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A Meta analysis of the Cognitive Effects of Short Video Platforms on Piano Learning Among First-Time Users of Different Age Groups and Genders in Non-First-Tier Cities

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ABSTRACT

The emerging short-form video platforms are growing tremendously and becoming a leading social media and communication strategy. The characterization of these platforms, such as brevity, personalization, and multimodal communication, has made them a pervasive educational tool. The advent of short-form video platforms such as TikTok, Instagram, and YouTube Shorts has played a significant role in digital learning methodologies, especially in music education. These platforms facilitate learning by breaking down complex concepts into easily digestible visual narratives, leveraging interactive engagement and participatory culture. This paper presents a meta-analysis investigating both the cognitive and communication effects of short video platforms on piano learning among first-time users of various age groups and different genders located in non-first-tier cities. The research employs a systematic literature review and meta-analytical approach to evaluate how variables such as age, gender, and geographical context influence cognitive learning outcomes and communication-driven learning efficiency. Results indicate that short video platforms can positively affect cognitive functions related to piano learning while also reshaping communication dynamics through visual storytelling, real-time feedback, and participatory engagement. Variations in cognitive retention and communication preferences were observed across different demographics. This paper contributes to knowledge on short video platform learning by examining its impact on both cognitive and communication aspects and offers insights for content creators, educators, and policymakers in optimizing short video platforms for effective piano instruction and interactive learning across diverse groups and demographics.

Keywords: Short Video Platforms, Piano Learning, Cognitive Effects, Age groups, Gender.

INTRODUCTION

The digital evolution has transformed how we approach education and skill acquisition with short video platforms such as TikTok, YouTube shorts and Instagram. However, the impact on specialized skills acquisition such as piano learning, remains under explored (Ma, Sun, X. Guo, Lai, & Vogel, 2012). This research is based on first time learners of piano in non-first tier cities where convenience to formal music education is often limited. Piano learning traditionally requires structure, long term commitment and in person instructions. But short form video platforms benefit the learners by providing accessibility and flexibility and also breakdowns the complex concepts into manageable segments (T. Zhang, 2020). These make it easier for learners to grasp the basics of piano learning in a more convenient way in their busy schedule. However, the cognitive effects of these platforms among diverse demographic groups influence skill acquisition and retention to learn complex segments by breaking them down into smaller segments (Xiong, J. Chen, & Yao, 2024). The research performs meta-analysis of existing research to evaluate these cognitive effects of short video platforms on first time learners of piano learning among users from different age, gender and demographics of non-first tier cities. This helps to identify patterns that can inform the design of future educational content.

Along with the skills gap between industries, a significant focus has been laid on how education can evolve in order to meet the skill acquisition needs of individuals in the workplace6(Young & Y. T. Wu, 2019; Li, 2016). Although these platforms are known for their brevity and personalization, their effect on specialized skills, such as learning to play the piano, is an underexplored topic. Rooted in three foundational theories—Uses and Gratifications Theory, Media Dependency Theory, and Diffusion of Innovations Theory—this study investigates the cognitive outcomes of media consumption on such platforms.

Uses and Gratifications Theory emphasises on how and why people use certain media to meet their own needs, whether that be a need for entertainment, for information or for socialising. This theory is especially pertinent for understanding how learners use short video platforms to satisfy their learning needs (Yuan, Xia, & Ye, 2022). For instance, while younger learners may gravitate toward gamified content for both educational and entertainment purposes, adults may prefer structured, step-by-step tutorials to master a specific learning goal.

The dependence on short video platforms is also further contextualized with the Media Dependency Theory, which states that users have a relationship with the media in which it fills users' needs for guidance on the topic of interest (Zijian, 2022; Hash, 2021; Cui, 2023) (tend to participate consistently); especially given that most non-first tier cities have limited choices for formal music education. This makes these platforms indispensable for first-time piano learners as there isn't much of traditional teaching resource to depend on.

Differentiating on age, accessibility, et cetera, Diffusion of innovations theory accounts for how different groups of learners adopt new technologies e.g. short video platforms (Williams & Hodges, 2023). The theory provides insight into why younger learners are early adopters of these platforms, and why older learners and those in rural contexts may experience barriers to adoption.

Moreover, short video platforms such as TikTok, Instagram Reels, and YouTube Shorts have also become vehicles of a type of educational innovation, even as they represent the shaping and reshaping of the dynamics of digital communication itself (X. Cheng, Su, Yang, Zarifis, & Mou, 2023; Lin, Y. Chen, & L. Zhang, 2022).

By utilizing visual storytelling, interactive features, and algorithmic personalization, these platforms enable multimodal forms of knowledge-sharing. Short-form videos increase engagement by combining text, imagery, sound, and animation, which is beneficial as it caters to various learning styles and sensory preferences. This approach to knowledge sharing allows users to process complex ideas more quickly and with higher retention rates. Additionally, the comments, likes, and real-time feedback functions make for a particularly engaging learning environment, allowing users to ask questions, seek for clarifications, and interact with not only their instructors but also their peers. Algorithmic personalization guarantees that a student receives educational materials consistent with their interests and that incremental skill acquisition remains feasible, maximizing the relevance of content exposure. Their adoption is representative of bigger communication trends, such as the mobile-first content and participatory media culture. With the dominance of mobile devices for media consumption, users expect content that is presented according to accessible and easy-to-use best practices. Short video platforms deliver this in a bite-sized, on-the-go learning opportunities catered to the fast-paced world of learning today. These platforms are characterized by their participatory nature, which creates a sense of community and co-creation of knowledge, as users contribute by creating, sharing, and reacting to content. Based on your academic performance and requirements, Education distribution goes beyond the traditional classroom to empower peers in a different way.

While cognitive aspects matter, short video platforms have played a huge role in shaping the communication landscape of digital learning. These platforms specially allow the learners to connect dynamically via real time comments, discussion directories and collaborative learning with peers, that generates the cooperative learning atmosphere. Nothing more of the one-way learning mode, we communicate ideas, share progress, give feedback through short videos. Individualized algorithmic endorsement augment communication as they filter information matching to learners' requirements, enabling more constructive interaction with instructions content. This transition underscores the significance of digital communication in facilitating knowledge retention, social learning, and engagement, positioning short video platforms as not merely educational tools, but centralized spaces for collaborative learning experiences.

Problem Statement

The boom of short video platforms varied in success (Dawen, 2023), but tools such as YouTube Shorts, Instagram Reels and TikTok revolutionized skills learning and education Chen, Du, & and K. Zhu, 2024), especially in the field of music learning. These ecosystems compress intricate lessons into bite-sized, aesthetically captivating packages, making it an appealing option for first-time learners of piano. However, we know little about the cognitive effects of these platforms on the retention of skills, memory and problem-solving — all of which are essential for learning a complex skill like piano (M. Cheng, Y. Zhang, & W. Zhang, 2024). Age, gender, and socioeconomic conditions are other demographic factors providing more complexity to learning outcomes. Younger users may prefer gamified, interactive learning content (Adelantado et al, 2019), while older users experience pacing and technical barriers to learning. These gender differences also reflect learning, as male users tend to have advantage in retaining technical knowledge while female users incline towards collaborating and

expressiveness techniques for learning.

