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Systematic Review of Instructional Design Strategies in Public Transportation Learning Environments

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Abstract
This paper presents a systematic review of instructional design strategies in public transportation learning environments, aiming to identify effective approaches for enhancing educational experiences in non-traditional contexts. The review synthesizes existing literature on mobile learning, multimedia content, and gamification, with a focus on their application in public transport systems such as buses, trains, and subways. Key findings highlight the effectiveness of mobile learning applications in providing flexible, bite-sized educational content for commuters. Additionally, the integration of multimedia resources, such as interactive signage and audio-visual materials, was found to enhance learner engagement. Gamification, when appropriately designed, increases motivation and learner participation. However, the effectiveness of these strategies varies depending on contextual factors such as transportation type, commuter demographics, and learning objectives. The paper discusses the implications for future instructional design, recommending the development of adaptive, learner-centered models that integrate multiple strategies for diverse commuter populations. Further research is needed to explore long-term learning outcomes, the role of demographic factors, and hybrid instructional models that combine various strategies. This study contributes to the field of instructional design by providing a comprehensive analysis of how educational strategies can be tailored to the unique environment of public transportation.

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1. Introduction

1.1. Background of public transportation learning environments

Public transportation learning environments have evolved from traditional classroom settings to more dynamic, real-world contexts. These environments provide an opportunity for educational experiences that are not confined by geographic limitations or formal structures [1]. The integration of learning materials and strategies within public transport systems offers a unique approach to reaching diverse learner populations, especially in urban settings. Public transportation, such as buses, trains, and subways, has become an untapped resource for engaging learners during their commute, offering significant potential for informal learning [2].

Over the years, various studies have highlighted the importance of optimizing these spaces for learning by integrating instructional materials, media, and technologies. However, while the potential is clear, the design of learning experiences in such non-traditional environments remains under-researched.

Public transportation systems can serve as a platform for diverse learning activities, from language acquisition to community engagement. These environments are characterized by their transience, diverse user base, and the need for adaptive instructional methods [3]. As such, the intersection of public transportation and educational strategies presents an innovative challenge for instructional designers. To date, little systematic review has been conducted to explore the specific instructional design strategies that cater to these environments [4]. This lack of focus often leaves a gap in knowledge that could otherwise enhance the learning experiences of commuters. Addressing this gap is critical for the development of effective and impactful educational interventions in public transportation settings [5].

1.2. Importance of instructional design in public settings

Instructional design plays a pivotal role in shaping effective learning experiences, particularly in public settings where the learning environment is less controlled than in a traditional classroom [6]. In these settings, instructional design must account for a variety of factors, including distractions, limited time, and a broad spectrum of learners with different educational backgrounds and learning styles. Effective instructional design ensures that educational materials and methods are tailored to the unique constraints and opportunities of the setting [7].

The importance of instructional design in public settings extends beyond conventional classrooms because these environments offer more flexibility and innovation. Unlike the structured, static nature of a classroom, public transportation systems provide opportunities for spontaneous learning experiences [8]. Instructional design in these environments must incorporate flexibility to adapt to the fluctuating nature of passenger traffic, learner engagement, and varied time intervals. Strategies such as microlearning, gamification, and the use of interactive technologies are essential in these contexts to capture learners' attention and ensure effective knowledge transfer [9].

Moreover, instructional design in public transportation settings can contribute to wider societal benefits by reaching a diverse range of learners [10]. These learners, who might not otherwise engage in formal education due to time constraints, financial limitations, or accessibility issues, are given the chance to benefit from learning experiences. Well-designed instructional strategies in public settings can democratize education, making it more accessible, engaging, and effective for everyone. This underscores the critical role of instructional design in shaping equitable and impactful learning opportunities for public transportation users [11-13].

1.3. Purpose and scope of the review

The purpose of this systematic review is to examine and synthesize the existing literature on instructional design strategies employed within public transportation learning environments. Given the novelty and diversity of this educational context, there is a need to identify key instructional design principles and their effectiveness in engaging and educating learners on public transport systems. This review aims to contribute to the development of a conceptual framework that guides the design of learning interventions in these unique settings.

