International Review of Applied Sciences
Vol. 12, No. 1, 1-9, 2026
ISSN(E) 2411-667X/ ISSN(P) 2518-0207
DOI: 10.20448/iras.v12i1.8702

A systematic literature review on m-learning supported by VANETs: Dissemination of educational content via RSUs and vehicular multi-hop in distance education environments

Santiago Cardoso[1] ✉
Adriano Fiorese[2]
Avanilde Kemczinski[3]

(✉ *Corresponding Author*)

[1,2,3]*Department of Computer Science, University of Santa Catarina State, Joinville, Brazil.*
[1]*Email: santiago.cardoso@edu.udesc.br*
[2]*Email: adriano.fiorese@udesc.br*
[3]*Email: avanilde.kemczinski@udesc.br*

Abstract

Distance Education (DE), driven by its mobile counterpart, Mobile Learning (m-Learning), relies on portable devices and stable connectivity. In regions with poor network infrastructure or during long commutes, this dependency significantly hinders the continuity of the learning process. Vehicular Ad Hoc Networks (VANETs) emerge as a promising alternative to mitigate this issue by creating opportunistic communication networks. The efficient dissemination of educational content, initiated via Roadside Units (RSUs) and propagated through multi-hop communication among vehicles, poses a significant technical challenge. This paper presents a Systematic Literature Review (SLR), following a structured protocol, to investigate how data dissemination mechanisms in VANETs support m-Learning environments. The results highlight that current literature predominantly focuses on the technical aspects of VANETs or on using vehicular technology as a teaching subject. Consequently, the SLR reveals a notable absence of studies on the practical implementation of VANETs as a support infrastructure for delivering general educational content in m-Learning contexts.

Keywords: Education, M-Learning, Multi-hop, RSU, SLR, VANET.

Citation | Cardoso, S., Fiorese, A., & Kemczinski, A. (2026). A systematic literature review on m-learning supported by VANETs: Dissemination of educational content via RSUs and vehicular multi-hop in distance education environments. *International Review of Applied Sciences*, *12*(1), 1–9. 10.20448/iras.v12i1.8702
History:
Received: 2 April 2026
Revised: 5 May 2026
Accepted: 13 May 2026
Published: 22 May 2026

Publisher: Asian Online Journal Publishing Group

Funding: This research was funded by the Coordination for the Improvement of Higher Education Personnel (CAPES), Brazil [Grant Number: PROAP/AUXPE]. Additional support was provided by the University of Santa Catarina State (UDESC) through the PROBIC scholarship.
Institutional Review Board Statement: Not applicable.
Transparency: The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.
Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.

Contents

Contribution of this paper to the literature

This paper is the first Systematic Literature Review to investigate the intersection of VANETs and m-Learning. Unlike previous works focusing solely on technical aspects or vehicular technology as a teaching subject, it explores how vehicular multi-hop communication and Road Side Units (RSUs) can mitigate connectivity challenges in mobile distance education.

1. Introduction

Distance Education (DE) has transformed access to knowledge, providing flexibility and overcoming geographical barriers [1]. With the notable presence of technologies such as portable mobile devices (e.g., smartphones and tablets), Mobile Learning (m-Learning) has emerged as an extension of DE, enabling learning to be carried out anywhere and at any time [2]. However, the ubiquitous learning model provided by m-Learning requires a continuous and high-quality Internet connection. In areas with low connectivity, such as rural areas, peripheral urban zones, or even during long commutes, the reliance on a constant connection is often unstable or non-existent, posing a significant challenge.

In parallel, Vehicular Ad Hoc Networks (VANETs) are mobile communication systems that enable information exchange between vehicles and roadside infrastructure, such as Roadside Units (RSUs) (e.g., antennas, communication base stations, and data pre-processing units) [3]. VANETs create dynamic and self-organizing networks through Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I), and Vehicle-to-Everything (V2X) communications, which traditionally support monitoring and alerting of critical traffic events in urban environments [3]. However, their high capacity to efficiently propagate and store data in highly mobile environments enables a wide range of applications related to the dissemination of general interest content [4].

This work addresses the challenge of ensuring continuous access to m-Learning content for students on the move in areas with limited Internet connectivity. The dynamic nature of VANETs, coupled with their intermittent connection topology, offers a potential solution: creating an opportunistic network for delivering educational content. In this sense, RSUs, positioned in strategic locations such as schools, universities, or public transport terminals, can act as content sources, distributing information into the vehicular network. This information can then be propagated in a multi-hop fashion until it reaches the devices of students requiring access.

Despite its potential, the application of VANETs for educational purposes is an underexplored area. This work is motivated by the need to systematically investigate how data dissemination mechanisms, already proposed and validated for other purposes in VANETs, can be adapted for the educational environment. The unification of these components is the first step toward designing robust systems that transform idle time in transit into a learning opportunity, allowing students in low-connectivity areas or on long commutes to access teaching materials.

This work aims to conduct a Systematic Literature Review (SLR) to synthesize and analyze existing studies on data dissemination in VANETs and characterize connectivity challenges in m-Learning. It is necessary to map the state of the art, identify the main challenges and opportunities, and research gaps between these two areas.

This work aims to provide an overview of the main issues related to connectivity and access to educational content in m-Learning environments within mobility contexts in low-connectivity areas. It also seeks to address the following questions: How can the information dissemination and data storage capabilities in VANETs be applied to mitigate the connectivity problems found? What are the research gaps and future directions at the intersection of VANETs and educational technologies? What are the requirements and challenges for implementing an m-Learning system over vehicular infrastructure?