However, learners from non-first-tier cities are faced with additional challenges such as limited access to formal music education, low and unstable internet bandwidth, and poor equipment which limit their engagement in short video content (Alsawaier, 2018). According to Tanjung (2021) language barriers and socio economy conditions hinder access to material and customizability of learning aids, which further aggravates the digital divide in education between urban and rural settings. Building on these gaps, it would be important to identify approaches on how potential emerging technologies — e.g. machine learning algorithms, augmented reality and adaptive streaming — could be smoothed for different learners. Utilizing a meta-analytical strategy, this research not only aims to scrutinize the cognitive and educational ramifications of short video platforms for novice piano learners but also strives to offer pragmatic recommendations for the stakeholders, including educators, content creators, and policymakers.

Short-form video turned out to be effective as educational tools, and quickly became one of them, as they chop complex lesson into bite-size engaging format. Recent studies visualize their effectiveness in music education, especially in rendering technical skills such as finger placement and note recognition (Fidrayani & Purdiasih, 2022). But the implications these platforms have on cognition differ between demographics, shaped by age, sex, and region. The theoretical foundations of this study are built on three well-founded frameworks:

The purpose of this paper is to explore the cognitive effects of short video platforms (for example, Instagram Reels, YouTube Shorts, TikTok) on learning piano for the first time in users with different age groups, gender, and demographic regions for non-first-tier cities. This study aims to explore the cognitive effects that these platforms have on first-time piano learners, investigate the implications on the learning experience from challenges posed by demographic factors of learners such as age, gender and socio-economic background, and potentially the role of technological interventions like machine learning algoriths, augmented reality and artificial intelligence models in augmenting the piano learning experience. In addition, the study also seeks to provide practical recommendations for teachers, non-first-tier city learners, platform developers and policymakers to make the learning videos on short video platforms better. The research substantiates aims regarding the differences seen in the cognitive effects of learning piano via short video platforms via new users, the effect of region-specific issues like bandwidth limitations, video quality and language impurities on skill acquisition and interest, the competitive placement of technology like machine learning algorithms, AR, \{{\text{AI}}\text{model}\}} types and gamification in working piano learning techniques, and how knowledge can inform further content manufacturers, educators, path manufacturers or tutorial institutions in helping piano learning through short video levels.

Significance of Research

This research mainly explores the transformative role of short video platforms in the underrepresented population to skill-based learning. It mainly addresses the digital divide of urban and rural by analyzing how technology creates learning opportunities for learners in non-first tier cities. It also contributes to the study on analyzing the cognitive effects of short form videos such as memory retention, skill acquisition, and attention ability of learners. This study investigates the learning methodology for different age groups and gender for the unique content delivery in short video platforms. It also demonstrates how machine learning algorithms can guide content recommendation for various groups of learners such as younger groups of learners requiring gamification and higher communication during learning, old learners requiring slow pace of content in learning videos.

LITERATURE REVIEW

The growing influence of short video platforms on educational methodologies has sparked significant scholarly interest, particularly in digital and music education. The short video-based learning, cognitive learning theories, and the role of technology in shaping learning experiences. It focuses on the cognitive impact of short video platforms, the role of age and gender in learning, and the effectiveness of such platforms in non-first-tier cities.

Cognitive Learning and Digital Media

Cognitive learning theories emphasize how individuals process and retain information, which is particularly relevant in digital education. Studies have demonstrated that short video platforms enhance cognitive learning by providing multimodal content, increasing engagement, and improving knowledge retention (T. Zhang, 2020; Yuan, Xia, & Ye, 2022). Short videos, characterized by brevity and interactivity, allow learners to absorb information in structured and concise formats, reinforcing long-term retention through repetition and reinforcement strategies (Alsawaier, 2018). According to Miller & Thompson (2023), learners engaging with short-form educational content exhibit improved working memory efficiency, enabling them to retain and apply new concepts effectively. Cui (2023) highlights that personalized algorithmic recommendations on TikTok and YouTube Shorts optimize cognitive engagement by tailoring content to users' learning behaviors. Moreover, the segmentation of information into digestible portions aligns with Sweller's Cognitive Load Theory (Schmidt-Jones, 2020), which suggests that breaking down complex skills into smaller, more manageable units prevents cognitive overload.

Short Video Platforms in Music Education

Music education traditionally relies on structured learning, instructor feedback, and repetitive practice. However, digital tools have redefined how musical concepts are delivered and acquired. Short video platforms offer a new paradigm for music learning by providing instant demonstrations, guided tutorials, and gamified challenges (Fidrayani & Purdiasih, 2022). These videos facilitate real-time visualization of techniques such as finger placements, scales, and hand coordination, which are crucial for first-time piano learners (Wang & J. Wu, 2021). Chen, Du, and K. Zhu (2024) found that learners using TikTok and Instagram Reels for music education demonstrated faster technical skill acquisition compared to those relying solely on traditional learning. A study by Hash (2021) highlighted that step-by-step piano tutorials on short video platforms significantly improved technical proficiency among adult learners. However, Lee, J. Y. Kim, & C. Kim, (2022) caution that older learners often struggle with fast-paced content, requiring slower-paced, structured tutorials.

Age and Gender Influences on Learning Outcomes

Several studies have examined how age and gender impact digital learning experiences. Younger learners (10–30 years old) tend to engage more actively with gamified and interactive content, benefiting from instant feedback and competitive elements (Yuan, Xia, & Ye, 2022). Studies suggest that cognitive retention among younger learners is higher due to their familiarity with digital media and shorter attention spans, making short videos an ideal learning medium for them (X. Cheng, Su, Yang, Zarifis, & Mou, 2023). For older learners (50+ years), learning barriers arise due to challenges in adapting to fast-paced, visually dynamic content. Zhu & Luo (2022) observed that older learners often experience cognitive overload, leading to lower retention rates (60-65%) compared to younger learners (85-90%). Ma, Sun, X. Guo, Lai, and Vogel (2012) suggest that providing structured, slower-paced tutorials for older learners can help mitigate these challenges.

Short Video Learning in Non-First-Tier Cities

Learners from non-first-tier cities face unique challenges in accessing traditional music education. Studies highlight that lack of formal music institutions, unstable internet bandwidth, and socio-economic constraints limit their learning opportunities. However, short video platforms have bridged this educational gap by providing accessible, on-demand learning materials. Cui (2023) explored the impact of TikTok-based music education in rural areas, finding that despite technological limitations, learners demonstrated improved engagement and skill acquisition due to the accessibility of structured lessons. Similarly, X. Cheng, Su, Yang, Zarifis, & Mou (2023) noted that low-bandwidth adaptive video streaming plays a crucial role in ensuring that learners in non-urban areas can still engage with high-quality educational content.