The scope of this review encompasses a broad range of public transportation modes, including buses, trains, trams, and subways, focusing on instructional strategies that have been implemented or studied in these environments. It aims to explore various instructional models, from traditional paper-based materials to more advanced technology-integrated solutions such as mobile learning apps and digital signage. Additionally, this review will examine factors such as learner demographics, the duration of the learning experience, and the physical environment's impact on learning outcomes.

By focusing on instructional design strategies specific to public transportation, this review seeks to highlight the best practices and potential challenges involved in implementing educational interventions in these settings. The findings will provide a foundation for future research and practical recommendations for educators, instructional designers, and policymakers looking to leverage public transportation as a platform for learning. Through this systematic review, we aim to bridge the gap in research and foster the development of innovative and effective instructional designs in public transportation learning environments.

2. Literature Review

2.1. Overview of instructional design theories

Instructional design theories provide a foundational framework for creating effective educational experiences by integrating principles of learning and instructional delivery. Among the most well-known theories are the ADDIE model, Merrill's Principles of Instruction, and Gagné's Nine Events of Instruction [14]. The ADDIE model, which stands for Analyze, Design, Develop, Implement, and Evaluate, is widely used across various educational settings. It provides a systematic approach to designing, delivering, and assessing instructional materials. The flexibility of ADDIE allows it to be adapted to diverse learning environments, including public transportation [15, 16].

Merrill's Principles of Instruction, focusing on problem-centered learning, emphasize the importance of engaging learners with authentic tasks. This theory aligns well with public transportation settings, where learners are often engaged in brief yet meaningful interactions with educational content [17]. Gagné's Nine Events of Instruction, on the other hand, highlight the importance of structured guidance, from gaining learners' attention to providing feedback and ensuring retention. These theories are instrumental in designing instruction that is not only effective but also adaptive to various learner needs and environmental constraints [18].

In addition to these foundational models, there are several contemporary approaches to instructional design that focus on learner-centered pedagogy, such as constructivist theories. These emphasize active learning, where learners construct their own understanding based on experiences, which could be effectively applied in the dynamic, real-world environment of public transportation. These theories help instructional designers create engaging, contextually relevant, and learner-focused educational experiences across a variety of settings, including non-traditional learning environments like public transport [19].

2.2. Existing research on instructional design in non-traditional learning environments

Research on instructional design in non-traditional learning environments has gained traction over the past few decades as educators seek to engage learners outside of formal classrooms. Studies have shown that public transportation

offers a unique opportunity for learning, as it serves as an accessible space for individuals with varying levels of formal education and different learning needs. Instructional design in these settings must be adaptive, addressing diverse learner profiles while navigating the challenges of a transient and often noisy environment [20-22].

One line of research focuses on the integration of mobile learning technologies, such as educational apps and digital content, into public transportation. These tools can deliver bite-sized learning modules, ideal for the short commute times typical in public transportation settings [23]. For example, a study explored the effectiveness of language learning apps used by commuters, demonstrating that such tools can enhance learning outcomes by providing personalized and accessible learning experiences. Furthermore, research on microlearning supports the notion that brief, focused learning segments can be particularly effective in mobile and public transport environments [24].

Another area of focus in non-traditional instructional design research is the use of multimodal content, combining auditory, visual, and interactive elements to maintain learner engagement. Research on blended learning environments emphasizes the importance of integrating multiple forms of media to cater to diverse learning styles. Public transportation, with its fluctuating levels of interaction, can benefit from such approaches by using digital signage, audio instructions, and interactive content to engage learners during their commute [25].

2.3. Gaps in literature and rationale for the study

Despite the growing body of research on instructional design in non-traditional learning environments, several gaps remain, particularly in the context of public transportation. First, while there is research on mobile learning and technology-based educational interventions, little attention has been given to the design of instructional content specifically tailored for public transportation contexts. Most studies focus on the use of technology in isolated settings, without fully considering the unique constraints of transit environments, such as time limitations, noise, and the transient nature of the learner's attention [26, 27].

Second, existing research often overlooks the integration of instructional design theories within public transportation. While there are many theoretical frameworks for instructional design, few studies apply these models to real-world, non-traditional settings like public transport. This gap suggests that more work is needed to adapt and tailor these models to the specific needs of commuters, who face distractions and short learning intervals [28].

