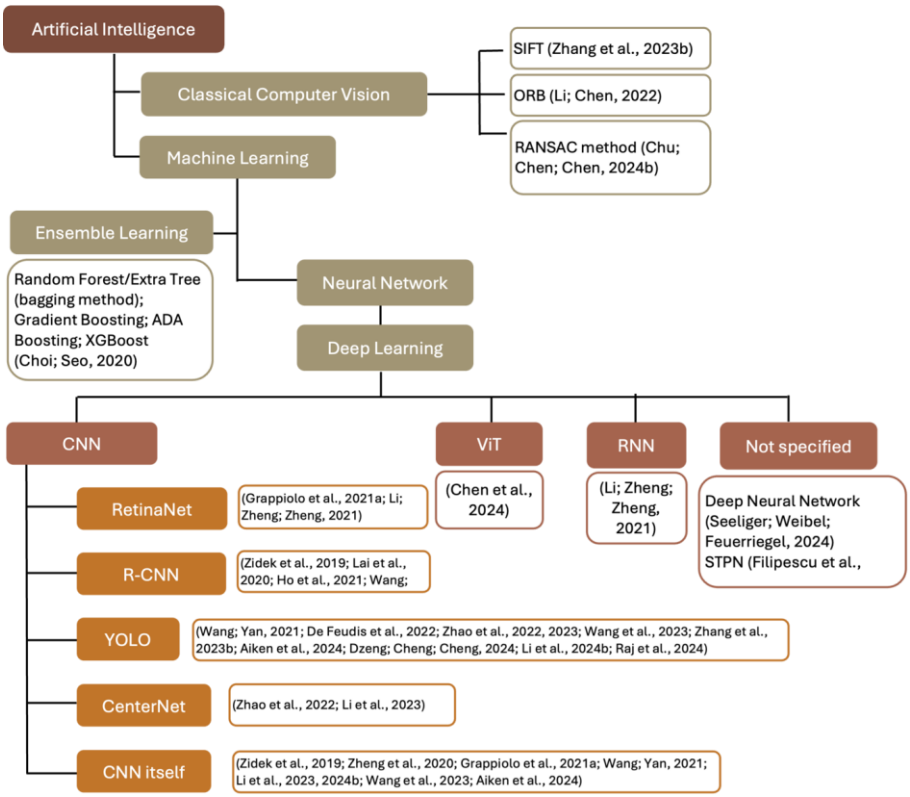

Figure 10. AI models identified in the studies.

AI models such as YOLO, CNNs, Mask R-CNN, ViT, and Faster R-CNN were employed in the studied assembly tasks, each catering to specific technical needs and specific purposes. YOLO is the most popular choice for real-time object detection, due to its speed and accuracy, making it ideal for identifying and locating assembly components. The CNNs were widely used for analyzing visual information, especially in object recognition and defect detection, as a model that covers not just the aforementioned YOLO but the other used models. Mask R-CNN and RetinaNet provided for the experimental studies in question precise segmentation and pixel-level accuracy, crucial for tasks requiring detailed component analysis.

It can be inferred that modern approaches like ViT are suitable for complex assembly scenarios, although they still do not represent an option that has been so widely implemented in studies over the last 6 years. Alternative methods such as OpenPose enable human pose estimation, enhancing safety and ergonomics during assembly but serves for more limited, serving specific analyses rather than comprehensive assembly task evaluation.

Which software and hardware were most used?

The reviewed studies utilized a range of software, with Unity being the most frequently used AR development engine, often combined with the Mixed Reality Toolkit (MRTK) for development of immersive AR environments (Wang et al., 2023; Zhao et al., 2023; Dzeng; Cheng; Cheng, 2024; Raj et al., 2024; Seeliger; Weibel; Feuerriegel, 2024). Many studies also employed Vuforia, a well-known AR Software Development Kit (SDK) associated to the aforementioned Unity (Ho et al., 2021; Li; Chen, 2022; Hu et al., 2023). Additionally, Unreal Engine was used for AR simulations by L. Zhang et al., (2023), while Apple ARKit was chosen for iOS-based AR applications by Chu et al., (2024).

Considering the focus of this analysis in the integration of AR and AI, many studies employed software for computer vision and AI model integration such as OpenCV, an open-source computer vision library, used for

image processing and object detection (Filipescu et al., 2024; Li et al., 2024b; Geng et al., 2025). Microsoft Visual Studio was also utilized for development environment for scripting and integrating AR with AI (Zhao et al., 2023; Chen et al., 2024; Geng et al., 2025). Additionally, Roboflow, a platform for computer vision dataset management, was employed for object detection models training (Dzeng; Cheng; Cheng, 2024).

Some studies also incorporate tools such as Blender and Blender-Proc2, frequently used for the development of 3D models for AR simulations (Zidek et al., 2019; Aiken et al., 2024), as well as SolidWorks (Raj et al., 2024) and FreeCAD (Grappiolo et al., 2021a), which were employed for generating 3D models used in AR assembly tutorials. In industrial settings, SCADA and SIEMENS TIA Portal were implemented for real-time monitoring and control of systems (Filipescu et al., 2024). Additionally, a statistical analysis software, SPSS, was applied for evaluating experimental results (De Feudis et al., 2022).

A diversity of hardware devices were highlighted in this review, with Head Mounted Displays (HMDs) being the most prominent for immersive experiences with Microsoft HoloLens being the most repeatedly used headset, appearing in 8 out of the total of 27 studies (Li; Chen, 2022; Zhao et al., 2023; Aiken et al., 2024; Chen et al., 2024; Cramer et al., 2024; Dzeng; Cheng; Cheng, 2024; Raj et al., 2024; Seeliger; Weibel; Feuerriegel, 2024). Additionally, HTC Vive, another commercial HMD for mixed reality experiences, was used by De Feudis et al., (2022) and Z. Wang et al., (2023). Some studies employed specialized AR glasses, such as HiAR G200 (Li; Zheng; Zheng, 2021) and Epson Moverio BT350 (Zidek et al., 2019; Ho et al., 2021).

Smartphones and cameras were also common categories of hardware for image capturing and processing. iPhones (Ho et al., 2021; Chu; Chen; Chen, 2024) and other unspecified smartphones (Generosi et al., 2022; Hu et al., 2023), were frequently used due to their embedded camera, mobility, practicality and ARKit support, the latter being exclusive to iPhones. Logitech cameras were repeatedly used for monitoring and recording assembly processes (Lai et al., 2020; Grappiolo et al., 2021a; Ho et al., 2021). Other non-specified webcams were used (Wang; Yan, 2021) as well as monocular cameras (Li et al., 2024b) and 3D IFM Cameras (Filipescu et al., 2024) for depth capture and object recognition data in various experimental setups.

Additionally, custom and specialized hardware platforms were utilized in some of the reviewed articles to support the integration of AR and AI assembly tasks in a more personalized way. For example, (Geng et al., 2025) developed a proprietary portable integrated desktop AR hardware platform named Smart Navigator of Industrial Operations (SNIO), developed for intelligent industrial assembly operations.

Out of the 27 articles analyzed, there was a particular emphasis on Unity (9 studies), Vuforia (4 studies) and MRTK (5 studies). Unity was the most widely used platform for AR development. It was often combined with MRTK and Vuforia to enhance AR functionalities, providing robust object recognition and AR overlay capabilities. It was noted that 7 studies do not mention any specific commercial software, which can suggest that there is still a need for the maturation or creation of software tailored to meet the demands of this sector.

The most used hardware in reviewed articles were HMDs, with Microsoft HoloLens being the most frequently utilized, used in 8 studies. Another important mention is the HTC Vive, employed for Mixed Reality experiences. Apart from HMDs, smartphones and cameras were also prevalent, highlighting the employment of iPhones and Logitech cameras, employed for monitoring and recording assembly processes. It is worth mentioning that the Microsoft Hololens 2 was discontinued in 2023, related to the company's current focus on its tool for military use of the U.S. Army, the Integrated Visual Augmentation System (IVAS) (Seiler, 2023).

How were AR and AI solutions adapted to different assembly scenarios?

The reviewed articles explore a diversity of assembly objects across different industries. Studies examined more complex connectors specific to the fields of aviation (Li; Zheng; Zheng, 2021), electromechanics (Zhang et al., 2023b) and electric (Geng et al., 2025), as well as mechanical parts like flanges (Chu; Chen; Chen, 2024). Specifically in the aviation sector, studies show efficacy of this application on aircraft parts, including cables (Zheng et al., 2020), exhaust vents (Li et al., 2023), and general aircraft components (Zhao et al., 2022), demonstrate the effectiveness of these technologies in high-precision and safety-critical environments.

In addition to mechanical components, several studies emphasize the assembly of electromechanical and structural elements, often used in aviation, maritime, and industrial applications. For instance, ship block assembly (Choi; Seo, 2020) and scaffolding structures (Dzeng; Cheng; Cheng, 2024) emphasizing the value of using AR and AI in large-scale assembly tasks that require precise positioning and alignment.

Another relevant category of assembly objects in this analysis included tools, brackets, and industrial systems that require AI-driven object recognition for improved guidance. For instance, studies on the assembly of cable brackets (Hu et al., 2023) and pneumatic cylinders (Raj et al., 2024) illustrate the application of AR-AI systems in the industrial context. The recognition and use of conventional tools such as screws, pliers, Allen keys, and drills (Lai et al., 2020; Wang; Yan, 2021; De Feudis et al., 2022; Zhao et al., 2023) accentuates how these technologies support floor workers in selecting and using appropriate instruments during assembly. Furthermore, research on specialized equipment, such as hydraulic fracturing valves (Aiken et al., 2024) luminaires (Grappiolo et al., 2021a), workpieces (Filipescu et al., 2024) and spindles (Li; Chen, 2022) revealing the adaptability of AR-AI integration across diverse engineering fields.

Some articles do not mention any specific assembly object but approaches the integration of AR and AI in general sectors, for example: manufacturing work operations (Generosi et al., 2022), construction scenarios (Chen et al., 2024), indoor environments (Seeliger; Weibel; Feuerriegel, 2024), hybrid medical device (Ho et al., 2021), that does not directly mention any specific assembly object but describes the use of assembly parts and related tasks, such as identifying screws, nuts, and other small components, used as well in (Zidek et al., 2019). Moreover, studies related to processes in surgical procedures (Cramer et al., 2024) showcase the potential of AR-AI integration in assisting with delicate operations.

AR and AI solutions were adapted to a variety of assembly scenarios such as aviation, industrial settings, structures and electromechanics. Even inside these sectors, it is visible that the integration of these technologies is applicable to bigger and robust assemblies (scaffoldings, ship blocks, etc.), but also to millimetric tasks (connectors, cables, etc.). Although there is a greater predominance of the integration of these technologies in manufacturing and industrial applications, it is possible to visualize its potential for versatility in other sectors such as surgical procedures and the medical field in general.

What were the common challenges and limitations in implementing AR and AI in assembly processes?
Despite the advantages of integrating AR and AI in assembly processes, there were several challenges in its application. Hardware constraints remain a significant barrier, as the use of HMDs and quality cameras can limit accessibility due to technical limitations such as lack of interoperability beyond specific platforms like HoloLens 2 and Unity (Li; Chen, 2022) and AR glasses usability problems like can be heaviness and fatigue, restricting long-term use (Zheng et al., 2020; Chen et al., 2024).

The computational complexity of AI-models for object detection and recognition requires substantial processing power, which can interfere in real-time responsiveness reported in slower processing times (Li; Zheng; Zheng, 2021) and recognition delays (Zidek et al., 2019). The authors also recognized the insufficiency of datasets in the deep learning models training, needing large and more diverse datasets. The data set limitations affected the system's ability to generalize and adapt to different assembly scenarios (Zheng et al., 2020; Li et al., 2024b). Besides that, (Li; Chen, 2022) also mention the lack of interoperability beyond specific platforms like HoloLens 2 and Unity.

Environmental factors were a common challenge for many studies that identified problems with variations in lighting and occlusions in the assembly space (De Feudis et al., 2022; Zhang et al., 2023b), which consequently affects sensors performance, causing limitations in the captured data. Among these difficulties it may be mentioned gloved hand detection (Generosi et al., 2022) and AR markers recognition (Choi; Seo, 2020). Addressing the user experiments authors mention the limitations of its participants study such as controlled environments, where participants lack industry experience, limiting real-world applicability (Seeliger; Weibel; Feuerriegel, 2024) and real-world conditions, such as weather and equipment availability, introducing unpredictability, further complicating industrial adoption (Chen et al., 2024).

What were the recommendations for future research or development in the application of AR and AI in assembly processes?
To advance the adoption and effectiveness of AR-AI integration, future research should address several key areas. The reviewed studies mentioned many improvements for future work, highlighting the enhancement of detection accuracy and robustness such as improving real-time tracking accuracy (Zhang et al., 2023b; Dzeng; Cheng; Cheng, 2024; Raj et al., 2024), dealing with occlusions, variations in lighting, and ensuring better hand/pose detection even under different circumstances (gloves, scaffolding obstruction, and non-standard scenarios) (Generosi et al., 2022; Dzeng; Cheng; Cheng, 2024; Filipescu et al., 2024).

Regarding errors during the assembly process, it was mentioned the necessity of implementation of fault correction and quality inspection during assembly processes could further streamline industrial applications (Geng et al.,

2025) and enhance operator training, allowing systems to predict assembler errors (Grappiolo et al., 2021a). This necessity is aligned with the results found in this review, since only four of the studies employed error detection in the developed applications.

Expanding AI applications to predictive analytics and dynamic scheduling optimization is another common recommendation, particularly for industries (Choi; Seo, 2020; Filipescu et al., 2024). Cloud-edge computing solutions could also improve inspection services, while adaptive learning models could improve object recognition and positioning accuracy without reliance on markers (Li; Zheng; Zheng, 2021; Li; Chen, 2022). Future research should also explore the enhancement of training methods, such as progressive learning systems for AR-based assembly instructions (Aiken et al., 2024) and studying human factors in technology adoption for better usability evaluation (Chen et al., 2024).

CONCLUSIONS

This SLR aimed to show the current state of research integrating AR and AI applied to assembly tasks objectifying the better understanding of the implementation and development of these technologies, as well as the challenges involved in the employment of those novelties. The existing research demonstrated a diversity of approaches, with no standardized method for effectively combining these technologies in assembly settings. This absence of a unified methodology results in fragmented implementations, making it difficult to assess and compare results. Future studies could establish a structured approach to guide the integration of AI and AR in assembly processes, ensuring consistency and efficiency across different scenarios.

A significant concern is the ephemerality of AR hardware considering an intent of long-term integration with AI. As a relatively new technology, AR devices are subject to rapid evolution, that often leads to short product life cycles and discontinuation of hardware, which was the case with Microsoft HoloLens. This instability makes it difficult for industries to invest in long-term solutions without the risk of obsolescence.