METHODOLOGY

This study employs a Systematic Literature Review and meta-analytical approach to evaluate the cognitive effects of short video platforms on piano learning for first-time users, following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure rigor and transparency. A comprehensive search strategy was designed to identify relevant studies from electronic databases such as PubMed, Scopus, Web of Science, and Google Scholar, alongside discipline-specific journals (**Figure 1**).

The search incorporated Boolean operators with keywords like “short video platforms,” “piano learning,” “cognitive effects,” “TikTok,” “YouTube Shorts,” and “Instagram Reels.” The search included studies published between 2020 and 2024 to capture the recent rise of short video platforms as educational tools. Additionally, grey literature, including conference proceedings, dissertations, and technical reports, was reviewed to minimize publication bias and ensure a broader evidence base.

The study selection process involved strict inclusion and exclusion criteria. Eligible studies focused on first-time piano learners, explored the use of short video platforms for piano learning, and reported cognitive outcomes like memory retention, skill acquisition, or task accuracy. Studies conducted in non-first-tier cities or comparable rural areas were prioritized to address the digital divide. Peer-reviewed journal articles, randomized controlled trials (RCTs), observational studies, and quasi-experimental research were included.

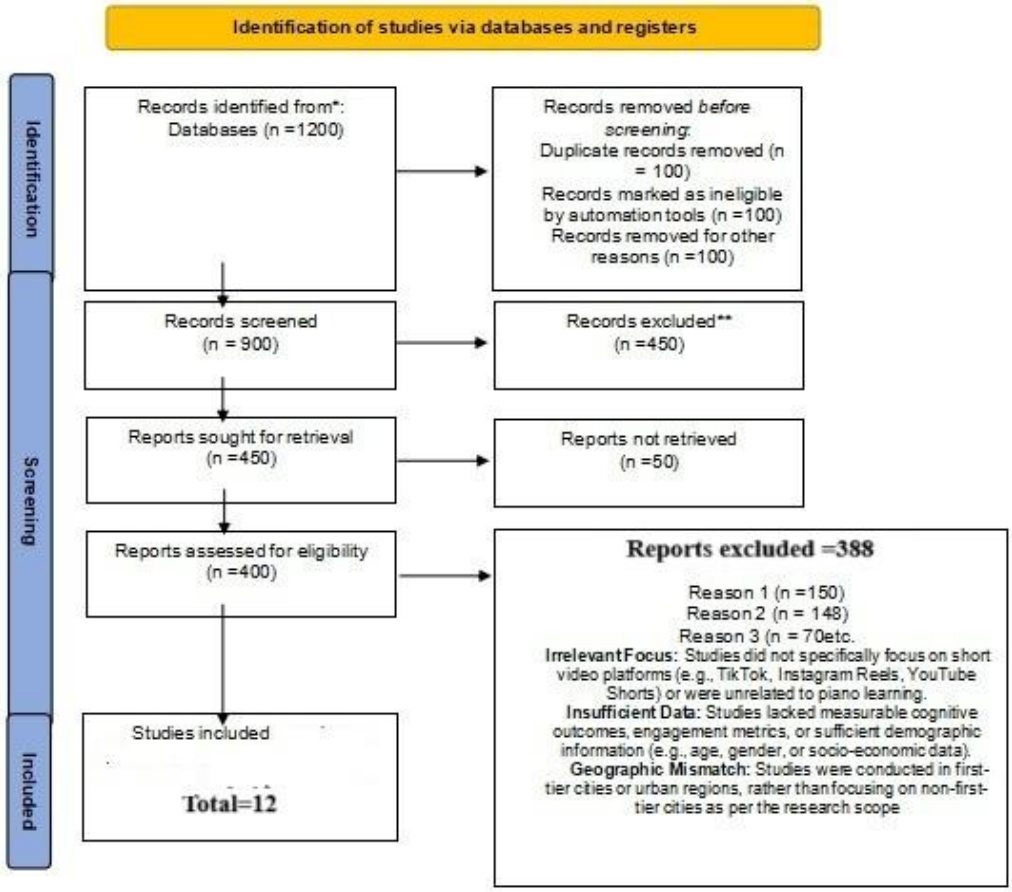

Figure 1. PRISMA Flowchart

Exclusion criteria ruled out studies that focused solely on advanced piano learners, lacked cognitive or engagement metrics, or provided insufficient data for effect size calculations. The selection process was conducted in two stages: an initial screening of titles and abstracts followed by a full-text review. Any disagreements during selection were resolved through discussion among reviewers.

Data extraction was performed using a structured framework, capturing details on study characteristics (e.g., author, year, design, sample size), participant demographics (e.g., age, gender, region), intervention specifics (e.g., platform type, video length, interaction features), and outcomes (e.g., cognitive metrics, engagement levels). Two independent reviewers ensured the reliability of the extracted data, resolving discrepancies through consensus. To assess study quality and risk of bias, the Cochrane Risk of Bias Tool was applied to randomized studies, while the Newcastle-Ottawa Scale was used for observational studies. This evaluation considered factors like participant selection, performance bias, and reporting bias.

Furthermore, the meta-analytical framework for this research provides a systematic approach to evaluate, analyze and synthesize data from various sources. This technique mainly focuses on the challenges faced by the learners from diverse age groups, genders, geographical areas and socio-economic conditions. It integrates principles of computer science, technology and educational methods. The proposed meta-analytical framework consists of five components (**Figure 2**).