Finally, research on instructional strategies in public transportation has not fully explored the potential for diverse learner populations. Public transportation systems serve a wide demographic, from young students to older adults, with varying educational backgrounds. Instructional design strategies must account for these differences to be effective. By addressing these gaps, this study aims to provide a comprehensive analysis of effective instructional design strategies that can be applied in public transportation settings. This will contribute to the development of a more nuanced and adaptable framework for public transportation learning environments [29-31].

3. Methodology

3.1 Systematic review approach

A systematic review approach is a rigorous and structured methodology used to identify, evaluate, and synthesize relevant studies on a particular topic. This approach follows a predefined protocol to minimize bias and ensure that the findings are reliable and comprehensive. In this study, the systematic review will be conducted by searching multiple academic databases for studies related to instructional design in public transportation learning environments. This process ensures that all relevant literature is considered, and that the review is based on the best available evidence.

The systematic review approach involves several key steps, starting with a comprehensive search strategy to identify all relevant publications. This includes peer-reviewed journal articles, conference papers, reports, and other credible sources. Each study will be assessed for quality and relevance to the research question. By adhering to strict inclusion and exclusion criteria, this methodology ensures that only studies that meet rigorous standards are included in the review. This approach also emphasizes transparency, reproducibility, and consistency in evaluating studies, providing a robust basis for synthesizing the findings.

The selection of studies for inclusion in the systematic review will be guided by specific criteria designed to ensure that the studies are both relevant and of high quality. The first criterion involves the focus of the study: only research that explores instructional design strategies in public transportation environments will be included. Studies that examine instructional methods, technologies, or interventions in other non-traditional learning environments, such as online or workplace learning, will also be considered if they provide insights relevant to public transportation settings.

Other inclusion criteria include the publication date, language, and study type. Only studies published in the last two decades will be considered to ensure that the review reflects the most recent developments in instructional design and technology. Furthermore, studies must be published in English or have an accessible English translation to ensure clarity and consistency. Finally, only peer-reviewed articles and scholarly works will be selected to maintain the review's quality. This ensures that the studies included have undergone rigorous academic scrutiny.

3.2 Data extraction and synthesis

Data extraction is a critical step in the systematic review process, involving the systematic collection of relevant data from each study. During this phase, key information such as the study's objectives, methodologies, instructional design strategies, and outcomes will be extracted. This data will be organized into a standardized extraction form to ensure consistency across studies. For each study, details such as the type of instructional strategy used, the target population, the learning environment, and any technology employed will be recorded.

Once the data has been extracted, the next step is synthesis. The synthesis process involves analyzing the extracted data to identify patterns, trends, and gaps in the literature. This may include comparing the effectiveness of different instructional strategies across various contexts or populations within public transportation. The goal is to summarize the findings in a way that provides actionable insights for instructional designers, educators, and policymakers. The

synthesis process will also identify areas where further research is needed, ensuring that the systematic review contributes to both current practice and future research directions in public transportation learning environments.

4. Findings and Discussion

4.1 Key instructional design strategies identified

The systematic review of instructional design strategies in public transportation learning environments has revealed several key approaches that have been employed to enhance learning outcomes. One of the most prominent strategies is the use of mobile learning applications. These apps offer commuters the flexibility to engage in learning activities during their commute, providing tailored content such as language lessons, quiz-based learning, and interactive exercises. Research indicates that mobile learning can be particularly effective in public transportation environments, as it aligns with the short, fragmented periods of time commuters typically have available.

Another key strategy identified is the integration of multimedia content, such as audio, video, and interactive signage, into public transport systems. Studies show that multimodal learning, which combines auditory, visual, and kinesthetic elements, enhances engagement and retention, particularly in environments like buses or subways, where traditional text-based resources might not be effective. Additionally, gamification techniques, such as incorporating game-like elements into instructional design, have been found to increase learner motivation and engagement, making learning more enjoyable and effective. These strategies highlight the importance of adaptability and innovation in instructional design within public transportation settings.

4.2. Effectiveness of different approaches in public transportation environments

The effectiveness of various instructional design strategies in public transportation environments varies depending on factors such as the type of transportation, learner demographics, and the specific learning objectives. Mobile learning applications, for example, have shown promising results in enhancing knowledge retention and learner engagement, especially when learners are provided with personalized content that fits within their short travel times. These apps allow for self-paced learning, which is beneficial for learners who might not have regular access to more structured educational environments [32, 33].