The durability and practicality of AR equipment in environments of industry and manufacture pose concerns since assembly tasks often involve physically demanding activities, which increase the risk of device damage and user exhaustion due to prolonged usage. The available AR devices did not present the practicality and resistance required for those environments, necessitating improvements in device design to enhance durability and usability. Moreover, real-time error detection and instant feedback for assemblers remain possible features that need further development, significantly improving the accuracy and efficiency of assembly tasks, minimizing errors.
Despite the challenges and possible improvements, the integration of AI and AR in manufacturing and industrial assembly is already well established, with significant space for expansion into other domains, such as medicine and surgical procedures. Considering the use of AI models, CNNs and YOLO continue to dominate, despite the emergence of modern models like ViTs that may offer promising improvements.

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Integrating Generative AI in Teacher Education: A Qualitative Exploration of TPACK Growth and Critical Reflection

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Abstract
This study investigates how generative AI technologies influence pre-service teachers' pedagogical thinking and instructional design practices within a vocational education context. Drawing on a qualitative framework, the research engaged students in a task-based learning environment that integrated tools such as ChatGPT and image generators into authentic teaching design tasks. Data were collected through reflective journals, interviews, and teaching artifacts.
Thematic analysis revealed three core trajectories of professional growth: (1) a shift from uncertainty to confidence in using AI tools; (2) the situated development of TPACK through iterative design and reflection; and (3) the emergence of critical awareness regarding AI ethics, accuracy, and bias. Students not only explored how AI could support their instructional creativity, but also expressed concerns about content reliability and the limitations of automated outputs. Their reflections illustrated an evolving understanding of AI not just as a tool, but as a co-participant in instructional reasoning.
The findings suggest that meaningful integration of generative AI requires more than technical training; it calls for pedagogical framing, ethical discourse, and reflective space. Teacher education programs must therefore cultivate not only AI fluency, but also critical and adaptive instructional mindsets capable of navigating the complexities of AI-supported teaching.
Keywords: Generative AI, TPACK, Pre-Service Teachers, Critical Reflection, Vocational Education, Instructional Design

1. Research Background and Rationale

The rapid advancement of generative artificial intelligence (AI) tools—such as ChatGPT, DALL·E, and other content generation systems—has introduced new possibilities and tensions in teacher education. While such technologies offer novel forms of instructional support, they also challenge pre-service teachers to rethink the roles of creativity, authorship, and judgment in designing learning experiences. In vocational education contexts, where instructional precision and applied problem-solving are crucial, these tensions become even more pronounced.

Pre-service teachers, often lacking extensive teaching experience, may struggle to make informed, pedagogically sound decisions when confronted with powerful yet opaque AI tools. Traditional teacher training programs tend to emphasize technological fluency or tool functionality, yet seldom provide the reflective space needed to critically interpret AI-generated outputs or ethically navigate their use in educational settings.

This study emerges from the need to better understand not just *how* pre-service teachers use generative AI in instructional tasks, but *how they make sense of it*. Rather than treating AI as a neutral aid, the study conceptualizes it as a co-actor in the instructional design process—one that mediates teacher cognition, amplifies design possibilities, and provokes reflection. By situating the research in an authentic, task-based learning environment, this study aims to explore the following:

- How do pre-service teachers experience the integration of generative AI tools into their instructional design practices?
- In what ways does AI use influence their development of TPACK-related thinking and teaching identity?
- What challenges, tensions, and ethical reflections arise in the process of using AI to solve authentic pedagogical problems?

In addressing these questions, this study contributes to a growing body of scholarship calling for critical, experience-based approaches to AI in education—ones that honor the complexity of teaching, and the evolving identity of teachers as designers, evaluators, and ethical agents in AI-supported classrooms.

2. Literature Review

2.1 TPACK as Situated Knowledge Construction

The Technological Pedagogical Content Knowledge (TPACK) framework has long been used to conceptualize how teachers integrate technology into subject-specific instruction. Originally proposed by Mishra and Koehler (2006), TPACK emphasizes the dynamic interaction between technological, pedagogical, and content knowledge. However, recent scholarship suggests that TPACK is not merely a static knowledge set but a contextualized and situated form of professional reasoning that unfolds through practice, negotiation, and reflection (Chai, Koh, & Tsai, 2013).

In vocational education, this situated nature becomes especially salient. Pre-service teachers must navigate highly specialized content, practical problem-solving, and the demands of instructional clarity. Yet, due to limited teaching experience, many struggle to enact TPACK in a purposeful and reflective manner. Studies have shown that meaningful TPACK development requires engagement in authentic teaching tasks, where technology is not taught in isolation but embedded within pedagogical decision-making processes (Angeli & Valanides, 2009).

This study builds on this perspective by framing TPACK not as a competence to be measured, but as a developmental trajectory revealed through how teachers talk about, justify, and reflect on their instructional choices—particularly when interacting with emergent technologies like generative AI.

2.2 Generative AI as Pedagogical Mediator and Ethical Disruptor

Generative AI tools—capable of producing text, images, code, and assessment content—are increasingly seen as promising supports for lesson design (Xie et al., 2023). For novice teachers, these tools offer accessible scaffolds for planning, visualization, and language refinement (Lo, 2023). However, researchers have raised critical concerns about the opacity, bias, and reliability of AI-generated content. AI systems often lack domain precision and may embed cultural or gendered stereotypes due to limitations in their training data (Floridi & Chiriatti, 2020).

More importantly, the process of interacting with AI itself becomes pedagogically consequential. Rather than simply enhancing productivity, AI tools shape how pre-service teachers frame instructional problems, imagine teaching scenarios, and construct knowledge. Holmes et al. (2022) suggest that AI may function as an "external cognitive agent," with the power to both extend and distort human reasoning. This calls for educators to approach AI not just as a tool, but as a pedagogical co-participant—one that requires interpretation, critique, and discernment. In response, recent literature advocates for embedding AI ethics and critical AI literacy into teacher education. Students must learn to ask: *What does the AI assume? Whose knowledge is being represented? How might these outputs shape learner understanding?* (Zawacki-Richter et al., 2019). These are not technical questions, but deeply pedagogical ones, and they must be addressed through dialogic, reflective instructional design experiences.

2.3 Self-Efficacy and Reflective Growth in AI-Supported Learning

Bandura's (1997) concept of self-efficacy offers a valuable lens to understand how pre-service teachers develop confidence in technology-mediated teaching. Self-efficacy arises not only from mastery experiences, but also from vicarious observation, social feedback, and emotional regulation. In the context of AI-supported instruction, efficacy is shaped by how students interpret their successes and failures when using unfamiliar tools in high-stakes learning design tasks (Teo, 2011).

However, elevated confidence in using AI does not always equate to pedagogical soundness. Research warns of the risk of overconfidence or uncritical dependence when students are not trained to evaluate or contextualize AI outputs (Lo, 2023). Therefore, self-efficacy in AI contexts must be developed alongside critical reflection, dialogic learning, and iterative redesign—practices more commonly found in qualitative, narrative-rich teacher education models.

This study thus positions self-efficacy not merely as a belief state, but as an emergent construct, visible through the language, struggles, and adaptive strategies students employ as they learn to use AI reflectively and responsibly in their teaching practice.

3. Instructional Design and Course Implementation

The instructional intervention in this study was grounded in a task-based learning (TBL) framework, designed not merely to teach pre-service teachers how to operate generative AI tools, but to immerse them in reflective, authentic experiences of instructional design. The goal was to cultivate both technical fluency and critical pedagogical reasoning within a situated, vocational education context.

3.1 Course Structure and Pedagogical Philosophy

The course was structured around the principle that teachers learn best by designing for real learners. Over a fifteen-week period, students were tasked with developing complete instructional units for vocational subjects (e.g., mechanical engineering, applied design, electronics), with generative AI used as a support rather than a directive force. Students were encouraged to make autonomous decisions about when, how, and why to incorporate AI-generated content into their lesson plans, materials, and assessments.

Each week introduced a new design challenge, accompanied by reflective prompts that asked students to evaluate their choices, difficulties, and discoveries. The learning environment emphasized creative experimentation, peer dialogue, and iterative revision.

3.2 Learning Phases and Activities

The course unfolded in three interrelated phases, each designed to scaffold both knowledge construction and reflective insight:

Phase 1: Exploration and Critical Familiarization

Students were introduced to a range of generative AI tools (e.g., ChatGPT for text generation, Bing Image Creator for visual design, and AI-based quiz generators). Rather than focusing solely on functionality, the instruction emphasized critical exploration: What kinds of knowledge can these tools generate? What do they obscure? Where might they mislead?

Students engaged in hands-on experiments with prompts, followed by group discussions about bias, accuracy, tone, and instructional applicability.

Phase 2: Design-in-Action

Each student selected a vocational topic and began constructing an instructional unit. AI tools were used to support:

- Drafting instructional goals and outlines,
- Generating teaching texts and diagrams,
- Designing formative assessment items.

However, students were explicitly encouraged to critique, adapt, or discard AI outputs as needed. This phase emphasized *productive struggle*—allowing students to encounter breakdowns, confront uncertainty, and engage in pedagogical decision-making.

Phase 3: Reflection and Iterative Redesign

Throughout the course, students maintained reflective journals, documenting their evolving beliefs, challenges, and strategies. Weekly peer review sessions were held, where students presented their AI-enhanced designs, received feedback, and discussed ethical or practical tensions encountered.

By the end of the course, each student submitted a comprehensive teaching unit along with a reflective narrative analyzing their use of AI, their reasoning behind instructional decisions, and their evolving understanding of technology's role in pedagogy.

3.3 Role of the Instructor

The instructor acted as a facilitator and provocateur, guiding students to not only use tools effectively, but to ask difficult pedagogical questions. When students struggled with AI-generated inaccuracies or ambiguous outputs, the instructor prompted deeper analysis:

- *What is this tool assuming about learners?*
- *How might this image reinforce stereotypes?*
- *Could this response mislead students?*

Rather than correcting students directly, the instructor modeled critical inquiry and design thinking, aligning with the course's broader goal of fostering adaptive, ethically aware teaching mindsets.

4. Research Methodology

4.1 Research Design

This study adopted a qualitative research design grounded in a phenomenological approach to explore how pre-service teachers construct their TPACK competencies and develop AI self-efficacy through the integration of generative AI tools in authentic instructional design tasks. By focusing on participants' lived experiences, the study aimed to understand how AI use shapes their pedagogical reasoning, instructional strategies, and reflective practices.

4.2 Participants and Context
The participants were 18 pre-service teachers enrolled in a vocational teacher education course at a university in Taiwan. The course was structured around a task-based learning model that required students to design a complete instructional unit with the aid of generative AI tools (e.g., ChatGPT, Bing Image Creator, AI quiz generators).

4.3 Data Collection
Multiple data sources were used to ensure credibility and triangulation:

- Reflective journals: Participants documented their experiences, challenges, and learning insights throughout the course.
- Teaching artifacts: Lesson plans, instructional materials, and AI-generated content served as evidence of instructional decision-making.
- Semi-structured interviews: Conducted with 12 representative participants to explore deeper perspectives on AI integration, instructional reasoning, and perceived growth.

4.4 Data Analysis
Thematic analysis was conducted following Braun and Clarke's (2006) six-phase process:

(1). Familiarization with the data;
(2). Generation of initial codes;
(3). Searching for themes;
(4). Reviewing themes;
(5). Defining and naming themes;
(6). Producing the report.

Coding was performed manually and iteratively. Three overarching themes and eight subthemes were identified to represent the trajectory of TPACK development and AI self-efficacy transformation.

5. Research Findings
Thematic analysis of reflective journals, interview transcripts, and teaching artifacts revealed three overarching themes that capture how pre-service teachers engaged with generative AI tools during instructional design. These themes illustrate a developmental trajectory from initial uncertainty toward empowered use, while also uncovering emergent tensions around ethics, content credibility, and professional identity.

5.1 Theme 1: From Tool Confusion to Pedagogical Confidence
5.1.1 Initial Uncertainty and Functional Struggles
Many students began the course with limited experience using generative AI. Early reflections expressed confusion, hesitance, and even frustration:
"I didn't know how to phrase my prompt. I asked it to make a quiz, but the questions didn't make sense for my topic."

(Participant C, Journal)
This unfamiliarity often led to reliance on default prompts or superficial applications of AI-generated outputs.
5.1.2 Confidence Through Iterative Design
As students engaged in repeated cycles of trial, critique, and refinement, they gradually developed confidence—not only in operating AI tools, but in deciding when and how to use them effectively:
"At first I used everything it gave me. But later, I started thinking like a teacher: 'Is this really what I want my students to learn?'"

(Participant L, Interview)
This transformation reflects a shift from passive tool usage to active instructional reasoning, marking an important phase in pedagogical growth.

5.2 Theme 2: Constructing Situated TPACK Through AI-Enhanced Tasks
5.2.1 Aligning Technology with Pedagogical Purpose
Students began recognizing that AI-generated content needed to be filtered through pedagogical intent:
"ChatGPT gave me a nice explanation, but I had to simplify it and add a visual so vocational students could understand."

(Participant A, Journal)
This illustrates the development of Technological Pedagogical Knowledge (TPK) in context—where teachers mediate between content, tools, and learners' needs.

5.2.2 Deepening Content Representations (TCK)
In designing materials for vocational subjects, students used AI to generate illustrations or analogies that clarified abstract or mechanical concepts. However, they often felt the need to correct or contextualize the outputs:
"The diagram looked polished, but the labeling was wrong. I had to edit it to match the actual machine structure."

(Participant F, Interview)
These moments reveal emerging Technological Content Knowledge (TCK), where students combine disciplinary accuracy with multimodal presentation.

5.3 Theme 3: Emerging Critical AI Literacy and Ethical Reflection
5.3.1 Questioning the Reliability of AI Outputs
While students appreciated the efficiency of AI tools, many expressed growing skepticism regarding accuracy and content validity:
"Sometimes it sounds confident but is actually wrong. I learned to double-check everything before using it in class."

(Participant D, Interview)
This cautious stance signified the beginnings of critical AI literacy, as students became more discerning evaluators rather than passive adopters.
5.3.2 Ethical Tensions and Representational Concerns
Several students raised ethical concerns about authorship and bias:
"The AI created a teaching story, but I felt uncomfortable—who owns it? Can I really say it's mine?"

(Participant K, Journal)
Others noticed stereotypical representations in AI-generated visuals:
"Most images showed men as engineers and women as assistants. I had to modify them to avoid reinforcing bias."

(Participant G, Interview)
These reflections indicate an evolving ethical awareness and a sense of responsibility toward inclusive and authentic educational representation.

5.4 Cross-Theme Synthesis: Becoming Reflective Instructional Designers
Across all themes, a consistent pattern emerged: students became more reflective, adaptive, and pedagogically intentional over time. They learned not just to use AI tools, but to interrogate them—to understand their affordances and limitations within specific teaching contexts:
"It's not about whether AI is good or bad. It's about how I, as a teacher, choose to use it—and why."

(Participant M, Final Reflection)
This evolving mindset aligns with the goals of teacher education in the digital age: to cultivate educators who are not only technologically capable, but critically aware, ethically grounded, and professionally self-directed.