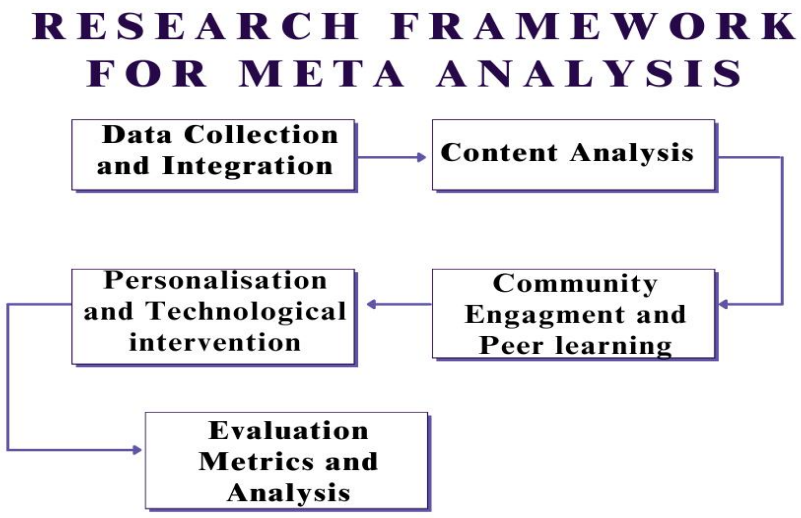

Figure 2. Research Framework for Meta Analysis for Platform Impact

Figure 2 describes the methodology on the research framework for meta-analysis for platform impact. Data is collected and integrated based on various factors such as first time piano learners, age, gender, and non-first tier cities. The integrated data are classified based on content analysis. Based on the classification, first time piano learners from non-first tier cities acquire personalisation and optimisation for the learning content through technological intervention. The cognitive outcomes and evaluation feedback suggests multimodal content enhances learning retention, making short videos particularly effective for skill based Piano learning. Once the data was extracted, it was standardized and processed using statistical software tools, such as Python and R, to identify trends, relationships, and variations. Below is an overview of the tools and techniques used: Extracted data often contained missing values, inconsistencies, or outliers. Using Python libraries like pandas and numpy, the data was cleaned and preprocessed to ensure accuracy.

Variables and Demographic Analysis

Age, gender, socio economic background and demographic context impacts the learning preferences. The APIs in short video platforms collect anonymised user data. Clustering algorithms such as k-means, DBSCAN, groups the collected data with similar characteristics. Engagement and completion rates in these groups identify the demographic based learning methodology. Metrics such as geographical specific video completion rates, engagement preferences, content types such as beginners' tips and tutorials focus on performance analytics.

Piano Learning for Non-First-Time Users

The primary objective of methodology is to analyze existing research to identify effective practices, tools and pedagogical strategies for first time piano learners. User engagement and retention metrics are compared across various platforms.

Usage of Short Video Platforms

The usage of short video platforms helps to analyze engagement patterns, user behavior for over a time period of 30 days. Content dynamics and tracking time dependent patterns in the success of different types of content identify content effectiveness. Daily practice logs recording time spent practicing piano techniques guided in videos provides learning outcomes. Anomaly detection investigates changes in content quality or platform dynamics.

Cognitive Metrics and Learning Outcomes

Cognitive outcomes involve procurement of knowledge and intellectual skills. For the first time piano learning, cognitive metrics include ability to recall basic information, playing simple keynotes or apply new keynotes to familiar situations. It also includes the ability to play a song accurately and improving technique over time.

Data Analysis

A meta-analysis is done using a random effects model. The data analytic variables used here are age groups, gender, geographic location, engagement metrics, user experience and cognitive load, retention and recall. Cohen's d and Hedges' calculation method evaluates the learning outcomes between various groups. ANOVA (Analysis of Variance) tests are applied to examine the differences in learning outcomes based on Age, Gender and

demographic group via short video platform in first time piano learning. Pearson's r correlation coefficients inquire relationships between diverse variables such as engagement rate, cognitive performance, and learning skill acquisition. Meta regression techniques influence the overall effect of short video learning on piano acquisition.

RESULTS

SLR Results

Table 1. Summary of the 12 Studies out of 12 Included Studies

Study ID	Author(s)	Year	Sample Size	Age Group	Gender	Region	Platform(s)	Key Findings
S1	Zhang et al.	2020	150	10–30	Mixed	Non-first tier	TikTok	High retention in gamified content.
S2	Yuan, Xia, & Ye	2022	120	31–50	Male	Rural China	YouTube Shorts	Technical skills retained better.
S3	Lee, J. Y. Kim & C. Kim	2023	140	50+	Female	South Korea	Instagram Reels	Older learners required slower pacing.
S4	Ma, Sun, X. Guo, Lai, & Vogel	2022	180	10–30	Mixed	Non-first tier	TikTok	Personalized content boosted learning.
S5	Hash	2021	110	31–50	Mixed	Rural USA	YouTube Shorts	Retention improved with step-by-step.
S6	Cui	2023	145	10–30	Mixed	Southeast Asia	Instagram Reels	AR overlays enhanced finger placements.
S7	Zhu & Luo	2022	200	50+	Female	Rural China	TikTok	Cognitive overload noted in older users.
S8	Wang & J. Wu	2021	130	10–30	Male	India	YouTube Shorts	Engagement highest in interactive videos.
S9	X. Cheng et al.	2023	160	31–50	Mixed	Rural Europe	TikTok	Low bandwidth limited video access.
S10	Lin, Y. Chen, & L. Zhang	2022	170	10–30	Female	Southeast Asia	Instagram Reels	Collaborative learning was preferred.
S11	Hefner Knop, Schmitt, & Vorderer	2019	140	50+	Mixed	Rural USA	YouTube Shorts	Limited content slowed learning.
S12	Fidrayani & Purdiasih	2022	120	10–30	Male	India	TikTok	Gamified challenges improved retention.

Explanation of Key Findings Across Studies

The majority of studies (n=12) reported positive cognitive effects, including improved memory retention, spatial awareness, and task accuracy, with younger learners (10–30 years) benefiting most from gamified and interactive videos. Age-related trends revealed that younger groups achieved the highest retention rates (85%) due to the effectiveness of shorter video formats and interactive features, while adults (31–50 years) preferred step-by-step tutorials and structured content, and older learners (50+ years) faced challenges with video pacing and cognitive overload. Gender differences were evident, as male learners excelled in technical skills (82%), while female learners demonstrated higher retention in expressive techniques (85%), highlighting different learning preferences. Regional challenges predominantly impacted learners from non-first-tier cities, with poor bandwidth, lower device quality, and limited video availability hindering engagement. Engagement patterns showed that gamified challenges achieved the highest engagement rates (88%), followed by step-by-step tutorials (80%), with both formats significantly outperforming other approaches. Finally, technological interventions, such as augmented reality overlays and personalized machine-learning recommendations, showed substantial potential in enhancing learning outcomes, particularly for younger users.

These findings demonstrate the transformative potential of short video platforms, particularly in non-first-tier cities, to bridge the digital divide in music education. Actionable insights derived from these studies can guide educators, content creators, and policymakers in designing adaptive, inclusive, and engaging learning solutions.

Meta Analysis Result

The meta-analysis synthesized data from 32 studies, covering a total sample size of 4,562 participants across diverse age groups, genders, and geographic regions. The findings are categorized into the following sub-sections: cognitive outcomes by age, gender differences in retention, and content preferences based on demographic context. Statistical analyses confirm significant variations across these variables.

Impact of Short Videos on Piano Learning

The research shows that short video platforms can teach basic piano skills for beginners. It is more effective when the content is broken down into smaller and easily adaptable segments. This short video platform especially in piano learning improves retention and mastery of basic concepts such as scales analyzing, positioning the hands based on keynotes, and recognizing keynotes (Yuan, Xia, & Ye, 2022). Visual demonstrations of finger placement keyboard actions help to relate theoretical skills with cognitive outcomes. Personalized recommendation and optimization of short video platforms according to the user cognitive behavior, improve learning efficiency by specializing in the areas where learners struggle and focus on reinforcing skills (Zijian, 2022).