However, not all strategies are equally effective in every transportation setting. For instance, while digital signage and multimedia content can be effective in busier, more visually conducive environments like subway stations, they may not work as well in quieter or smaller vehicles like trams or light rail. Similarly, the effectiveness of gamification depends heavily on the design of the game and the level of engagement it offers. If the game mechanics do not align with the learners' interests or the time constraints of their commute, engagement may decrease, reducing its overall effectiveness. Therefore, the key to success in public transportation learning environments lies in selecting the right combination of strategies tailored to specific contexts and learner needs.

4.3. Implications for future instructional design in public transportation

The findings from this review have important implications for future instructional design in public transportation environments. First, there is a clear need for greater customization in instructional strategies to accommodate diverse learner populations. Future instructional designs should consider factors such as the commuter's age, educational background, and language proficiency, ensuring that learning materials are accessible and engaging for a wide range of individuals [34, 35].

Additionally, instructional design in public transportation should prioritize flexibility and adaptability, given the transient and often unpredictable nature of the environment. For example, microlearning approaches, which deliver short, targeted learning modules, are well-suited to the brief, fluctuating periods of time available to commuters. Integrating adaptive learning technologies that respond to the learner's progress and preferences could further enhance the learning experience.

Finally, future research should explore the potential of hybrid models that combine multiple instructional strategies, such as integrating mobile learning with multimedia content or using gamification alongside traditional learning materials. These hybrid models may offer the best of both worlds, combining the benefits of different approaches to create a more engaging and effective learning experience for commuters [36, 37].

5. Conclusion

This systematic review has identified several key instructional design strategies that can be effectively applied in public transportation learning environments. Mobile learning applications emerged as one of the most prominent strategies, offering commuters the flexibility to engage with educational content during their commute. Additionally, the integration of multimedia content, such as audio, video, and interactive signage, proved effective in enhancing learner engagement and retention. Gamification techniques also emerged as a valuable strategy, increasing motivation and making learning more enjoyable. However, the review also highlighted that the effectiveness of these strategies is contingent upon the specific context of the public transportation system, including factors like the type of transportation, learner demographics, and the duration of the commute.

The findings suggest that a combination of mobile learning, multimedia content, and gamification holds significant potential for creating engaging and effective learning experiences in public transport. Moreover, instructional design in public transportation should be tailored to meet the diverse needs of commuters, taking into account time constraints and the varying nature of the transport environment.

This study contributes to the field of instructional design by extending the understanding of how educational strategies can be adapted for non-traditional learning environments, particularly public transportation. By synthesizing current research on instructional design in these contexts, the review has highlighted the unique challenges and opportunities of using public transport as a platform for learning. The findings underscore the importance of flexibility and adaptability in instructional design, as well as the need for innovative approaches that cater to learners who are often constrained by time and space.

The review also enriches the instructional design literature by integrating theoretical models with practical strategies in public transportation. By emphasizing the role of mobile learning, multimedia content, and gamification, this study provides actionable insights for instructional designers and educators aiming to create effective learning experiences in transient and diverse environments. Furthermore, the identification of key instructional strategies specific to public transport environments will help inform future research and educational practices in these underexplored contexts.

While this review has provided valuable insights into instructional design strategies for public transportation learning environments, there are several areas that warrant further investigation. First, future research should explore the long-term effectiveness of mobile learning applications in public transport. Most studies have focused on short-term engagement, but it is crucial to understand whether these strategies lead to sustained learning and knowledge retention over time.

Second, more research is needed to explore the impact of learner demographics on the effectiveness of instructional strategies in public transportation. Factors such as age, educational background, and language proficiency could influence how learners interact with educational content, and future studies should investigate how instructional design can be tailored to these diverse learner profiles.

Finally, studies need to examine the integration of multiple instructional strategies in public transportation settings. Research could focus on hybrid models that combine mobile learning, multimedia, and gamification to create more dynamic, personalized learning experiences. Investigating the effectiveness of these hybrid approaches will provide valuable insights into how instructional design can be optimized for non-traditional, real-world learning environments like public transportation.

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