6. Conclusion and Recommendations

6.1 Summary of Findings
This study explored how pre-service vocational teachers engaged with generative AI tools during a task-based instructional design course. Drawing on thematic analysis of reflective journals, interviews, and instructional artifacts, the findings reveal three key trajectories of learning and professional growth:

(1). From Tool Confusion to Pedagogical Confidence: Students initially struggled with prompt formulation and AI tool usage. However, through iterative experimentation and peer-supported reflection, they gradually developed confidence in using AI as a purposeful aid in teaching design.
(2). Situated Construction of TPACK: As students worked on authentic instructional tasks, they deepened their understanding of how technology intersects with pedagogy and content. Generative AI facilitated practical engagement with TPK and TCK, helping students internalize TPACK as a responsive framework rather than a static model.
(3). Emerging Critical AI Literacy and Ethical Awareness: Students became increasingly aware of issues related to content accuracy, algorithmic bias, and authorship. They expressed concern over stereotypical representations, questionable content credibility, and the ethical implications of using AI-generated materials in education.

6.2 Implications for Teacher Education
The findings underscore the need for a more reflective and ethically grounded approach to integrating AI in teacher education:

- Embed AI Use Within Authentic, Task-Based Contexts: Rather than teaching AI tools in isolation, they should be embedded in meaningful instructional design scenarios that require pedagogical reasoning and contextual decision-making.
- Emphasize Reflective Practice: Structured opportunities for self-reflection, peer feedback, and lesson redesign enable students to connect AI use with deeper insights into their teaching beliefs and design intentions.
- Integrate AI Ethics and Prompt Literacy into Core Curricula: Teacher preparation programs should systematically address AI-related issues such as bias detection, source transparency, and intellectual authorship, alongside developing skills in prompt design and content evaluation.

6.3 Recommendations for Future Research and Curriculum Design

(1). Broaden the Research Scope Across Contexts: Future studies can explore how AI-supported instructional design is experienced across general education disciplines and different stages of teacher development.
(2). Develop Scaffolded AI-TPACK Design Modules: Create progressive design templates and instructional materials that guide novice teachers from basic AI tool usage toward sophisticated, context-aware integration.
(3). Foster AI-Pedagogy Co-Design Communities: Establish communities of practice where pre-service teachers collaboratively explore, critique, and share AI-enhanced instructional strategies, fostering innovation through shared reflection.

6.4 Concluding Remarks

Generative AI offers powerful opportunities for teacher growth, but only when its use is embedded within pedagogically meaningful, ethically conscious, and reflective practices. This study demonstrates that pre-service teachers can evolve from tentative users to critically engaged designers through situated, AI-supported experiences. As the role of AI in education continues to expand, teacher education must prepare future educators not only to use these tools, but to do so with discernment, creativity, and professional responsibility.

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Thematic Content Analysis for Curriculum Literacy in Education

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ABSTRACT
This study was conducted to understand the importance of curriculum literacy in education and current trends in the literature. The research covers national and international academic studies published on SCOPUS. Studies on curriculum literacy during this period were examined to determine the contents and trends addressed at different levels of education. Data were collected using thematic content analysis method and analyzed with a qualitative approach. The research design was determined as document review; coding and thematic classification methods were used. The findings obtained in the research show that the role of curriculum literacy in education is increasingly emphasized and the literature in this field is expanding. In addition, it was determined that curriculum literacy studies focused especially on digital literacy, teaching methods and content integration. The results reveal that curriculum literacy is a critical skill for individuals to exist effectively in the digital world. However, since a limited number of databases were examined, a more extensive literature review is needed. In the future, it is recommended that applied and interdisciplinary studies be conducted to increase the integration of curriculum literacy into teaching processes.
Keywords: Algorithmic Thinking, Coding, Content Analysis, Digital Literacy, Programming Literacy.

INTRODUCTION

While literacy has historically been shaped as a concept that only covers writing and reading skills, today it has gained a much broader meaning. Today's literacy includes individuals' access to information, making sense of this information, and using it with critical thinking skills (Aydın and Seferoğlu, 2023). With the innovations brought by the digital age, this concept has evolved even further, and has included skills such as accessing information and using technology effectively. In parallel with this expanding understanding of literacy in education, curriculum literacy also stands out as an important concept. Curriculum literacy includes the skills of understanding the structure of curriculum, evaluating its content, and analyzing its applicability so that individuals can be more effective and efficient in their learning processes (Sur, 2022). In this context, curriculum can play an important role not only in course content, but also in how this content will be presented and evaluated to students.

Educational programs can fulfill a critical function in the development of individuals in a society and in the process of their adaptation to social life. Well-structured educational programs can support individuals' lifelong learning skills by enabling them to make informed decisions. The effectiveness of these programs may depend not only on the knowledge and skills of teachers or educational administrators, but also on how well they understand and implement the educational program. Educational program literacy can have an important place in the process of providing this critical skill for teachers and other educational stakeholders. Because individuals who read and evaluate educational programs correctly can contribute more directly to the development of students.

The development of curriculum literacy has progressed in parallel with the changing needs in education systems and the digital transformation processes of societies. In the 21st century, education is shaped by more technological integration and innovative teaching methods (Bozkurt & Coşkun, 2018; Kazu & Kuvvetli, 2023). This transformation has required teachers to understand how to integrate technology and develop students' digital skills, beyond just mastering traditional curriculum. In this context, curriculum literacy enables teachers to use educational materials effectively. It enables them to adapt and integrate these technologies into their teaching

processes. In addition to improving the quality of education, program literacy can also provide students with a broader learning experience.

This research aims to address the scope, importance and role of curriculum literacy in education. Curriculum literacy can have a significant impact on the development of not only teachers and educational administrators but also students. Students can have a better learning experience through correct and effective educational programs. Therefore, the fact that teachers and educational administrators have acquired curriculum literacy is a factor that will directly affect students' success. Therefore, curriculum literacy is becoming increasingly important today as an important component that increases the quality of education.

Literature Review

Definition and Importance of Curriculum Literacy

Curriculum literacy is a concept that is generally associated with understanding the purpose of educational programs, evaluating their content, and analyzing their applicability. However, different researchers define this concept in different ways. For example, while some researchers define curriculum literacy as the ability to use educational materials effectively (Drake et al., 2014), others emphasize how educational programs can be adapted to the individual needs of students (Cairney, 2002). Both definitions reveal how multifaceted a concept program literacy is. The basic components of curriculum literacy include understanding the content of the program, evaluating teaching methods, analyzing outcomes and learning materials, and evaluating outcomes (Wyse et al., 2016). These components can help educators develop effective programs that are appropriate for the needs of students.

The contributions of program literacy to the education system are quite extensive. Teachers and education administrators being program literate can ensure the development of more innovative practices and an egalitarian teaching approach in education (Çöğmen and Yılmaz Özelçi, 2024). Gaining this skill not only contributes to teachers' own professional development, but also increases students' success. Program literacy allows teachers to create a more flexible, creative and effective teaching process (Ennis, 2015). In addition, increasing program literacy plays an important role in reducing inequalities in education (Berson et al., 2022). Equality in education means supporting each student according to their own learning pace and needs, which can be possible by correctly analyzing and implementing teaching programs.

Lack of Program Literacy in Education

Today, education systems must adapt to changing needs and technologies. In this adaptation process, curriculum literacy stands out as one of the greatest strengths of teachers. However, there are serious difficulties in the development of curriculum literacy around the world and especially in Türkiye. Research shows that teachers' curriculum literacy levels are generally not at the desired level (Aslan and Gürlen, 2018; Demir and Toraman, 2021; Yar Yıldırım, 2020). Similarly, Tuncel and Kazu (2019) emphasize that one of the main reasons for teachers' inadequacies in evaluating success during the instructional process is their insufficient level of program literacy skills. Therefore, they suggest that courses or course contents aimed at developing this skill should be included both in Faculties of Education and in Pedagogical Formation Education Programs. This deficiency is usually attributed to factors such as inadequate teacher training, time constraints, and bureaucratic obstacles. It is based on. In addition, the constant change of the curriculum makes it difficult for teachers to adapt to existing programs. These difficulties are important factors that prevent the improvement of quality in education.

The importance of program literacy is increasingly recognized in the education system. However, the obstacles that prevent educators from acquiring this skill need to be overcome. Providing more education and resources to teachers and providing the necessary environments for teachers to use digital tools effectively will ensure that program literacy becomes widespread. In order to use quality programs in education, teachers need to receive training that meets the needs of students and includes contemporary teaching methods.

Purpose and Scope of the Study

The purpose of this study is to investigate the role and importance of curriculum literacy in education and to reveal the factors that hinder the development of curriculum literacy. The study is based on a current literature review on how well teachers understand and implement curriculum. This study will discuss the basic components and suggested strategies required for teachers to gain curriculum literacy. The scope of the study will not be limited to teachers alone, but will also address the contributions of educational administrators and other educational stakeholders to curriculum literacy. This study aims to develop applicable strategies for a more efficient education system while emphasizing the place and importance of curriculum literacy in education. In this context, the originality of the study is that it contributes to the existing literature and offers suggestions that will increase the integration of curriculum literacy into education systems.

This research addresses and seeks answers to the following questions that have not been adequately addressed in the literature:
1. What is the demographic information of the studies conducted?
2. What is the distribution of common keywords of the studies by year?
3. What is the distribution of academic studies on curriculum literacy by year?
4. What kind of distribution is observed among the topics of the studies on curriculum literacy?
5. What are the common themes of studies on curriculum literacy?

METHOD

Research Design

In this study, thematic content analysis method was chosen. Thematic content analysis is an approach that allows for the systematic examination of qualitative data (Ültay et al., 2021). This type of analysis allows the separation, classification and interpretation of existing text, visual or audio materials into meaningful categories. In accordance with the purpose of the research, the researcher will examine the contents in depth to better understand a particular phenomenon, concept or theme.

Data Collection Tools

In the study, content analysis, one of the qualitative data collection methods, was used as a data collection tool. Thematic content analysis was conducted by using the information in the titles, keywords, abstracts and conclusion sections of the articles. Data were obtained from articles written in English and Turkish, scanned with the keyword "curriculum literacy" through the Scopus database. The contents of these articles were collected and analyzed under certain criteria. Within the scope of the study, main categories such as the distribution of the articles by year, which subtopics were focused on and which countries they were conducted in were determined.

Data Analysis Method

The data obtained were examined using qualitative analysis techniques. Content analysis allows the identification of certain patterns, themes, and categories in the texts (Ültay et al., 2021). Within the scope of this study, each article was classified according to predetermined key categories in order to analyze the distribution by year, distribution by subject, and distribution by country. Then, the data in these categories were presented with descriptive statistics and the trends in the literature were revealed. In the light of the obtained data, it was evaluated in which years, in which sub-subjects, and in which countries the developments in language learning and program development were concentrated.

Reliability and Validity

In order to ensure the reliability and validity of the research, a meticulous method was followed in the data collection and analysis process. Care was taken to carry out the content analysis independently of the researcher's personal interpretations and prejudices. In addition, each article was examined under certain categories, thus increasing the accuracy of the analysis. The validity of the findings obtained during the analysis was evaluated based on previous studies conducted on similar subjects in the literature. As a result, the findings of the research are accepted as reliable and valid.

Inclusion and Exclusion Criteria

This search includes only academic articles written in English on the subjects of artificial intelligence, program development and language learning. Detailed information is provided in Table 1.

Table 1. Inclusion and Exclusion Criteria.

Inclusion Criteria		**Exclusion Criteria**	
Topic	Articles on Curriculum Literacy	**Publication Type**	Common types of academic work such as literature reviews, reports, books, conference proceedings
Language	Studies conducted in English and Turkish.	**Suitability**	Program Studies that make indirect or limited contributions to the field.
Publication Type	Peer-reviewed (refereed) in journals.	**Access Status**	Accessible (full text) articles
Keywords	Studies were search using the keyword	**Originality**	Direct to the field of program literacy contributing original research.

	"Curriculum literacy.

The articles retrieved from the database were searched with the keyword “curriculum literacy”. However, only articles published in accessible, peer-reviewed journals were analyzed. As an exclusion criterion, previously published literature reviews, reports, books, or conference proceedings were not included in the study. In addition, only original studies that directly contributed to the field of curriculum literacy were focused on. After excluding 6 studies that were determined not to be related to curriculum literacy from the 35 studies obtained, the remaining 29 studies were included in the study.

FINDINGS

The bibliometric analysis results obtained by examining the keywords of the studies in the literature are shown in Figure 1.

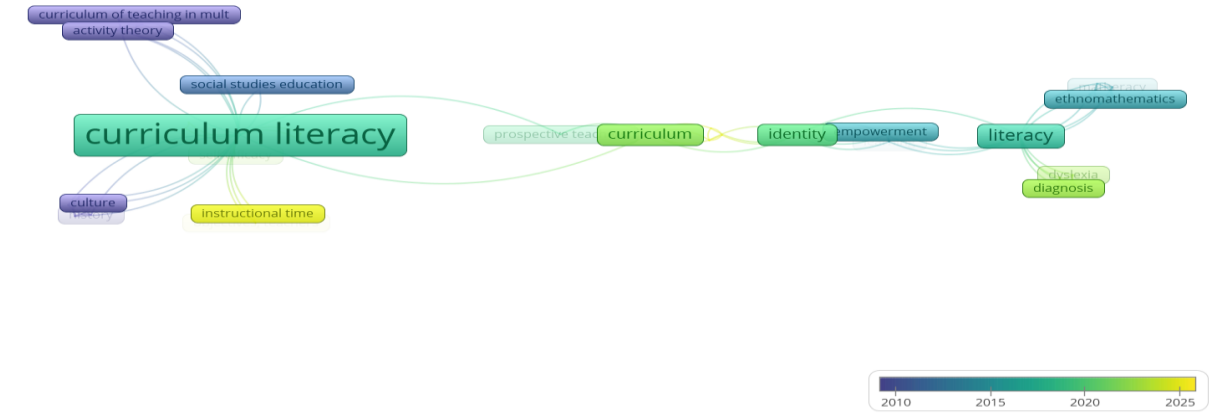

Figure 1. Analysis of the Distribution of Studies According to Keywords

As a result of VOSviewer, in the period 2010-2015, basic concepts such as "curriculum literacy" and "social studies education" come to the fore. In these years, social sciences and The importance of curriculum literacy has been emphasized, and the relationship between social science education and curriculum literacy has been particularly focused on. Research has shown that social science education can be a supportive tool for more effective understanding and implementation of the curriculum (Duckworth & Brzeski, 2015).

Between 2015 and 2020, concepts such as "activity theory" and "culture" began to attract more attention. During this period, studies on activity theory and the integration of cultural elements into education increased. Researchers examined the impact of cultural context on learning processes and focused on how activity-based approaches can support learning (Evmenova & King-Sears, 2013; M. Modiba & Van Rensburg, 2009). Taking cultural diversity into account in education and shaping learning activities accordingly has become an important research topic.

In the 2020-2025 period, terms such as "dyslexia," "diagnosis," and "empowerment" are at the forefront. In recent years, studies on literacy-related diagnosis and learning disabilities have accelerated, with particular emphasis on diagnosing learning disabilities such as dyslexia and supporting practices for these individuals (de Bree et al., 2022). In addition, the goal of empowering individuals and ensuring that they take a more active role in their learning processes has also become an important area of research in this period (Duckworth & Brzeski, 2015).

The distribution of academic studies on curriculum literacy by year has shown a significant increase in recent years. The distribution by year is given in Figure 2.