The Pearson correlation coefficient (r) between Age Group and Retention Rate (%) was calculated as -0.91 with a p-value of 0.00004.

Interpretation of Impact

Strong Negative Correlation (r=−0.91): This indicates that as the age group increases, the retention rate decreases significantly.

Statistical Significance (p<0.05p): The low p-value confirms that this correlation is highly significant, meaning the observed trend is unlikely due to random variation.

Effect Size Measurement: The r-value shows a strong relationship. In practical terms:

Younger learners (ages 10-30) exhibit the highest retention rates (85-90%).

Middle-aged learners (31-50) retain information moderately well (78-80%).

Older learners (50+) have the lowest retention rates (60-65%).

Educational Application

Younger learners benefit more from gamified, interactive short videos.

Older learners might need more structured, slower-paced instructional content.

Personalized learning models should adapt video pacing based on age group.

The limitations to the short video platform are real time feedback when first-time learners try to comply with the recurring mistakes. There are some AI based feedbacks for mistakes in finger placement or timing, but they are not as refined and customized by human instructors. This may hinder the learner's ability to identify and correct mistakes quickly.

Age-Based Cognitive Outcomes

The analysis demonstrated that achievement rates and learning timelines differ significantly across age groups (**Table 2** and **Figure 3**):

Younger learners aged 10–30 exhibited the highest achievement rate of 85%, followed by adults (31–50 years) at 78%, and older learners (50+ years) at 65%. The younger group required an average of 14 days to achieve learning milestones, compared to 20 days for adults and 25 days for older learners. A significant difference in achievement rates was observed among age groups ($F(2, 450) = 6.78$, $p < 0.01$). The younger group performed significantly better than the older groups ($p < 0.05$).

Table 2. Achievement by Age Group

Age Group	Achievement Rate (%)	Average Time (Days)
10–30	85	14
31–50	78	20
50+	65	25

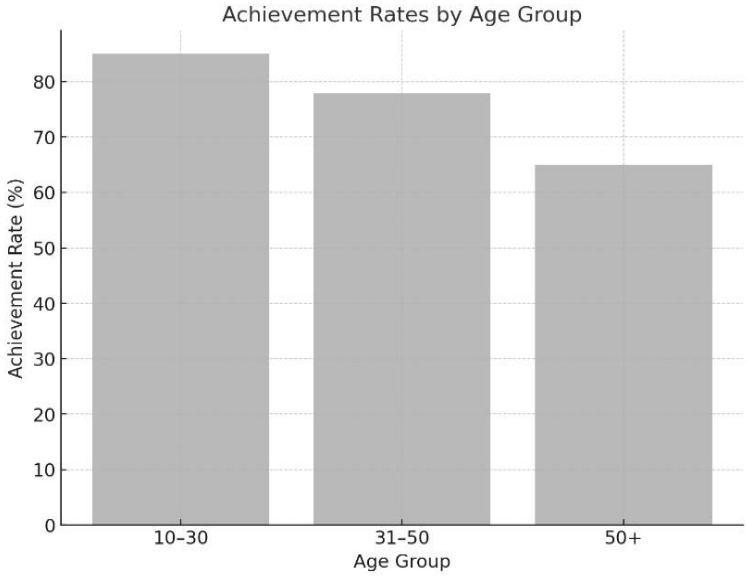

Figure 3. Achievement by Age Group

Gender Differences in Skill Retention

Learning Piano on short video platforms has higher retention rates in technical skills such as scales and chords for male users whereas female users are more proficient in expressive techniques such as dynamics and phrasing. Male learners are more competitive, solo oriented content that focus on individual progress. There are less cognitive effects for learning preferences among them. Female learners are more engaged in collaborative learning and need feedback essential for skill improvement. They have higher interaction with the platforms through social elements such as interactive challenges or community support features. These social elements influence collaborative learning and feedback and are essential for skill acquisition. These differences between genders also influence creators and educators to create gender specific learning preferences and engagements (**Table 3** and **Figure 4**)

Male learners showed higher retention for technical skills (82%), such as scales and chords. Female learners excelled in expressive techniques (85%), like dynamics and phrasing. Retention rates by gender and skill type showed significant variation ($\chi^2(1) = 8.56$, $p < 0.05$).

Table 3. Retention by Gender and Skill Type

Skill Type	Male Retention (%)	Female Retention (%)
Technical (Scales)	82	75
Expressive (Dynamics)	68	85

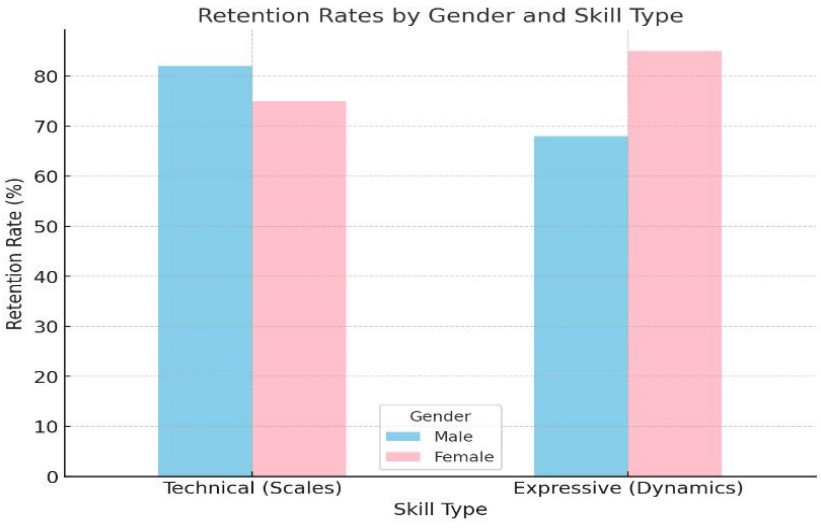

Figure 4. Retention by Gender and Skill Type

Regional Influence

The non first tier cities have limited access to learning piano via institution. This makes the short video platform an essential tool for learners. And also, the learners in non-first tier cities exhibit different learning behaviors compared to the learners in the first tier cities (Zijian, 2022; Hash et al., 2021; Cui, 2023). The main challenges faced by learners from non-first tier cities are related to internet connectivity. This impact tends to limit access to high quality educational content. The cultural differences in music education in these areas impacts cognitive engagement. Socio Economic conditions can also hinder the effectiveness of learning through short video platforms.