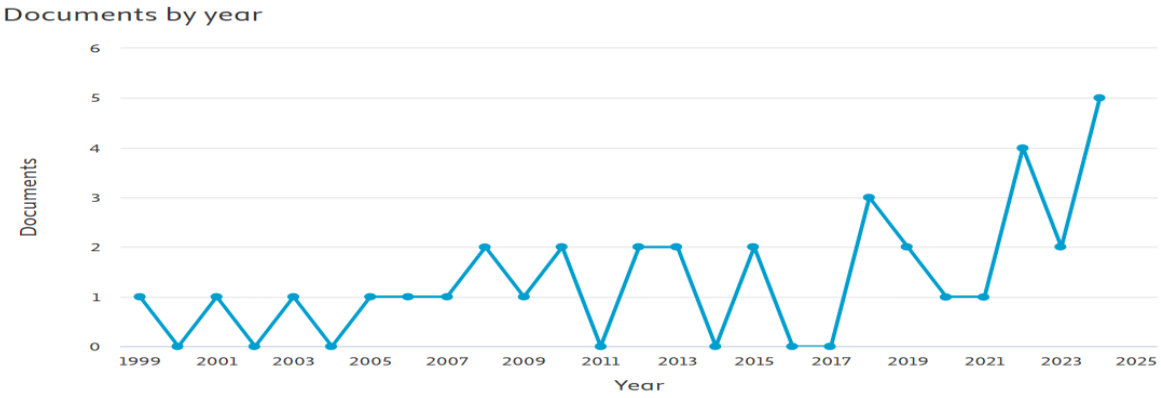

Figure 2. Distribution of Studies by Year

When the distribution of studies on curriculum literacy is examined by year, it is seen that the studies in the period 2000 and before are quite limited. Only a few studies were conducted in these years; for example, only 5 studies were conducted before 2000. A total of 10 studies were reached between 2000-2010. These data are It shows that it did not receive widespread attention in the academic community at that time and that the emphasis was mostly on basic conceptual frameworks.

There was a noticeable increase in the number of studies between 2010 and 2015, and a total of 11 studies were conducted. During this period, it is seen that research aimed at better understanding and implementation of programs came to the fore. The importance of the field has gradually begun to be recognized, but studies have generally remained limited to theoretical and small-scale applications.

It is noteworthy that the number of studies increased rapidly in the period 2015-2020 and reached a total of 26 studies. During this period, more in-depth research was conducted, especially on activity theory, cultural contexts and the effects of educational technologies on program literacy. Digitalization and interdisciplinary integration efforts in education can be considered among the main reasons for this increase.

In the years 2020-2025, research on curriculum literacy has made a leap forward, reaching a total of 89 studies. The focus of the studies conducted during this period has been on current educational themes such as artificial intelligence, digital learning tools and specific learning disabilities. For example, diagnostic studies on specific learning disabilities such as dyslexia and research on empowering individuals in their educational processes are noteworthy. These data show that interest in curriculum literacy has increased steadily over the years and that this field has become central to educational research today. Figure 3 shows the distribution of studies by discipline.

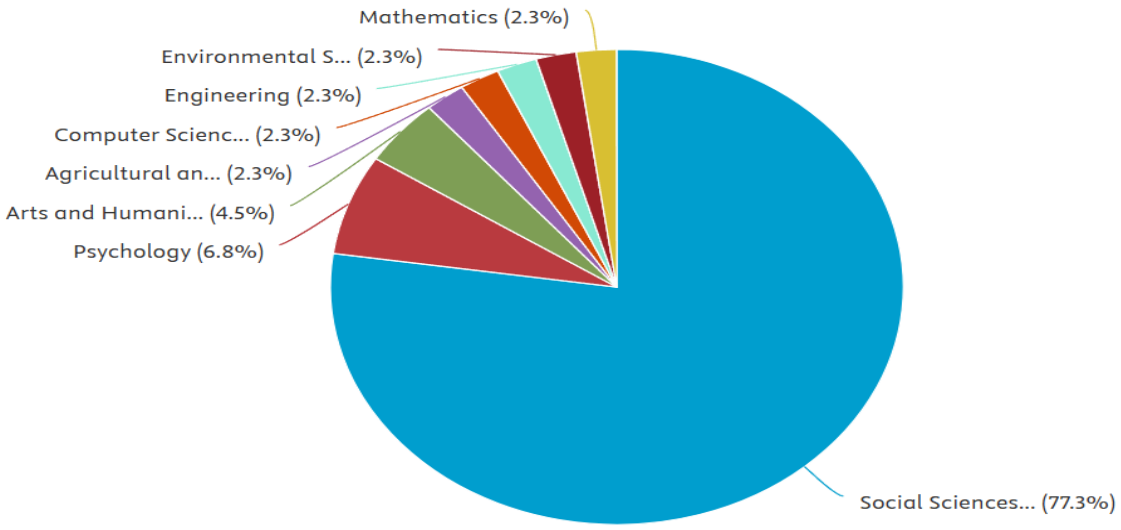

Figure 3. Distribution of Research by Discipline

When the distribution of studies on curriculum literacy is examined according to subject areas, it is seen that the most studies were conducted in the field of social sciences (24 studies). This situation reveals the close relationship between curriculum literacy and education, social structures and the interactions of individuals in social contexts. Social sciences have hosted the most comprehensive studies in terms of the applicability and widespread effects of curriculum literacy.

In the field of psychology, three studies were conducted. This indicates the existence of research examining the relationship between curriculum literacy and individual awareness, learning processes, and behavior. In the arts and humanities, two studies examined how curriculum literacy is related to creative processes and cultural contexts. Other fields, such as agricultural and biological sciences, computer science, engineering, environmental science, and mathematics, were represented by one study each. The limited studies in these fields reflect the interdisciplinary potential of curriculum literacy, but these issues have not yet been addressed in depth.

In general, while a distribution dominated by social sciences is striking, the few studies conducted in other fields point to opportunities where curriculum literacy can be addressed within a broader disciplinary framework. This situation reveals that curriculum literacy can potentially span a multidisciplinary field, but is currently mainly centered on social sciences. Figure 4 shows in which countries research on curriculum literacy issues is concentrated.

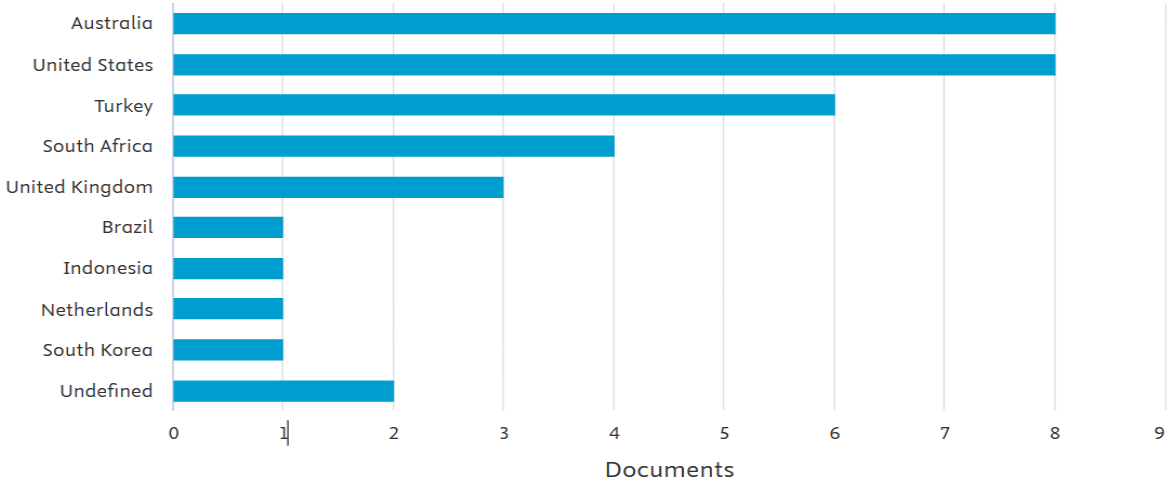

Figure 4. Distribution of Studies by Country

In the distribution of studies on curriculum literacy by country, it is seen that Australia (8 studies) and the United States (8 studies) host the most studies. This situation shows the importance given to curriculum literacy in these countries and the intensity of academic activities in this field. Turkey ranks third with 6 studies, revealing that curriculum literacy is a remarkable research topic in Türkiye as well.

Four studies were conducted in South Africa, indicating that curriculum literacy is considered important in the region's education systems. The United Kingdom was represented by three studies, while Brazil, Indonesia, the Netherlands and South Korea each had one study. The limited number of studies in these countries suggests that curriculum literacy is addressed with varying intensities in different geographies.

In addition, the location of two studies was not specified (not defined). Overall, the geographical distribution of the studies suggests that interest in curriculum literacy is concentrated in certain regions around the world and that this area needs to be explored more globally. While countries such as Australia, the United States, and Turkey have taken a leading role in this area, the paucity of studies in other countries suggests that this area needs to be addressed more broadly, both interdisciplinary and geographically. The frequency percentages of the themes obtained from the studies are shown in Figure 5.

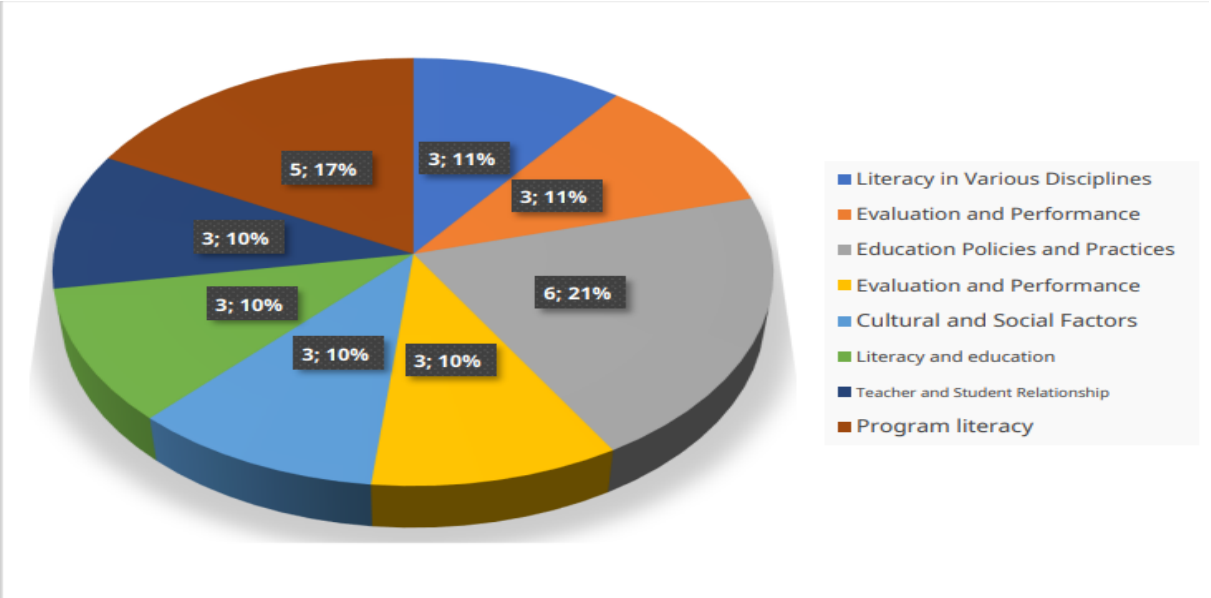

Figure 5. Frequency Percentages of Themes Obtained from Research

The findings of these studies show that developing a deeper understanding of preservice teachers' curriculum literacy and educational policies can greatly affect teaching and learning processes (Erik & Yilmaz, 2024). The role of curriculum literacy in increasing pre-service teachers' relationship with the curriculum and their ability to connect program decisions contributes to the development of their critical reflection skills. In addition, the impact of teachers' curriculum literacy levels and teaching duration on students' conceptual understanding and competence emphasizes the importance of interactive and applied teaching methods in education.

These findings, which show a weak but positive relationship between teacher candidates' digital literacy and technology use levels and curriculum literacy, are of interest to educational policies and This relationship between educators' curriculum literacy and digital technology use presents an important opportunity for teachers to develop their skills in using teaching tools and materials more effectively.

Studies also show the importance of making education more inclusive and equitable, especially for low-income students (Hallman & Kindelsperger, 2018; M. Modiba & Van Rensburg, 2009; Yuan & Grant, 2023). Using creative writing and multimodal opportunities in education can provide these students with a more equitable educational experience (Yuan & Grant, 2023). In addition, it has been found that teachers' ability to critically evaluate instructional materials is associated with pedagogical content knowledge and is critical for the integration of 21st century skills into the teaching process (Schroeder & Curcio, 2022).

The literacy skills that students apply in the classroom produce more meaningful and effective results when aligned with learning opportunities (Miller & Satchwell, 2006). However, if the curriculum is not flexible, these learning opportunities can be limited. Therefore, teachers need to design learning processes by considering students' individual needs and contextual factors. Integrated approaches in education are especially important for the development of curriculum literacy and cultural awareness (de Bree et al., 2022; Hallman & Kindelsperger, 2018; Moon et al., 2021). These studies provide a guide on how social and cultural factors can be integrated into educational processes while developing the literacy skills of teachers and students. The demographic information of the studies is provided in Table 2 below.

Table 2. Demographic Information of the Studies and Thematic Content Analysis Findings

Author	Year	Title	Themes	Method	Sample	Sample Group
(Marek vd., 2024)	2024	A framework for curriculum literacy in initial teacher preparation: Policy, practices, and possibilities	Program Literacy	Literature Review	Access Not Provided	Prospective Teachers
(Mdaka & Modiba, 2024)	2024	Instructional time as social time: Teachers' curriculum literacy and expertise in teaching mathematics	Curriculum Literacy	Quantitative Interview	4	Math Teachers
(Kerimoğlu & Altun, 2024)	2024	Backward design in pre-service teacher education to enhance curriculum knowledge	Education Policies	Qualitative Action Research	37	Prospective Teachers
(Lee, 2024)	2024	Developing a college course model for enhancing pre-service English teachers' curriculum development competency via collaboration with in-service teachers	Teacher and Student Relationship	Qualitative Action Research	13	Prospective Teachers
(Erik & Yilmaz, 2024)	2024	Lifelong learning center trainers: What are their perceived curriculum literacy and digital technology usage levels?	Various Disciplines in Literacy	Qualitative	628	Teachers
(Öner & Cırık, 2023)	2023	Exploring curriculum literacy skills: An in-depth analysis through explanatory sequential design	Curriculum Literacy	Mixed	98	Primary School English Teachers
(Yuan & Grant, 2023)	2023	Digital storytelling of two "underperforming" and "misbehaving" boys of color in a 2nd-grade classroom	Cultural and Social Factors	Qualitative	2	2 Students
(de Bree vd., 2022)	2022	A stitch in time: Comparing late-identified, late-emerging and early-identified dyslexia	Integrated Approach	Quasi Experimental	116	Dyslexia Students
(Schroeder & Curcio, 2022)	2022	Critiquing, curating, and adapting: Cultivating 21st-century critical curriculum literacy with teacher candidates	Literacy in Education	Quasi Experimental	44	Prospective Teachers
(Yasin vd., 2022)	2022	Self-efficacy of English language teachers with low and high curriculum literacy in Indonesian schools	Teacher and Student Relationship	Scales, Quantitative	251	English Teachers
(Innes, 2022)	2022	History curriculum: Literacies and democracy in NSW syllabuses	Education Policies	Literature Review	Access Not Provided	Official Curriculum (1990s to early 2000s)
(Taylor-Leech, 2020)	2020	Languages	Various Disciplines in Literacy	Literature Review	Access Not Provided	Access Not Provided
(Aslan, 2019)	2019	An analysis of prospective teachers' curriculum literacy levels in terms of reading and writing	Curriculum Literacy	Quantitative Questionnaire	383	Prospective Teachers
(Moon vd., 2019)	2019	Can secondary teaching graduates support literacy in the classroom? evidence from undergraduate assessments	Integrated Approach	Quantitative	393	Prospective Teachers
(Dickens & Lewis, 2018)	2018	The story maker: Helping 4-11 year olds to write creatively	Assessment	Qualitative	Access Not Provided	Access Not Provided
(Sural & Dedebali, 2018)	2018	A study of curriculum literacy and information literacy levels of teacher candidates in department of social sciences education	Curriculum Literacy	Scales, Quantitative	895	Prospective Teachers

(Hallman & Kindelsperger, 2018)	2018	Reconceptualizing curriculum, literacy, and learning for school-age mothers	Integrated Approach	Qualitative Action Research	Access Not Provided	Parents
(Rosa & Orey, 2015)	2015	A trivium curriculum for mathematics based on literacy, matheracy, and technoracy: an ethnomathematics perspective	Curriculum Literacy	Quantitative Scientific Advise	Access Not Provided	Historical Documents
(Duckworth & Brzeski, 2015)	2015	Literacy, learning and identity: Challenging the neo-liberal agenda through literacies, everyday practices and empowerment	Teacher and Student Relationship	Qualitative Action Research	2	Students
(Nsibande & Modiba, 2012)	2012	'I just do as expected'. Teachers' implementation of continuous assessment and challenges to curriculum literacy	Assessment	Quantitative Interview	Access Not Provided	Primary School Teachers
(Van Kraayenoord, 2012)	2012	Pedagogical practices for the development and improvement of reading	Education Policies	Literature Review	Access Not Provided	Curriculum Literacy Studies on Teachers and Students in Different Contexts
(White & Cranitch, 2010)	2010	Multigrade schools course with richness practices based activity theory effect on pre-service student teachers' self-efficacy	Various Disciplines in Literacy	Quantitative Questionnaire	105	Students
(M. Modiba & Van Rensburg, 2009)	2009	Cultural diversity in the classroom: Implications for curriculum literacy in South African classrooms	Cultural and Social Factors	Quantitative Scientific Advise	Access Not Provided	Access Not Provided
(M. M. Modiba & Odhiambo, 2008)	2008	Promoting nationhood through teaching: Fallacy or reality?	Cultural and Social Factors	Qualitative Action Research	1	History Teachers
(Miller & Satchwell, 2006)	2006	The effect of beliefs about literacy on teacher and student expectations: A further education perspective	Curriculum Literacy	Literature Review	Access Not Provided	Access Not Provided
(Spencer, 2005)	2005	Developing library classroom children's collections in English for a Catalunyan private school	Assessment	Qualitative Action Research	Access Not Provided	Access Not Provided
(Wyatt-Smith & Cumming, 2003)	2003	Curriculum literacies: Expanding domains of assessment	Education Policies	Quantitative Scientific Advise	Access Not Provided	Access Not Provided
(McGuinn, 2001)	2001	Snargets, mage-seamasters and englands of the mind	Education Policies	Literature Review	Access Not Provided	Access Not Provided

When the studies obtained were examined in detail, the following results regarding program literacy emerged. Program literacy is an important skill set that allows teachers to manage educational processes more effectively, use teaching materials more efficiently, and contribute more effectively to students' learning processes (Marek et al., 2024). This skill set covers not only the use of digital technologies, but also a broader area such as how to integrate curricula, how to manage teaching processes, and how to monitor students' development.

Research shows that there is a positive but weak relationship between teachers' digital technology usage skills and program literacy (Erik & Yilmaz, 2024). Teachers who are particularly familiar with digital technologies can integrate educational materials more effectively and interact more efficiently with students. However, the fact that this relationship is not strong reveals that the level of digital literacy needs to be increased and teachers need to adapt more to digital technologies.

The effect of curriculum literacy also shows itself in developing teachers' pedagogical skills and improving students' learning processes (Hallman & Kindelsperger, 2018). Teachers can provide more effective education to their students by understanding their curriculum better and using digital tools. This reveals that teachers can increase their students' success levels by improving their curriculum literacy. However, there is also an important relationship between the content of the curriculum and teachers' curriculum literacy. Teachers may have difficulty using digital tools in line with the curriculum. This shows that teachers need more support in creating content and developing pedagogical strategies (Lee, 2024). For education systems to keep pace with the digital age, they need to transform into a more innovative and technology-integrated structure (Kazu & Kaplan, 2025). Making the curriculum compatible with digital platforms can improve teachers' curriculum literacy and allow them to offer more creative solutions in educational processes. In addition, it has been found that teachers' skills in using digital educational materials are directly related to curriculum literacy (Nsibande & Modiba, 2012). The effective use of these materials contributes to the development processes of students as well as the pedagogical skills of teachers. The role of digital materials in education is important for teachers to use technological tools more effectively, and teachers learning how to use digital materials is a factor that improves program literacy.

DISCUSSION

This research, unlike other studies on curriculum literacy, focuses on digital literacy and interdisciplinary integration. Considering that previous studies (Drake et al., 2014; Çöğmen and Yılmaz Özelçi, 2024) generally focus on issues such as effective use of teaching materials and adaptation to individual needs of students, this study's focus on innovative themes such as digital transformation and artificial intelligence creates a significant difference. This different approach reveals the potential of curriculum literacy to adapt to changing educational dynamics.

The findings of the research obtained through thematic content analysis showed that curriculum literacy focused on digitalization and artificial intelligence integration, especially in the 2020-2025 period. This finding reveals that, despite the limited scope of previous studies focused on social sciences (Duckworth & Brzeski, 2015), it offers a broader perspective. This indicates that curriculum literacy should be addressed with an innovative and inclusive perspective in education.

From a methodological perspective, this study identified important trends in the development of curriculum literacy using thematic content analysis method. While other studies in the literature generally prefer quantitative approaches, this study provided an in-depth look at the subject by offering a qualitative perspective. This method offers significant added value for understanding the different dimensions of curriculum literacy. In addition, the study examined the global distribution of curriculum literacy and showed that intensive research in this area has been conducted in certain countries such as Australia, the USA and Turkey. However, the limited number of studies conducted in different geographies reveal that studies in this area should be addressed with a broader global perspective. This study has the potential to fill this gap with the findings it presents in the context of Türkiye.

Finally, this study highlighted the importance of considering curriculum literacy from an interdisciplinary perspective and suggested that more research should be conducted in different areas. In particular, the integration of digital technologies and artificial intelligence into educational programs suggests that curriculum literacy will be a critical area for future studies.

CONCLUSION

The research findings once again emphasize the critical role of curriculum literacy in educational processes. Curriculum literacy stands out as a basic skill set that allows teachers to use digital technologies and pedagogical strategies effectively. It has been demonstrated that this skill enables teachers to communicate more effectively with students and provide solutions appropriate to individual learning needs. Indeed, Özdemir and Kazu (2010)

revealed that university students have low levels of readiness in using basic information technologies, highlighting the need for these processes to be carefully monitored and supported.

The positive but weak relationship between digital literacy and curriculum literacy indicates that teachers' digital skills need to be developed. This situation reveals the importance of education policies providing teachers with more digital resources and training. In addition, adopting an interdisciplinary approach in the development of curriculum literacy will contribute to making educational processes more inclusive and effective.

The research suggested that curriculum literacy should be expanded outside of social sciences. Studies in different disciplines such as technology, engineering and art can provide a broader perspective on this field. This diversity will help to adapt educational programs to the needs of the age. Equity and inclusiveness in education stand out as an important factor in the development of program literacy. In particular, making educational programs for low-income students more equitable and inclusive is a critical step in spreading this skill. In this context, Teachers need to be further supported to improve their curriculum literacy.

In conclusion, this study reveals the critical role of curriculum literacy in education and its potential for development. Educational policies and practices should be rearranged to support the spread of this skill. In this way, teachers' pedagogical and digital skills can be improved and students can receive a more qualified education.

SUGGESTIONS

The emergence of curriculum literacy as a fundamental skill in teacher education reveals the necessity of teacher candidates receiving training on digital platforms and teaching materials. Such training will help teachers better embrace the digital transformation in education and provide the best education to their students. Student participation is also a factor directly related to curriculum literacy. By improving their curriculum literacy, teachers can encourage students to participate more actively in educational processes. This allows teachers to communicate more effectively with students and to be more involved in learning processes. Students taking an active role in education can be considered an indicator of curriculum literacy. Finally, there is a strong relationship between teachers' ability to use innovative teaching methods and curriculum literacy. By improving their curriculum literacy, teachers can create more creative and effective teaching strategies. This enriches students' learning experiences and ensures more effective results in education. Curriculum literacy is not only about the skills to use digital tools, but also a process that improves teachers' pedagogical skills.

Educators receiving training in curriculum literacy will enable teachers to play a more productive and effective role in education. As a result, curriculum literacy is a skill set that improves teachers' pedagogical and digital skills and is an important part of the transformation in education. This literacy will provide more effective results in education and help teachers manage their education processes more efficiently. Developing curriculum literacy will enable teachers to provide higher quality education to students and contribute to the digital transformation process in education.

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Through Project-based Learning to Discuss the Relations of Knowledge Absorptive Capacity, Listening, and Multiple Intelligence Acquisition

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Abstract
This study aimed to investigate the relationships between knowledge absorptive capacity, listening, and multiple intelligences. Data were collected and analyzed from 79 students at Tainan First Boys' School and Anping Junior High School. An experimental design was implemented, dividing participants into two groups: a didactic instruction group and a project-based learning (PBL) group. The findings revealed that students in the PBL group demonstrated significantly higher levels of knowledge absorptive capacity, listening skills, and multiple intelligences compared to those in the didactic instruction group. Furthermore, regression analyses confirmed the following relationships:

1. Knowledge absorptive capacity positively influences multiple intelligence acquisition—students with greater absorptive capacity are more likely to develop multiple intelligences through PBL.
2. Knowledge absorptive capacity enhances listening skills—students with a higher ability to absorb knowledge tend to be more engaged listeners in the classroom.
3. Listening skills facilitate multiple intelligence acquisition—students who actively listen in class are better able to develop multiple intelligences through PBL.
4. Listening serves as a mediating factor between knowledge absorptive capacity and multiple intelligences, reinforcing its crucial role in the learning process.

These findings provide empirical support for the effectiveness of PBL in fostering knowledge acquisition, active listening, and multiple intelligence development.

Keywords: knowledge absorptive capacity; listening; multiple intelligence; interdisciplinary curriculum; project -based learning

Introduction

Listening plays a crucial role in acquiring multiple intelligences, as it is fundamentally linked to knowledge absorptive capacity. However, in the cyber generation, where students are raised with mobile devices and an overwhelming amount of visual information, listening skills have been increasingly neglected. The dominance of audiovisual content not only fosters addiction to digital media but also diminishes students' natural ability to engage in active listening. Additionally, traditional spoon-feeding instruction (McKay & Kember, 1997) remains prevalent in Taiwan, where educators emphasize rote learning and repeated pen-and-paper tests to enhance students' exam performance. While this approach has been effective in improving test scores, it has simultaneously led to the gradual erosion of other essential competencies, particularly listening skills. Recent studies have shown that this teaching method is detrimental to meaningful learning (Gordon, Dehler, & Welsh, 2014). Neither the cyber learning environment nor conventional educational instruction places sufficient emphasis on developing students' listening abilities.

In response to these challenges, some scholars have advocated for the flipped classroom model, which has influenced many young educators to embrace student-centered learning. One of the most widely adopted student-centered pedagogies at the global level is Project-Based Learning (PBL). Designed to engage students in active learning, PBL encourages them to focus on completing projects through a combination of classroom study and teamwork. Barron et al. (1998) highlighted that PBL enables students to apply acquired knowledge to complete assigned tasks, thereby enhancing their practical skills and problem-solving abilities. The emergence of PBL (Barron et al., 1998) has provided valuable insights for students seeking real-world applications of their knowledge. Through project work, students not only enhance their listening skills and knowledge absorptive capacity but also develop multiple intelligences. Furthermore, PBL instruction facilitates the acquisition of practical knowledge by encouraging active engagement with real-world challenges (Edutopia, 2016).

Despite its benefits, PBL has its challenges, as team discussions often lead to conflicts and disagreements. To address these issues, this study incorporates Social Learning Theory and Promoter Theory. Social Learning Theory emphasizes how environmental and cognitive factors interact to shape learning and behavior, making it a useful framework for understanding team-based learning dynamics. Meanwhile, Promoter Theory suggests that heterogeneous expertise can be leveraged to drive innovation and overcome obstacles in the collaborative learning process.

In this study, PBL participants share their individual knowledge through absorptive capacity and apply listening skills to engage in team brainstorming and intensive discussions. These collaborative efforts enable them to develop feasible solutions for their assigned projects, demonstrating the practical benefits of PBL in fostering both cognitive and social competencies.

Literature Review

Theories

Project-Based Learning (PBL) is a student-centered pedagogy where students gain practical knowledge by actively exploring real-world challenges (Edutopia, 2016). According to Barron et al. (1998), PBL encourages students to complete assigned tasks by participating in specific activities or applying the knowledge they have acquired. This process aims to cultivate a variety of capabilities, including **designing, decision-making, autonomy, presentation skills**, and the ability to develop **real products** (Thomas, Mergendoller, & Michaelson, 1999). Blumenfeld et al. (1991) emphasized that the primary goal of PBL in schools is to help students acquire both intellectual knowledge and practical competencies during the process of completing assignments. In line with this, Maros, Korenkova, Fila, Levicky, and Schoberova (2023) confirmed the effectiveness of teaching **economics through Project-Based Learning**. The growing prevalence of PBL has sparked significant discussions about its role and impact on education (Almulla, 2020). While working in teams to complete projects, conflicts and disagreements are inevitable. To address these challenges, **Social Learning Theory** and **Promoter Theory** offer potential solutions. Social Learning Theory focuses on the continuous reciprocal interaction among **cognitive, behavioral, and environmental factors** and explores the connections between the **behaviors, attitudes, and emotional responses** of individuals (Bandura, 1977).

Promoter Theory consists of four types of promoters: **power promoters**, **expert promoters**, **process promoters**, and **relationship promoters**. **Power promoters** influence through hierarchical authority, while **expert promoters** contribute specialized knowledge (Witte, 1977). **Process promoters** focus on organizational expertise (Hauschildt, 1999), and **relationship promoters** engage in the integration of internal and external resources (Gemunden & Walter, 1995). In this research, **Project-Based Learning (PBL)** offers students increased opportunities to collaborate with peers. **Social Learning Theory** helps participants understand their teammates' **cognitive processes**, **attitudes**, and **emotional responses**. On the other hand, **Promoter Theory** supports team leaders in interdisciplinary teams by guiding them in recruiting the right mix of **heterogeneous specialists**. Through listening to diverse opinions and fostering close collaboration within teams, students not only enhance their **independent thinking** and **problem-solving skills** but also improve their **interpersonal abilities**.