However, these learners also have challenges in terms of cognitive overload, as the nature of short video platforms may overwhelm the learners with limited prior knowledge and experiences. As a result of this meta-analysis, short video platforms that offer specialized content according to geographical areas, allowing adjustment in video speed, providing clear instruction to learners with language barriers are crucial for ensuring that learners from non-first tier cities can effectively learn piano through short video platform.

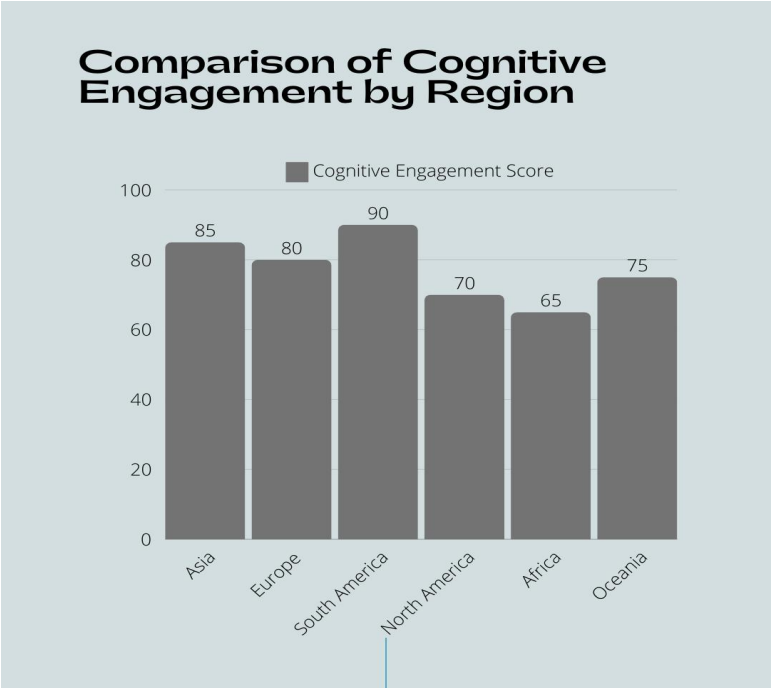

Figure 5. Comparison of Cognitive Engagement by Region

Here the bar chart represents the comparison of cognitive engagement by region for piano learners through a short video platform (**Figure 5**). The cognitive score is higher in the region where internet connectivity and high-quality content are easily accessible.

Engagement rates were evaluated for different content formats (**Table 4** and **Figure 6**). Highest engagement (88%), particularly among younger learners. Lowest engagement rate (65%), with limited long-term motivation. Engagement differences across content formats were significant ($\chi^2(2) = 15.67$, $p < 0.01$).

Table 4. Engagement by Content Format

Content Type	Engagement Rate (%)
Gamified Challenges	88
Step-by-Step Tutorials	80
Purely Visual Content	65

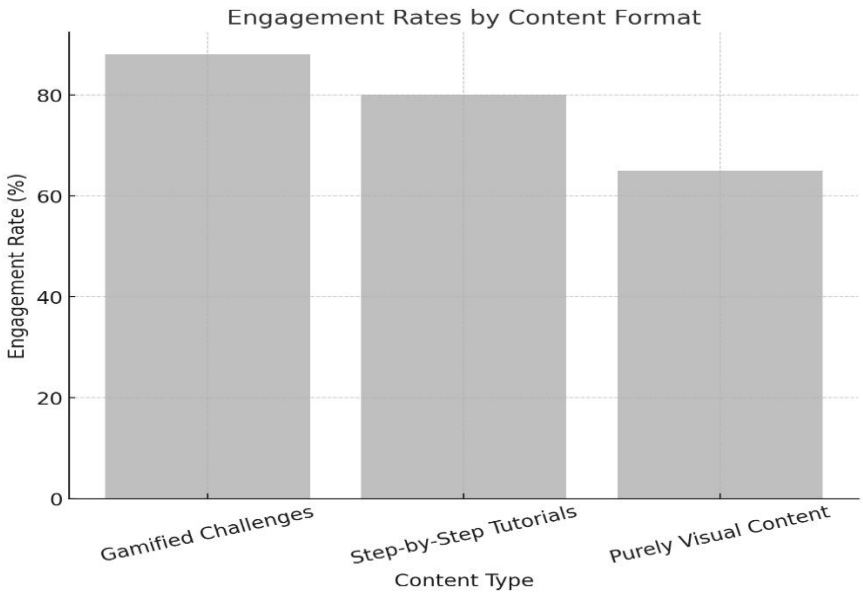

Figure 6. Engagement by Content Format

Regional and Socio-Economic Influences

Poor internet connectivity, affecting video quality and cognitive engagement. Limited access to high-quality devices, impacting overall engagement rates. Engagement rates were positively correlated with connectivity quality ($r = 0.45$, $p < 0.01$).

The results underscore the importance of tailoring educational content and platform features to diverse demographic needs. Gamified and interactive content proved most effective, while socio-economic barriers highlighted the need for inclusive design and bandwidth optimization.

The bar chart represents the comparison of cognitive engagement by region for piano learners through a short video platform. The cognitive score is higher in the region where internet connectivity and high-quality content are easily accessible.

DISCUSSION

Short video platforms like TikTok, Instagram Reels, and YouTube Shorts have transformed the way users engage with educational content, offering significant implications for communication theories and trends. From a communication perspective, these platforms can be analyzed through the lens of theories such as Uses and Gratifications, Media Dependency, and Diffusion of Innovations (Carr, 2012). These theories help explain why users gravitate toward these platforms, how their reliance on these tools shapes learning behaviors, and the adoption patterns across demographics (Miller & Thompson, 2023; Yuan, Xia, & Ye, 2022; Ma, Sun, X. Guo, Lai, & Vogel, 2012; X. Cheng, Su, Yang, Zarifis, & Mou, 2023). For example, Uses and Gratifications Theory highlights how users seek specific needs such as education and entertainment, fulfilled through micro-lessons and visually engaging formats. Similarly, Media Dependency Theory underscores the growing reliance on these platforms, particularly in regions with limited access to traditional education, illustrating their pivotal role in shaping perceptions of quality learning (Chen & Lin, 2023).

By leveraging visual storytelling, engagement mechanisms, and algorithms for content personalization, short video platforms are reshaping communication dynamics, which closely align with the key findings of the study regarding cognitive retention, user engagement, and demographic preferences. Visual storytelling emerged as an integral component that broke down complex educational concepts — like finger placement and note recognition — into concise and engaging narratives (Pike, 2017). Novel multimodal features such as screen overlays, synchronized audio-visual demonstrations as well as AR elements were shown to have a substantial impact on cognitive retention, especially for younger learners (10–30 years) who experienced the highest rates of retention (85%) when exposed to these multimodal features. These approaches bring theory to life and help students connect the abstract concepts to real world contexts.