In conclusion, the curricula that combine **Social Learning Theory**, **Promoter Theory**, and **PBL**, as proposed in this study, enable students to effectively improve their **knowledge absorptive capacity**, **listening skills**, and **multiple intelligences** through real-world practice, achieved by completing assigned projects.

Multiple Intelligence Acquisition

Gardner (1999) defined intelligence as a bio-psychological potential to process information and solve problems. Sternberg and Detterman (1986) stated that some scholars are fond of reasoning ability but others prefer examining behavioral functions. Even though Herrnstein and Murray (1994) indicated that intelligence quotient scores are positively correlated with measures of societal socioeconomic success. However, Gardner and Hatch (1989) argued that IQ tests, which rely on paper-and-pen examinations, can only evaluate competences in linguistic and logical-mathematical areas but not the competences related to thinking and learning. Gardner (1987) also stated that the purpose of schooling is to help people reach appropriate vocational goals corresponding with their specific intelligences in verbal-linguistic, musical-rhythmic, logical-mathematical, visual-spatial, bodily-kinesthetic, intrapersonal, interpersonal, and naturalist areas. Barrington (2007) stated that the concept of multiple intelligences, a term originated in the 1980s, has been implemented in some elementary and secondary schools. In addition, the U.S. Department of Labor (1991) suggests that mathematics, reading, writing, speaking, and listening are essential for students to function effectively in the workplace as well as to improve their capabilities in critical thinking, effective communication, and problem solving. Therefore, McKenzie (2005) suggested learners should have multiple intelligences in the competitive cyber age. Currently, the theory of multiple intelligences has been widely adopted by the education communities (Greenberg, Zheng, & Maloy, 2020). Besides, recently educational

policies in Taiwan have drastically changed from score domination to heterogenous literacy cultivation. Thus, we posited here that multiple intelligence is a viable educational perspective. In this study, we borrowed measurements of competitive competence (Wagner, 2010) to assess multiple intelligence. In the following sects, we will have further discussions on listening competence and knowledge absorptive capacity.

Listening Competence

Murphy (2020) argued that listening via the processes of participating, understanding, and connecting with others will guide people to gain success. Listening is the primary communication mode (Barker, Edwards, Gaines, Gladney, & Holley, 1980; Wilt, 1950) and skill (Wolvin & Coakley, 2012) by which to create well-rounded learners (McAnally, 2007) and acts as a crucial element in academic success (Wolvin & Coakley, 2012) and better job performance (Bitterly, Brooks, & Schweitzer, 2017). Volioti and Williamon (2020) depicted that listen competence could support students' learning through trial and error, enhance creative insight, and strengthen self-efficacy. Ramsey and Sohi (1997) argued that listening is categorized into three dimensions: sensing, proceeding, and responding (Comer & Drollinger, 1999), which they suggested are the most important factors in listening. Sensing not only involves hearing the actual words of the speaker, but also includes receiving nonverbal signals like body language and facial expressions (Wolvin & Coakley, 2012). Proceeding includes four stages: understanding, interpreting, evaluating, and remembering messages (Brownell, 1985) and focuses on organizing and transforming information into meaningful messages through simultaneous sequential activities. Finally, responding refers to signals sent and received by both speakers and listeners (Wolvin & Coakley, 2012). When speakers are assured that listeners have received their messages, they will continue to engage in further dialogue. Therefore, sound listening competence has to build on sensing, proceeding and responding. Other studies also indicated that listening is not only serving a key factor in academic success (Zahra & Gerard, 2002) but also has positive connections with students' knowledge absorptive capacity and multiple intelligence acquisition (Wolvin & Coakley, 2012). Therefore, we may reason that students' listening competence may serve as critical element to acquire multiple intelligences.

Knowledge Absorptive Capacity

Knowledge absorptive capacity serves as an important element in the acquisition of multiple intelligences. Cohen and Levinthal (1990) stated that knowledge absorptive capacity is constructed by cognitive, assimilation, and exploitative capacities. Meanwhile, absorptive capacity is depicted as the processes involved in knowledge acquisition, transformation, and exploitation (Zahra & Gerard, 2002). Prior studies have proven that knowledge acquisition helps students expand their new skills and new ideas related to existing knowledge (Davis & Linn, 2000). Shulman (1987) argued that developing content knowledge, identifying concepts, and reshaping teaching approaches maximize comprehensibility for learners. Adenfelt and Lagerström (2006) found that people who exploit their domain knowledge exhibit better performance. Schilling (1998) advocated that people with great absorptive capacity help expand heterogeneous knowledge. Cohen and Levinthal (1990) indicated that absorptive capacity is the most important pillar among innovative capabilities. Zahra and Gerard (2002) suggested that knowledge absorptive capacity, which is accumulated through learning experiences, can be exploited to develop innovative approaches and achieve better performance. Other studies had verified that effect of absorptive capacity and co-creation on innovation performance (Dahlin, Moilanen, & Pesämaa, 2019; Popescu, Ceptureanu, & Alexandru, 2019). Hence, technical capability development strongly relies on knowledge absorptive capacity. A detailed literature review will be discussed in the following pages.

Knowledge acquisition: Knowledge acquisition, which is one aspect of knowledge management, occurs as a result of meeting existing needs as well as identifying and exploiting existing knowledge assets to develop new opportunities (Quinstas, Lefrere, & Jones, 1997). Grant (1996) indicated that knowledge acquisition is an individual activity that can occur in a variety of ways (Almeida, Dokko, & Rosenkopf, 2003) such as through informal or formal collaboration. Acquisition refers to the capability of identifying and acquiring external knowledge in terms of intensity, speed, and direction (Zahra & Gerard, 2002). Thus, knowledge acquisition and application (Huber, 1991) have been regarded as measures of innovation (Fiol, 1996).

Knowledge transformation: Transformation is defined as supplementation of the existing knowledge base (Desforges, 2000). The processes of transformation relies on interactions with heterogeneous experts to develop additional knowledge (Muller & Zenker, 2001). People internalized the gained heterogeneous knowledge from internal and external sources via intensive social interaction (Nonaka & Takeuchi, 1995) to develop collective knowledge (Zahra & Gerard, 2002).

Knowledge application: Knowledge application, which is built based on prior knowledge, involves collecting and making use of information (Bij, Song, & Weggeman, 2003). Arygris and Schon (1978) argued that knowledge application utilizing 'plan-do-check-act' processes improves existing knowledge or leads to the development of innovative concepts. Additionally, Zahra and Gerard (2002) indicated that applying and integrating heterogeneous knowledge may lead to the development of new learning approaches. Thus, new knowledge absorptive capacity

in the context of this study includes *knowledge acquisition, transformation, and knowledge application.* The terms listening and knowledge absorptive capacity (KAC) may serve important factors to gain multiple intelligences.
In this paper, we first intend to explore the connections among knowledge absorptive capacity, listening, and multiple intelligence acquisition through the innovative curricula. Besides, we also plan to examine whether knowledge absorptive capacity, listening, and multiple intelligence acquisition exist differences between project-based learning and spoon-feeding instruction. Accordingly, some research questions were developed as follows:

1. Does Knowledge absorptive capacity have connections with multiple intelligence acquisition?
2. Does Knowledge absorptive capacity have connections with listening?
3. Does listening have connections with multiple intelligence acquisition?
4. Does listening serve as mediating effect between knowledge absorptive capacity and multiple intelligence acquisition?
5. Does project-based learning on students' listening enhancement increase exist difference comparing to spoon-feeding education?
6. Does project-based learning on students' knowledge absorptive capacity increase exist difference comparing to spoon-feeding education?
7. Does project-based learning on students' multiple intelligence acquisition exist difference comparing to spoon-feeding education?

Methodology

Case Introduction

Spoon-feeding education, a lateral teaching approach, focuses on instilling knowledge into students' blank mind. This instruction, which is lacked of opportunities to engage in communications and social interactions either with teachers or students, makes students feel bored in classroom learning. However, project-based learning grasps a great attention currently. It emphasizes learning by doing to complete assigned projects through teamwork. This study adopted project-based learning to teach students. The teacher in senior high school assigned his students to publish a book as their project; however, the other teacher in junior high school demanded her students to make microfilms instead. We expect that project-based learning make students feel comfortable and enjoyable in learning as well as improve their listening, knowledge absorptive capacity and multiple intelligences. The following sections will discuss research framework, operational definition, experimental procedures and samplings.

Curriculum design & teaching processes

The open interdisciplinary curriculum goal intends to support student to gain multiple intelligences as well as interpersonal skills through external resources (see figure 1). In order to achieve the curriculum goal of senior high school in this study, sub goals are required in the following four phases. At theme selection phase, students experienced the three different atmospheres in three types of shops and gave grades through the atmosphere for each shop. Then, choose the most favorable shops in the three different type ones as target shops for interview. At the icebreaker phase, through the process of persuading the participating owners to accept the interview invitations, it trained students to have skills of oral expression, icebreaker, and interpersonal communication. At the social interaction phase, it aims at improvements of listening skills, which includes sensing, proceeding, and responding. Through listening to the experiences of managing those shops, students had in-depth understandings from the owners' thoughts. Therefore, the interview results can be writing materials for the upcoming tour book. At the book writing and compiling phase, the focal points are organizing each article into a book, drawing skills, proofreading, and contacting with the publisher.

In order to finish assigned projects, students have not only to pay great attentions to listen advice from both teachers and teammates, but to complete outstanding contents as well. Students via listen have clear understanding of the gained knowledge. Then, they internalize the knowledge and transfer into individual knowledge. Through application of the existing knowledge on the assigned projects, students via learning by doing obtain practical multiple competencies in the real-world practice. In conclusions, this innovative curriculum is designed to help senior high school students not only enhance absorptive capacity and listening competence, but also gain multiple intelligences and interpersonal skills. The detailed information was shown in table 1.

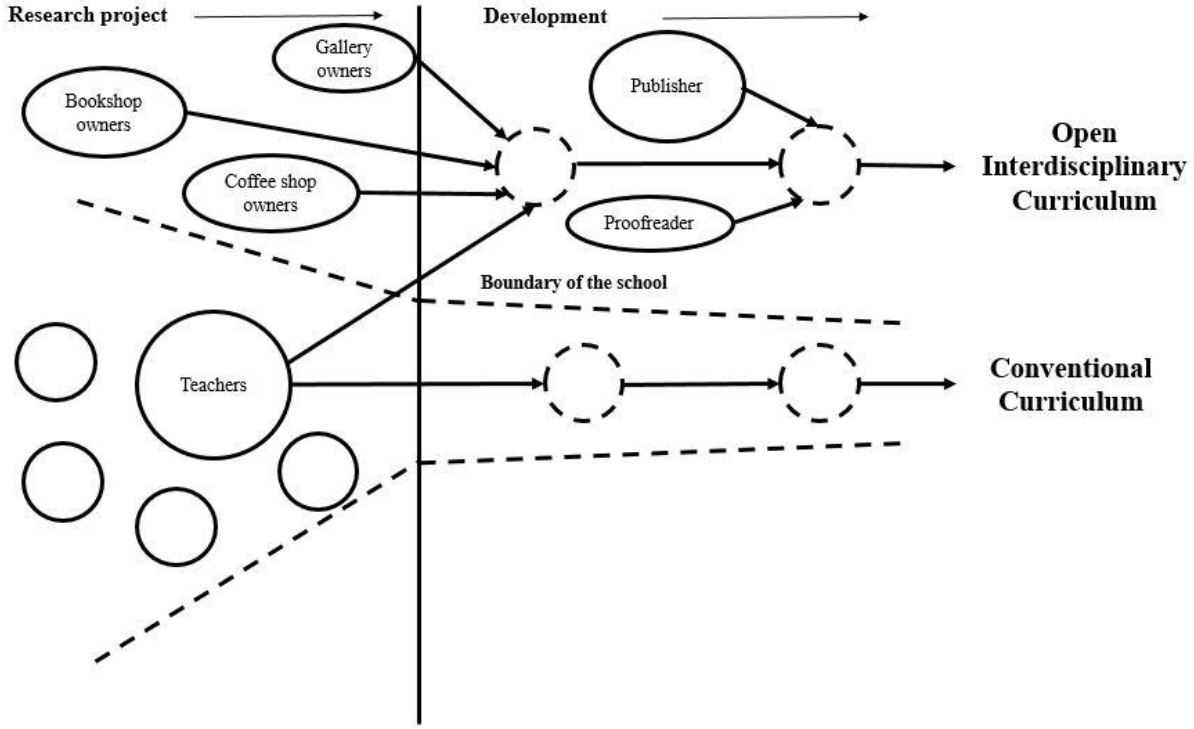

Figure 1. Open interdisciplinary curriculum design

Table 1. Curriculum & teaching design

Phases	**Curriculum goals/** *teaching approaches*
Tour study Phase	**Visiting galleries, bookstores, and coffee shops/** *writing materials* Team information searching Team critical thinking Team Knowledge absorptive capacity Team target shops selection through evaluations.
Icebreaker Phase	**Contacting with the owners of the target shops/** *Icebreaker* Oral expression skills Communication skills Interpersonal skills
Social interaction Phase	**Interviewing those owners/** *Question development &interview* Sensing skills Proceeding skills 0. Responding skills 1. Information analysis 2. Interpersonal skills
Book writing compiling Phase	**Completed a tour book/** *Book compiling* 3. Imagination 4. Cooperation 5. Writing skills 6. Adaptation 7. Problem-solving

Research framework, experimental procedures & samplings

Research framework: We adopted many measurements to examine the research framework. Song, Bij, and Weggeman (2005) developed knowledge application. Additionally, knowledge transferring and acquisition (Lane, Koka, & Pathak, 2006) were modified and developed. Furthermore, we took listening (Comer & Drollinger, 1999) as another measurement. Moreover, multiple intelligence adopted the items in competitive competence (Wagner, 2010) as measurements in this study. Consequently, we combined knowledge acquisition, transformation and application to develop knowledge absorptive capacity construct. Therefore, the entire framework was developed and shown on figure 2. Table 2 lists operational definition with detailed items of questionnaire *Samplings:* The selective sampling were students from Tainan first boy senior high school and Anping junior high school. Twenty-

five students are from Tainan first boy school and fifty-four students are from Anping junior high school. The sample size is seventy-nine students. *Experimental procedures:* Questionnaires were held to measure the changes in each construct in two different time phases and groups and to examine framework. Figure 3 is the pictures of the students participating in different activities through PBL.

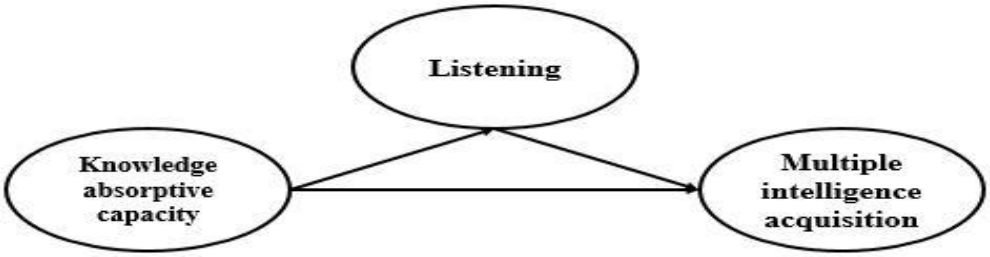

Figure 2. Research framework

Table 2. Operational Definitions of Constructs

Operational Definitions
Sensing: Sources: Comer & Drollinger (2005), seven-point Likert scale
EN 1. I am aware of what my teacher (teammates) imply but do not say.
EN 2. I sense how my teacher (teammates) feels.
EN 3. I listen for more than just the spoken words.
EN 4. I am aware of my teachers' (teammates') unique concerns
EN 5. I sense why my teachers (teammates) feel the way they do.
Processing: Sources: Comer & Drollinger (2005), seven-point Likert scale
RO 1. I assure teachers (teammates) that I will remember what they say by taking notes when appropriate.
RO 2. I keep track of points my teachers (teammates) make.
RO 3. I summarize points of agreement and disagreement when appropriate.
RO 4. I remember important details of previous conversations with my teachers (teammates).
RO 5. When I am not certain of the meaning of my teachers' (teammates') statements, I ask for clarification.
Responding: Sources: Comer & Drollinger (2005)), seven-point Likert scale
ES 1. I assure my teachers (teammates) that I am receptive to their ideas.
ES 2. I show my interest by asking questions or using probes to gain more information and to clarify points.
ES 3. I ask questions that show my understanding of my teachers' (teammates') positions.
ES 4. I show my teachers (teammates) that I am listening by my body language.
Knowledge acquisition: Sources: Lane et al., (2006), seven-point Likert scale
A 1. I gain knowledge easily from classroom lecturing.
A 2. I gain skills in a limited time.
A 3. I gain knowledge through community resources.
Knowledge transformation: Sources: Lane et al., (2006), seven-point Likert scale
T 1. I classify the learned knowledge.
KT 2. I improve my competence of knowledge absorption through constant practices.
T 3. I have the ability to modify the learned knowledge.
Knowledge application.: Sources: Song et al., (2005), seven-point Likert scale
AP 1. I will apply the learned knowledge to the assigned projects.
AP 2. I will use the learned knowledge to solve problems.
AP 3. As soon as I learned new knowledge, I will try to use it to the assigned projects.
AP 4. I review the learned knowledge and make sure it is applied to the assigned projects.
Multiple intelligence acquisition: Sources: Wagner (2010), seven-point Likert scale
II 1. Independent thinking & problem solving.
II 2. Cooperation.
II 3. Environmental adaptation.
II 4. Creativity.
II 5. Oral expression and writing skills.
II 6. Playing the digital orchid game can be an interface leading to interactions among people.
II 7. Information collection and analysis.

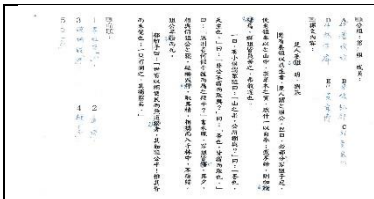	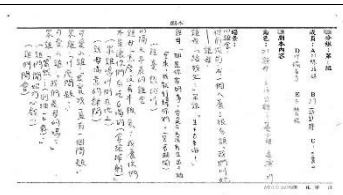	
Group study in reading	Team playwriting	Team brainstorming
		
Narrating	Role play	Film
		
Gallery	Department store	bookstore
		
Tainan Leisure map	A picture of authors	Autograph session

Figure 3. Pictures of the students participating in different activities through PBL

Results and Analysis

Validity and Reliability (EFA)

Some criteria for validity and reliability are given as follows: KMO >0.5, communality >0.5, eigenvalue >1, factor loading >0.6, Cronbach's alpha > 0.7, and item-total correlation >0.6. The six items measuring multiple intelligence have factor loadings of 0.89, 0.93, 0.89, 0.83, 0.88 and 0.90 (α=0.94). Listening comprising sensing, proceeding, and responding is determined based on the literature. The three items assessing sensing have factor loadings of 0.88, 0.89 and 0.89 (α=0.87). The five items measuring proceeding have factor loadings of 0.85, 0.89, 0.91, 0.88 and 0.77 (α=0.90). The four items assessing responding have factor loadings of 0.91, 0.91, 0.90 and 0.88 (α=0.92).

Knowledge absorptive capacity comprised knowledge transformation, acquisition and application. The three items assessing knowledge transformation have factor loadings of 0.93, 0.94, and 0.92 (α=0.92). The three items measuring knowledge acquisition with factor loadings of 0.89, 0.84 and 0.79 (α=0.79). The four items assessing knowledge application with factor loadings of 0.81, 0.85, 0.89 and 0.80 (α=0.86).

Finally, the three items assessing listening have factor of loadings of 0.89, 0.91 and 0.89 (α=0.88). The three items measuring knowledge absorptive capacity have factor loadings of 0.90, 0.88 and 0.87 (α=0.86). The detailed figures show on table 3.

Table 4 shows the detail information of validity and reliability. The values of convergent validity were 0.92, 0.91 and 0.95, while those of AVE were 0.80 0.78 and 0.78. These are all higher than the criteria for composite reliability and average variance, which are 0.6 and 0.5 (Fornell, 1981), respectively. Hair argued that the square root of AVE

should be at least 75% higher than the correlation coefficients among the constructs (Hair, Anderson, Tatham, & Black, 1998). The square roots of AVE values were 0.89, 0.88 and 0.88, and thus met the criterion, as shown on Table 3, and so the constructs showed good discriminant validity.

Table 3. Validity and Reliability

Construct	Items	Factor Loading	α	CR	AVE
Listening	LS1. Sensing.	0.89	0.88	0.92	0.80
	LS2. Proceeding.	0.91			
	LS3. Responding.	0.89			
Knowledge Absorptive capacity	KM1. Knowledge acquisition.	0.90	0.86	0.91	0.78
	KM2. Knowledge transformation.	0.88			
	KM3. Knowledge application.	0.87			
Multiple intelligence	MI1. Independent thinking & problem solving.	0.89	0.94	0.95	0.78
	MI2. Cooperation.	0.93			
	MI3. Environmental adaptation	0.89			
	MI4. Creativity.	0.83			
	MI5. Oral expression and writing skills.	0.88			
	MI6. Information collection and analysis	0.90			

Table 4. Discriminant validity

	Listening	Knowledge absorptive capacity	Multiple intelligence
Listening	(0.89)		
Knowledge absorptive capacity	0.72***	(0.88)	
Multiple intelligence	0.76***	0.69***	(0.88)

Analysis of Listening

Table 5 shows the descriptive statistics and results of the independent samples t test for the learners' listening in class. The mean values in the questionnaire were 5.49 and 6.64 respectively for the adopting project-based learning, and 4.52 and 5.64 for the students adopting spoon-feeding education. The results of the independent samples t test show that significant effects are found for listening ($t=4.26$, $p<0.001$) and ($t=2.81$, $p<0.01$). This suggests that project-based learning could help the students to enhance listening more than spoon-feeding education is able to.

Table 5. Descriptive Data and T Test Results of listening in two different school students

Experiment design (junior high)	N	Mean	SD	Std. error	t
Spoon-feeding education	54	4.52	0.98	0.13	4.26***
Project-based learning	54	5.49	0.84	0.16	
Experiment design (senior high)					
Spoon-feeding education	25	5.64	1.36	0.34	2.81**
Project-based learning	25	6.64	0.38	0.096	

Analysis of knowledge absorptive capacity

Table 6 shows the descriptive statistics and results of the independent samples t test for the learners' knowledge absorptive capacity. The mean values in the questionnaire were 6.57 and 5.50 respectively for the adopting project-based learning, and 5.90 and 4.73 for the students adopting spoon-feeding education. The results of the independent samples t test show that significant effects are found for listening ($t=2.05$, $p<0.05$) and ($t=3.54$, $p<0.001$). This suggests that project-based learning could help the students to increase knowledge absorptive capacity more than spoon-feeding education is able to.

Table 6. Descriptive Data and T Test Results for knowledge absorptive capacity in two different school students

Experiment design (junior high)	N	Mean	SD	Std. error	t
Spoon-feeding education	54	5.90	1.17	0.29	2.05*
Project-based learning	54	6.57	0.56	0.14	
Experiment design (senior high)					
Spoon-feeding education	25	4.73	0.94	0.12	3.54**
Project-based learning	25	5.50	0.80	0.16	

Analysis of multiple intelligences

Table 7 shows the descriptive statistics and results of the independent samples t test for the learners' multiple intelligence acquisition. The mean values in the questionnaire were 6.81 and 5.87 respectively for the adopting project-based learning, and 5.29 and 5.00 for the students adopting spoon-feeding education. The results of the independent samples t test show that significant effects are found for listening (t=5.49, p<0.001) and (t=3.86, p<0.001). This suggests that project-based learning could help the students to acquire multiple intelligences more than spoon-feeding education is able to.

Table 7. Descriptive Data and T Test Results for multiple intelligence in two different school students

Experiment design (junior high)	N	Mean	SD	Std. error	t
Spoon-feeding education	54	5.29	1.05	0.26	5.49***
Project-based learning	54	6.81	0.34	0.08	
Experiment design (senior high)					
Spoon-feeding education	25	5.00	0.98	0.13	3.86***
Project-based learning	25	5.87	0.83	0.16	

Results and Research Model

The criteria for the good model fit of structural equation models are as follows: CMIN/DF=2.03, NFI= 0.88, RFI= 0.85, IFI=0.93, TLI=0.91 and CFI=0.93. The VIF values of the model were below 10, which show there were no issues related to multicollinearity. With regard to the hierarchical regression, we first examined the relationship between knowledge absorptive capacity and multiple intelligences. The results show that the more knowledge absorptive capacity students possess, the easier they will acquire multiple intelligence (β=0.14，p>0.05). Second, we examined the relationship between knowledge absorptive capacity and listening. The results showed that the more knowledge absorptive capacity students need, the greater listening they have to possess while teachers are lecturing (β=0.86，p＜0.001). Third, we examined the relationship between listening and multiple intelligences. The results demonstrated that the greater listening students possess in class, the easier for them to acquire multiple intelligence (β=0.66，p＜0.001). The resulting framework is shown in Figure 4.

Finally, we also examined the mediation effect of knowledge absorptive capacity, listening and multiple intelligences. First, the results show that knowledge absorptive capacity has a positive influence on the multiple intelligence (β=0.70, p＜0.001). Second, knowledge absorptive capacity when supported by listening has a positive influence on the multiple intelligence acquisition (β=0.32, p＜0.01), (β=0.54, p＜0.001) as shown in Table 8. Third, knowledge absorptive capacity has a positive influence on listening (β=0.72, p＜0.001) as shown in Table 9. These values meet the requirements of partial mediation (Baron & Kenny, 1986). Thus, the results indicate that listening acts as a role of mediator between knowledge absorptive capacity and multiple intelligence acquisition.

Table 8. Regressions of knowledge absorptive capacity and listening with regard to multiple intelligences

		Multiple intelligence
Intercept	***	
Knowledge absorptive capacity	0.70***	0.32**
Mediator		
Listening		0.54***
Adjusted R^2	0.48	0.61
R2 Change	0.48***	0.62***

Note: *p＜0.05, **p＜0.01, ***p＜0.001

Table 9. Regressions of knowledge absorptive capacity on listening

	Listening
Intercept	***
Knowledge absorptive capacity	0.72***
Adjusted R^2	0.52
R^2 Change	0.52***

Note: *p＜0.05，**p＜0.01，***p＜0.001

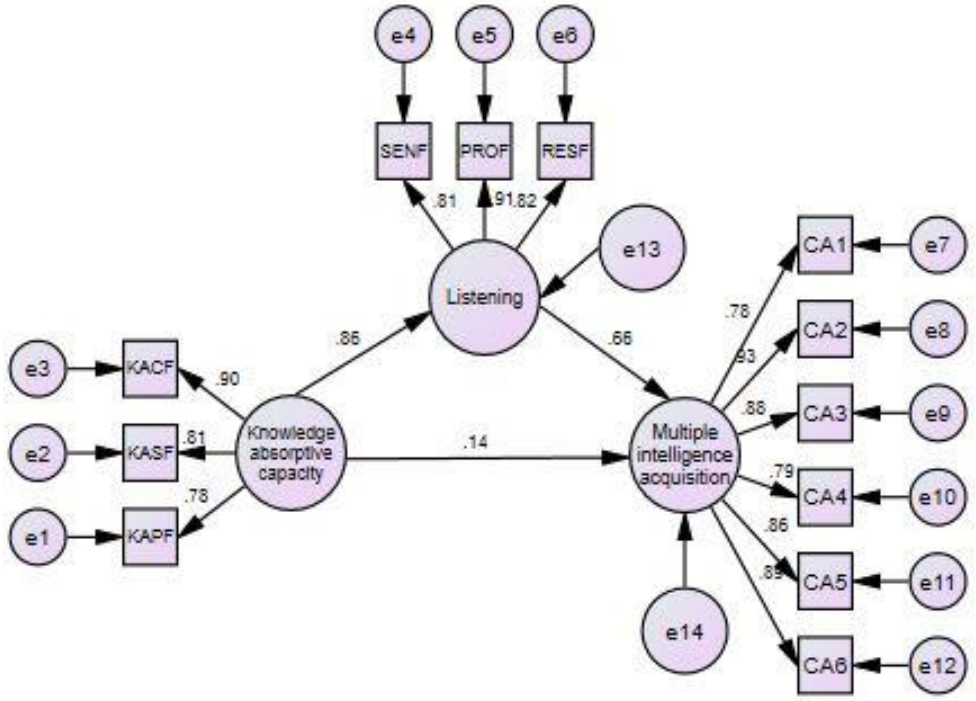

Figure 4. Research framework

Conclusions and Discussions

This research identifies two key contributions. First, it develops interactive curricula that integrate project-based learning, drawing upon the principles of social learning theory and the role of a facilitator. The curricula include two case studies: one designed for junior high school students and the other for senior high school students. In the junior high curriculum, the teacher presents an ancient Chinese story about bullying and then assigns students, working in teams, to write scripts and produce microfilms as their final projects. For senior high school students, the curriculum involves collaborative writing, where participants co-author a tourist guidebook. The ultimate goal of this project is to publish the **Tainan Leisure Map**. Second, the curricula have positively influenced students' attitudes and behaviors. Specifically, they have enhanced students' listening skills, improved their ability to absorb and retain knowledge, and fostered the development of multiple intelligences.