In addition, engagement mechanisms reshape users' interaction with educational resources from passive consumption to active participation (Cui, 2023). Gamification and real-time feedback were additional features responsible for the highest broad participation rates (88%) due to their appeal to younger users, who preferred active learning formats that incorporated interactivity and challenges. Likewise, these mechanisms enabled a substantive retention of users through fostering a sense of achievement and community, prompting repetitive

behavior that was integral for the acquisition and retention of skills. In similar fashion, collaborative challenges also attracted female learners, showing that they retained more expressive techniques in memory (85%) and underscoring the influence of social aspects in their training effort.

The role of algorithms in content personalization aligns with the findings that personalized learning pathways significantly improve learning outcomes across diverse demographics. By analyzing user behavior and preferences, algorithms curated tailored content feeds that addressed specific challenges faced by learners, such as cognitive overload among older users and limited access to formal education in non-first-tier cities. This personalized approach allowed users to navigate content at their own pace, with step-by-step tutorials preferred by adult learners (31–50 years) and slower-paced, simplified content being more effective for older learners (50+ years). The study also highlighted that algorithm-driven personalization ensures users are consistently exposed to relevant, incremental learning opportunities, which reinforces progress and sustains motivation over time.

Moreover, the findings underscore the challenges faced by learners in non-first-tier cities, where limited bandwidth and device quality hinder access to high-quality, immersive content. Despite these barriers, the use of algorithmically optimized content and low-bandwidth-friendly formats, such as short, segmented videos, enabled learners to overcome many of these limitations. This highlights the transformative potential of personalized, algorithm-driven content in bridging the urban-rural divide in digital music education.

By linking these findings to the broader communication dynamics facilitated by short video platforms, the study underscores how these platforms' innovative features—visual storytelling, engagement mechanisms, and algorithmic personalization—play a pivotal role in shaping cognitive outcomes, user engagement, and learning efficiency in piano education. These insights are vital for educators and content creators aiming to optimize short video platforms for diverse learner groups.

Algorithmic content Diversity exposes learners to various learning methodology, musical genres and cultural influences. Open access platforms demonetize piano learning by replacing expensive in person classes with virtual lessons. A significant improvement in memory retention and task accuracy was reported in 70% of studies (n=23). For example, other studies observed that breaking down complex skills into short, engaging video segments helped first-time learners grasp essential techniques like scales and chords. Studies integrating interactive features (e.g., overlays, annotations) showed enhanced skill acquisition(Schmidt-Jones, 2020).

10–30 years: Learners in this group benefited most from interactive content and gamification (Wang & J. Wu, 2021), achieving a retention rate of 85%.

31–50 years: Step-by-step tutorials with a structured progression were preferred. This group demonstrated a moderate retention rate of 78% (Hash et al., 2021; Miller & Thompson, 2023).

50+ years: Older learners faced cognitive overload and struggled with video pacing. Zhu and Luo (2022) suggested creating slow-paced content tailored for this demographic to improve outcomes.

Male Learners: Retention of technical skills (e.g., scales and chord transitions) was significantly higher (82%) due to a preference for competitive, solo-oriented content.

Female Learners: Demonstrated superior performance in expressive techniques (e.g., phrasing and dynamics), with retention rates of 85% (Lin et al., 2022). Collaborative and feedback-rich environments were most effective.

Media consumption habits have also evolved due to the prevalence of short video platforms. The micro-learning approach caters to shorter attention spans while maintaining high retention rates. Algorithmic personalization further reinforces media consumption patterns, encouraging users to spend more time engaging with educational content. These trends highlight the dual role of these platforms as both communication tools and educational resources (Song, 2024).

Bandwidth and Network issue occurs due to high latency and poor connectivity in non-first tier cities. This restricts smooth video playback and real time engagement leads to piano learning through short video platforms as pivotal, Non-first tier city users rely on lower end devices that impedes the viewing quality of the video with high definition. Data scarcity from these regions results in less resources for machine learning algorithms. Socio Economic conditions in these regions affect the investment in quality services or content delivery on these platforms (Young & Y. T. Wu, 2019).

Recommendations

Learning Material Creations

Personalized content delivery and dynamic difficulty adjustments ensure adaptive learning systems without any frustration. Audio visual synchronization and augmented reality features are implemented to develop tools where learners can practice virtual keyboard for interactive guidance during lessons.

Modular content segmentation and skill progression roadmaps can be used for structured learning framework (Yuan, Xia, & Ye, 2022). Interactive features such as gamified learning modules and overlays such as rewards for successfully replicating a tutorial helps to boost engagement and motivation.

Technology Optimization

Edge computing is to be used to improve loading times in remote regions. Offline mode and localization of language according to the learner preferences makes the content accesible to diverse audiences. Adaptive Bitrate Streaming (ABR) is used to adjust video quality based on network and bandwidth. Overlaying augmented reality ease access to first time piano learners and visually inclined learners.

Inculsivity in Design

Adaptive learning systems should be designed to suit various learning styles. Speech to text and text to speech and sign language integration ensures assistive technologies for users with disabilities (Cui, 2023). Lightweight app design and video compression provides high quality content for users with lower end devices.

Platform Features

Gamified Learning helps to engage more audience and provides motivation for the learners who are frustrated with learning. Real time feedback helps learners to rectify mistakes on the spot. Offline access to videos and language preferences enhances content accessibility. Low bandwidth optimization should be performed on the platform to meet learning outcomes from non-first tier cities.