The influence of listening on Project-based learning

A project-based learning (PBL) approach, in which students complete assigned projects, has been shown to enhance their attention to classroom instruction and engagement in discussions with peers. The process of completing assigned projects requires active listening, which is essential for effective learning. Listening in this context consists of three stages: sensing, processing, and responding. From the sensing perspective, students must interpret meanings, emotions, and body language through continuous communication with their teachers. In the processing stage, students need to confirm, comprehend, adapt, and retain key concepts introduced in class. Additionally, teammates must share their individual knowledge and integrate it into structured, modular knowledge. Finally, in the responding stage, students must propose feasible solutions to their assigned projects and complete them. The case study involving senior high school students illustrates the role of listening at each stage of project-based learning. The process begins with team formation and task division. Next, team members engage in information gathering relevant to their assigned tasks. They then share findings and engage in discussions, which may involve developing interview questions, drafting written materials, creating illustrations, and refining the layout of their project. Following this, students compile the final product and seek feedback from their advisor. Lastly, they publish the book and engage in marketing efforts at bookstores. The detailed process is illustrated in Figure 5. To navigate challenges at each stage, participants must become skilled listeners. In conclusions, we argue that the structured process of sensing, processing, and responding fosters students' listening competence. Understanding people's emotions, habits, and motivations requires extensive listening, making it the most effective and efficient tool for comprehending interpersonal interactions, individual motivation, and decision-making tendencies. Thus, listening plays a crucial role in project-based learning. These findings align with previous research (Blumenfeld et al., 1991; Comer & Drollinger, 1999; Gardner, 1983). Table 10 illustrates the acquisition of diverse competencies through the processes of sensing, processing, and responding.

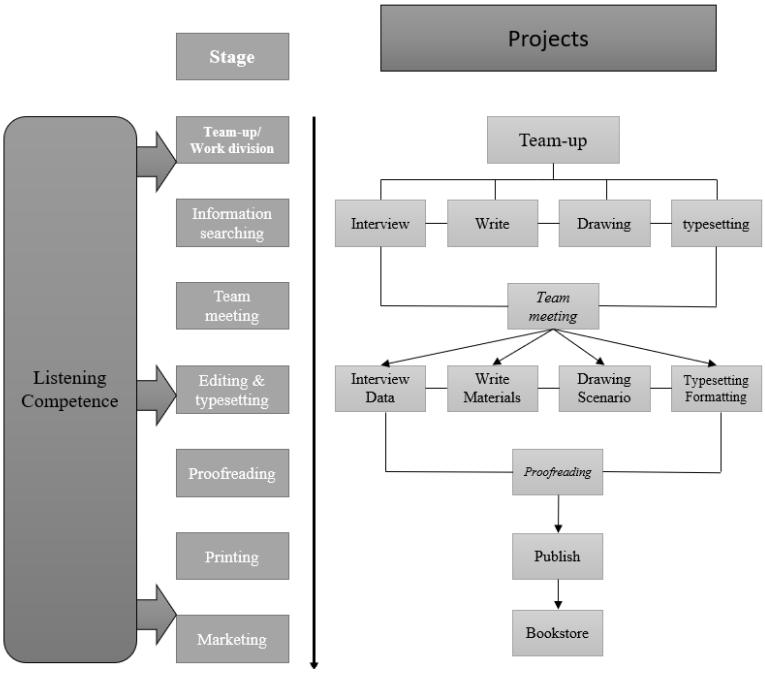

Figure 5. The processes of writing a book named Tainan leisure map

Knowledge absorptive capacity & multiple intelligence acquisition

The innovative curriculum has been validated as an effective approach for enhancing students' knowledge absorptive capacity and fostering the development of multiple intelligences. From the perspective of knowledge absorptive capacity, participating students acquire fundamental knowledge—such as interviewing techniques, writing skills, and artistic concepts—through formal classroom instruction. Additionally, they deepen their domain-specific knowledge through informal activities, engaging in intensive interactions with their peers. Through team brainstorming, students internalize existing knowledge and generate new insights, such as refining written materials and improving image editing techniques. They then integrate individual contributions into modular knowledge, applying these insights to complete a tourism guidebook. Finally, students negotiate with publishers to print the book and organize an autograph session. Completing this project significantly enhances students' ability to acquire, transform, and apply knowledge, thereby improving their overall absorptive capacity. Figure 6 presents detailed information on this process.

From the perspective of multiple intelligence acquisition, developing practical competencies depends on the processes of knowledge acquisition, transformation, and application in real-world contexts. In the case of the senior high school project, students demonstrate a willingness to listen to their teammates' ideas, reinforcing their ability to collaborate effectively. Additionally, Promoter Theory enables team members to leverage their strengths in different roles, including expertise, leadership, relationship-building, and process management. Furthermore, the implementation of the PDCA (Plan-Do-Check-Act) cycle allows students to iteratively refine their project, including outlining and structuring content, formulating interview questions, improving writing and photography skills, designing page layouts, and coordinating with printers to publish the Tainan Leisure Map. Figure 7 illustrates the relationship between multiple intelligence acquisition, knowledge absorptive capacity, and the listening process, while Table 11 compares the stages of sensing, processing, and responding in two different schools. The innovative curriculum fosters students' functional competencies, including independent thinking, problem-solving, adaptability, creativity, oral communication, writing proficiency, and information collection and analysis. Additionally, teamwork processes enhance students' interpersonal skills, such as cross-disciplinary communication, cooperation, and collaboration. The results are presented in Tables 12 and 13. These findings align with prior research (Wagner, 2010; Zahra & Gerard, 2002).

In conclusions, this study provides empirical evidence that project-based learning (PBL), when integrated with social learning theory, is more effective than traditional lecture-based (spoon-feeding) education in enhancing students' knowledge absorptive capacity, listening skills, and multiple intelligence acquisition at both the junior and senior high school levels.

Three key contributions emerge from this research:

1. Effectiveness of PBL: PBL has been demonstrated as an efficient teaching approach for fostering students' practical skills and multiple intelligences.
2. Development of π-Shaped Talents: PBL not only improves students' knowledge absorptive capacity and listening competence but also cultivates learners into π-shaped talents—individuals with both deep expertise in specific areas and broad interdisciplinary knowledge.
3. Moderating Role of Listening: Listening serves as a crucial moderating factor in the learning process, facilitating knowledge acquisition and application.

Limitation

This study acknowledges two primary limitations: sample size and the inherent challenges of Project-Based Learning (PBL). First, the sample size consists of only seventy-nine students from two different schools. To enhance the generalizability of the findings, we plan to expand the study by inviting additional schools to participate in future research. Second, while PBL is an effective and engaging teaching method, it presents several challenges. The following are five common limitations:

1. **Time-Consuming**: Implementing PBL requires substantial time for planning, execution, and reflection, making it difficult to integrate into tightly structured curricula.
2. **Resource-Intensive**: Successful PBL often necessitates a variety of resources, including materials, technology, and specialized tools, which may not be readily available in all educational settings.
3. **Challenges for Certain Learners**: Some students, particularly those who require additional support, may experience confusion or anxiety in a PBL environment, making it difficult for them to thrive.
4. **Teacher Training Requirements**: Educators may need specialized training and ongoing support to effectively implement PBL, which can be a barrier to its widespread adoption.
5. **Group Work Challenges**: PBL frequently involves collaborative learning, which may lead to conflicts among students or issues related to unequal participation, such as free-riding.

Despite these challenges, experienced educators who effectively design and implement PBL can foster active student engagement and enhance learning outcomes.

Future research

Future studies should focus on increasing the sample size and addressing the shortcomings of Project-Based Learning (PBL). First, experimental education schools in Taiwan have been rapidly expanding. In 2016, only sixty schools adopted experimental education; however, by the end of 2024, this number has grown to 250. Principals and teachers in these schools are highly supportive of project-based learning, as it enables students to apply classroom knowledge to real-world competencies through hands-on projects. Common themes explored in these projects include environmental protection, marine ecosystems, local culture, technology, and food and agriculture. To further our research, we plan to collaborate with faculty members in these schools to gain a deeper understanding of their programs. Through their participation, we anticipate achieving a larger sample size in future studies. Second, to address the challenges associated with PBL, we propose several improvements. These include designing new PBL curricula that can be implemented within limited timeframes, preparing teaching materials in advance, providing additional support for slow learners, encouraging teachers to participate in professional development training, and establishing peer assessment mechanisms to enhance collaborative learning.

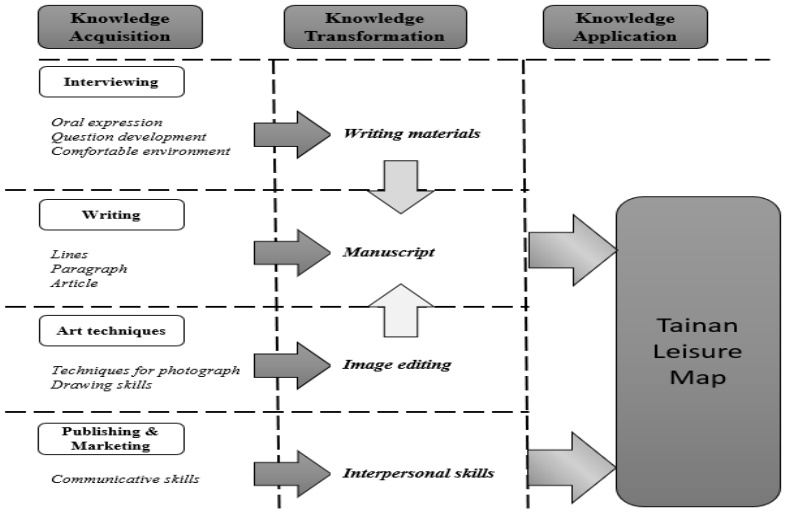

Figure 6. The processes of completing a book, Tainan Leisure Map, via knowledge absorptive capacity

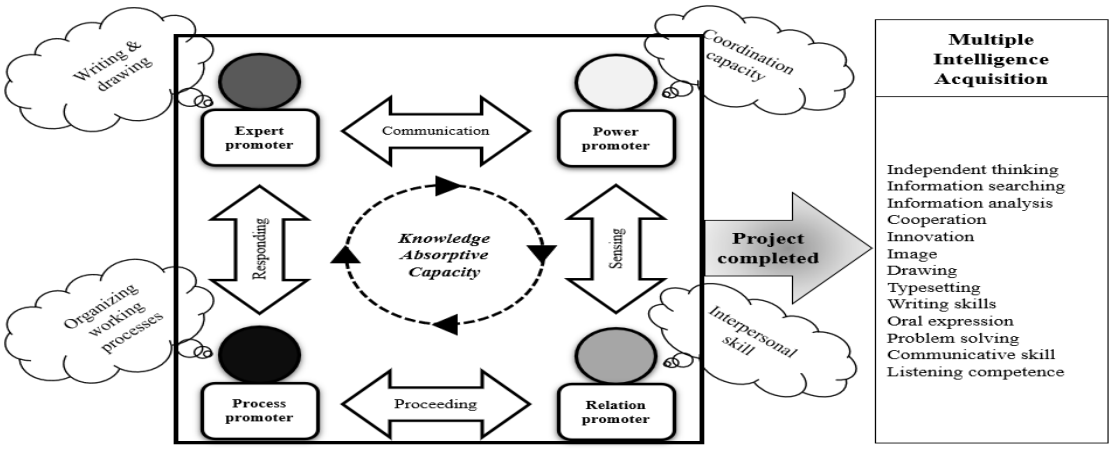

Figure 7. Connections of knowledge absorptive capacity, listening, and intelligence acquisition

Table 10. The process of sensing, proceeding and responding in two different schools

Listening Competence Training in Project-based Learning				
Curricula	**Goal**	**Sensing**	**Proceeding**	**Responding**
Chinese Class **Junior High school** **High School**	**Make micro-films** **Publish a book**	***Competence*** ● Self-awareness ● Perspective taking ● Emotional regulation ● Affective response ● Empathetic attitude	***Approaches*** ● Taking notes ● Refresh the important ideas ● Agreement and disagreement summary ● Memorizing the previous conversations ● Keeping asking questions	***Feedback:*** ● Receiving other ideas ● Probe information ● Emotional expressions ● Body language

Table 11. The process of knowledge absorptive capacity in two different schools

Knowledge Absorptive Capacity Training in Project-based Learning				
Curricula	**Goal**	**Knowledge Acquisition**	**Knowledge Transformation**	**Knowledge Application**
Chinese Class in Junior High School	***Make micro-films***	***Single knowledge*** ● Listening ● Bullying stories ● Image ● Independent thinking ● Oral expression ● Writing skills ● Use shooting software ● Virtual platform	***Module knowledge*** ● Write a short story ● Acting ● Film editing ● Oral presentation ● Interpersonal skills ● Managing Facebook	***System knowledge:*** *(Completing projects):* ● **Make Bullying films**
Chinese Class In Senior High School	***Publish a book***	***Single knowledge*** ● Listening ● Understand owners' expertise ● communicative skill ● Interview draft ● Independent thinking ● Problem solving ● Oral expression ● Writing skills ● Oral expression ● Information collection & analysis ● Virtual platform	***Module knowledge*** ● Interdisciplinary knowledge ● Diverse life experiences ● Interpersonal skills ● Creativity ● Writing skills ● Oral presentation ● Autograph session ● Managing Facebook	***System knowledge:*** *(Completing projects):* ● **Tainan leisure map (a book)**

Table 12. Results of multiple intelligence acquisition for senior high students

Multiple Intelligence	Tainan Leisure Map	Remarks
Independent thinking	● How to start writing ● content integral	*The plot of Tainan leisure map*
Problem solving	● Communicative & collaborative skills ● Competence in knowledge integration ● Interdisciplinary competence Acquisition	*Proofread* *Contact with bookstores & printers* *Publish Tainan leisure map*
Cross-field cooperation	● Booksellers ● Printers ● Tainan Education Bureau ● Primary schools in Tainan city ● Bookstores, Art Exhibition and Coffee & tea shop owners	*Collaboration with the supply chain*
Environmental adaptation	● Trends of Leisure tourism	*Aware of environmental changes*
Creativity	● Literary writing ● Interdisciplinary learning ● Modularization	*Observation from different angles*
Oral expression	● Final presentation ● Autograph session ● Forum ● Writing experience sharing	*Communicative skills* *Knowledge & experience sharing*
Writing skills	● Written report ● Tainan leisure map	*Polishing writing skills*
Information collection & analysis	● Interview owners ● Experience the philosophy of life ● Draw a downshifting Tainan map	*Understand where to find the information*

Table 13. Results of multiple intelligence acquisition for junior high students

Multiple intelligence	Making Micro films		Remarks
Independent thinking	Story planning Showing the short films Film editing skill	Scenario development Film shooting Uploading the film -loading	*Showing the short film*
Problem solving	Peer communication and collaboration Knowledge sharing and integration	Acting Film shooting and editing	*Completed short film*
Cross-field cooperation	Story writing Film shooting and editing	Acting skills Up-loading to YouTube	*External resource cooperation*
Environmental adaptation	Acute environmental observation Follow the latest editing software	Film editing Popular platform	*New generation preference*
Creativity	Directing plays based on literature Team work project	Training the imagination Interdisciplinary learning	*Innovative teaching approach*
Oral expression	Final exam presentation Personal expressions	Teamwork Communication Acting	*Fluent and logical oral presentation*
Writing abilities	Rough draft Pictures, stories, books	Assignment (film shooting) Report writing	*Text polishing abilities*
Information collection & analysis	Reading other classical literature Sharing life experiences with peers	Teacher instructions Film shooting and editing	*Expert, book, and online world knowledge*

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