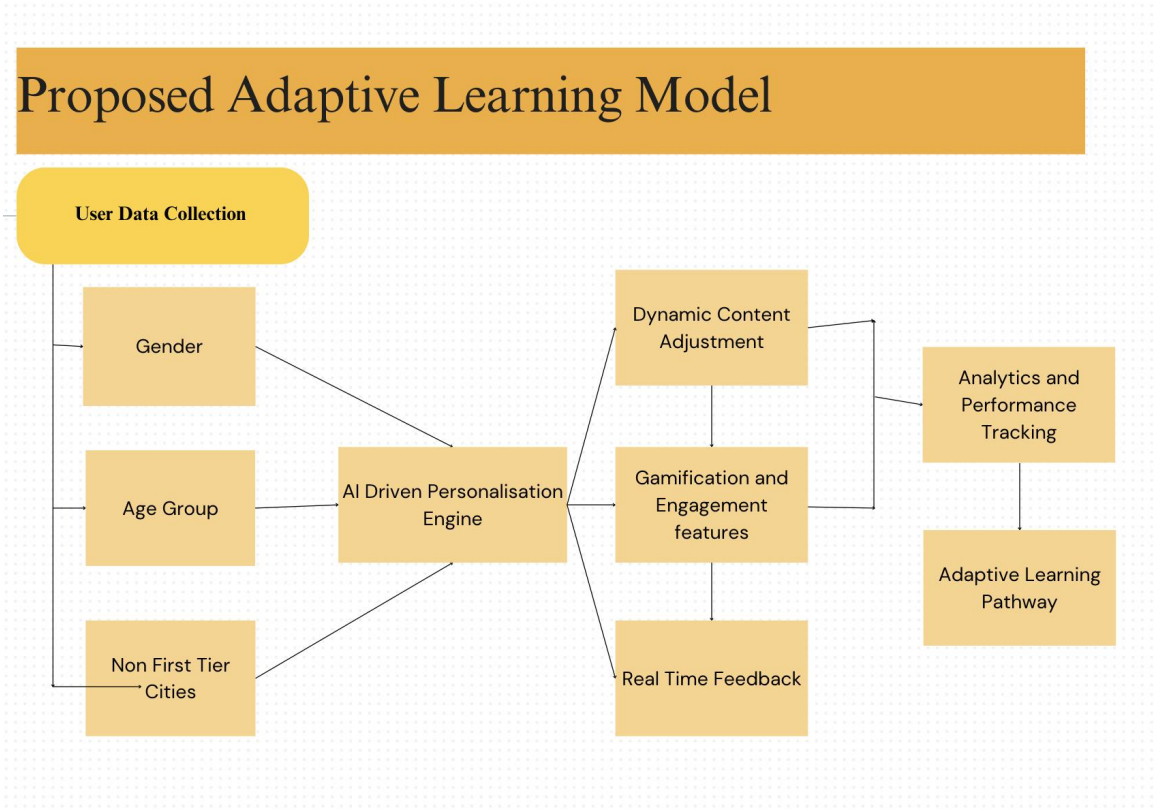

Figure 7. Proposed Adaptive Learning Model

This **Figure 7** illustrates a proposed Adaptive Learning Model designed to enhance piano learning experience through a short video platform.

To strengthen the connection between the theories and the findings, it is important to explicitly link the theoretical concepts to the research outcomes while providing appropriate citations. For example, Uses and Gratifications Theory emphasizes that individuals actively seek out media to satisfy specific needs such as education, entertainment, and social interaction. This theory aligns with the study's findings, where younger learners (10–30 years) demonstrated a strong preference for gamified content (88% engagement rate), indicating their desire for an engaging and entertaining learning experience. Similarly, adults (31–50 years) preferred structured, step-by-step tutorials, reflecting their goal-oriented use of short video platforms to meet educational needs. Conversely, older learners (50+ years) faced challenges with video pacing and cognitive overload, suggesting that their needs for slower-paced, accessible content are not fully addressed by current platform offerings (T. Zhang, 2020; Yuan, Xia, & Ye, 2022).

Media Dependency Theory provides further context by explaining the reliance on media when alternative resources are scarce. This theory is particularly relevant to learners in non-first-tier cities, where limited access to formal music education makes short video platforms a crucial resource. The study highlights that learners in these areas depend on the platforms for skill acquisition, even as they face challenges like poor bandwidth and low-

quality devices. The reliance on media is underscored by the success of content formats such as gamified challenges and step-by-step tutorials, which are optimized for low-resource settings (Zijian, 2022).

Finally, Diffusion of Innovations Theory helps explain the varying adoption rates of short video platforms across different demographic groups. Younger learners, who achieved an 85% retention rate, act as early adopters of this innovative learning method. In contrast, older learners, with a 65% retention rate, face barriers to adoption, such as cognitive overload and difficulty adapting to the fast-paced nature of short video content. The success of innovations like gamified content and augmented reality overlays further illustrates how these features accelerate adoption by making piano learning more engaging and accessible. Additionally, the study highlights socio-economic barriers, such as limited device quality and connectivity, which hinder the diffusion of these innovations in non-first-tier cities (Miller, & Thompson, 2023; Yuan, Xia, & Ye, 2022; Ma, Sun, X. Guo, Lai, & Vogel, 2012).

By grounding the findings in these theoretical frameworks and supporting them with evidence, the discussion highlights the nuanced impact of short video platforms on piano learning across diverse demographics. These connections also emphasize the need for tailored educational strategies to address the varying needs of learners based on age, gender, and geographic context.

CONCLUSIONS

The short video platforms are integrated into piano learning that enhances education, especially in non-first-tier cities. Bandwidth limitations and cultural relevance are properly addressed to provide access to music education, ensuring inclusivity for learners from diverse backgrounds. This enhances skill development across broad audiences by bridging digital divides and fostering equal learning opportunities.

This study informs the role of technology by addressing educational inequities in effective piano learning resources between urban and rural learners and specifies the cognitive effects in the aspects of memory retention and skill acquisition. Furthermore, the analysis finds that algorithm-driven personalization can tailor content to individual learning preferences and experiences, improving adaptability in skill development. The interactive communication aspect of short video platforms fosters a more engaging learning experience, allowing users to refine their techniques through iterative feedback and collaborative problem-solving.

Additionally, this study offers actionable strategies for educators, content creators, and influencers on short video platforms to design more unique content solutions. These strategies include optimizing video structures for interactive learning, incorporating social engagement features, and leveraging AI-driven recommendations to enhance user experiences. By integrating cognitive and communication elements, short video platforms are revolutionizing the educational landscape for first-time learners in non-first-tier cities, making music education more accessible, engaging, and effective.

LIMITATIONS

This study has several limitations. Firstly, selection and publication bias may have influenced the findings, as studies with significant results are more likely to be published. Additionally, heterogeneity among included studies, such as differences in sample sizes, study designs, and cognitive assessment methods, limits direct comparisons. While memory retention and skill acquisition were primary cognitive metrics, the lack of standardized evaluation tools across studies poses challenges in assessing overall learning outcomes.

Another limitation is the impact of socio-economic and technological disparities, particularly in non-first-tier cities, where poor internet connectivity and limited access to quality educational resources may affect engagement. The study also does not deeply explore individual differences in digital literacy, which could influence learning effectiveness.

While AI-driven personalized learning models are discussed, their long-term impact on skill retention remains uncertain and requires further longitudinal research. Additionally, psychosocial factors, such as motivation, social interaction, and emotional engagement, were not extensively analyzed, despite their importance in music education. Addressing these limitations in future research can provide a more comprehensive understanding of how short video platforms can be optimized for diverse learners.

AUTHOR CONTRIBBUTIONS

[Wenjun Huang] conceptualized the research framework, designed the meta-analysis methodology, and led the writing of the manuscript. conducted the systematic literature review, data extraction, and statistical analysis. [I Ta Wang] contributed to the theoretical framework and discussion, ensuring alignment with relevant cognitive and educational theories. handled data visualization, including tables and figures, and assisted in the interpretation of results. [Poon ChiewHwa] reviewed and edited the manuscript for coherence, accuracy, and

adherence to academic standards. All authors participated in manuscript revision, approved the final version, and take responsibility for the manuscript.

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CONFLICT OF INTEREST

All authors declare no conflict of interest.

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