To achieve the objective and answer the research questions, this work conducted an SLR. This study adopts the general protocol proposed by Kitchenham and Charters [5], a consolidated methodological reference in the field of Software Engineering and Computing. The protocol is structured in three main phases: planning, conducting, and synthesizing the results. The online tool Parsifal was used to support the execution and management of this protocol. Furthermore, the Connected Papers tool, based on Artificial Intelligence (AI)-driven search, was used to find related works for the proposed SLR.

The remainder of this paper is structured as follows. Section 2 presents the fundamental concepts of m-Learning, SLR support tools, and communication in VANETs. Section 3 presents related works. Section 4 details the protocol followed to conduct the SLR. Section 5 presents and discusses the results extracted from the selected studies. Section 6 discusses the analyzed works and proposes an experimental scenario for the use of m-Learning in VANETs for future work in the area. Section 7 concludes this paper, synthesizes the findings, and points to directions for future research.

2. Background

This section presents the fundamental concepts and tools that provide the basis for this work, addressing the characteristics of m-Learning, the technologies used to support the SLR, and the communication principles in VANETs.

2.1. Mobile Learning (M-Learning)

Mobile Learning (m-Learning) is a DE modality that uses mobile devices, such as smartphones and tablets, as the primary tools for the learning process [2]. Its main advantage is flexibility, allowing students to access content and perform activities from anywhere and at any time. This modality has gained significant adoption due to the widespread availability of mobile devices and the increasing demand for ubiquitous access to educational resources, proving particularly beneficial for adult learners, professionals, and individuals in remote or underserved areas [6].

Among the prominent pedagogical approaches in this field is microlearning, which delivers flexible and concise educational modules via mobile applications [6]. Furthermore, modern platforms are increasingly integrating AI to offer personalized learning paths and real-time feedback, significantly enhancing student engagement and instructional efficiency [6].

However, the adoption of m-Learning faces substantial technical and socioeconomic challenges. These include the digital divide, which is the disparity in technology access across different regions, as well as concerns regarding data privacy and the lack of hardware and software compatibility across diverse mobile ecosystems [6].

Central to these challenges is the fact that the effectiveness of m-Learning is intrinsically dependent on the quality of the network connection. In mobility scenarios, such as daily commuting (especially by road), or in regions with deficient network infrastructure, the intermittency or absence of connectivity presents itself as one of the major challenges for the continuity and quality of the educational experience [1].

2.2. SLR Support Tools

To ensure the rigor and reproducibility of this SLR, two main tools were employed.

- Parsifal: An online platform specifically designed to support the execution of SLRs. It was used to document the research protocol, define the search string, manage the selection of articles based on inclusion and exclusion criteria, and perform the data extraction phase; and

Connected Papers: • An artificial intelligence-driven tool used to build visual graphs of related works. It helped identify seminal papers and recent studies through co-citation analysis. In this review, it was used for a more in-depth search based on the following keywords: VANET, Vehicles, Autonomous, Education, m-Learning, and Electronic Learning (e-Learning), complementing the manual search in digital libraries.

2.3. Communication in VANETs

Communication in VANETs requires a constant exchange of information. To enable this, communication strategies involving vehicle clustering [7], V2V, V2I, and V2X are identified as effective solutions [3]. These three types of communication (V2V, V2I, and V2X) are constantly employed in VANETs, as shown in Figure 1 and defined below.

- Vehicle-to-Vehicle: In V2V communication, vehicles in the network transmit traffic-related information to other nearby vehicles without the need for a central infrastructure. This type of communication greatly favors the creation of a cooperative driving environment, since vehicles use the information received from others to be informed about accidents, adverse traffic conditions, and to protect themselves from sudden stops by other drivers, among other real-time situations [8]. Thus, V2V is a crucial element for VANETs, as it allows vehicles to adjust their routes and behaviors based on the information received from other vehicles, in addition to being able to disseminate content among themselves. Applied to m-Learning, this decentralized exchange is what allows vehicles to act as mobile caches, sharing downloaded educational materials directly with other vehicles via multi-hop communication, enabling students to access content even in areas completely lacking Internet infrastructure.
- Vehicle-to-Infrastructure: In V2I communication, vehicles in the network transmit traffic information directly to the road infrastructure, such as traffic lights, sensors, base stations, and cameras. This type of communication aims to improve traffic management, transport system efficiency, and other aspects that allow vehicles to receive critical information to act in real time [8]. Thus, the smart infrastructure in V2I communication is a crucial element for VANETs, as it can collect real-time data and pass it on to the vehicles, allowing continuous optimization of traffic conditions and information dissemination within the network. Furthermore, in an m-Learning environment, V2I acts as the primary source for content distribution. Strategic infrastructures, such as RSUs installed at universities or bus terminals, can store and transmit educational modules directly to passing vehicles, injecting the data into the network so it can be carried to low-connectivity areas.
- Vehicle-to-Everything: In V2X communication, the V2V and V2I models are combined, enabling interaction with other network elements (e.g., pedestrians, cellular network, and cloud) [9]. The goal of V2X is to create a highly connected ecosystem in which all participants share information to maximize the benefits of VANETs. For example, in the m-Learning scenario, a student with a smartphone could automatically share educational information with nearby vehicles, enabling proactive data caching, among other actions. Therefore, V2X communication represents the possibility of a highly cooperative transport system that ensures maximum efficiency and enables ubiquitous access to educational materials across diverse mobile elements, extending the learning environment beyond the vehicles themselves.

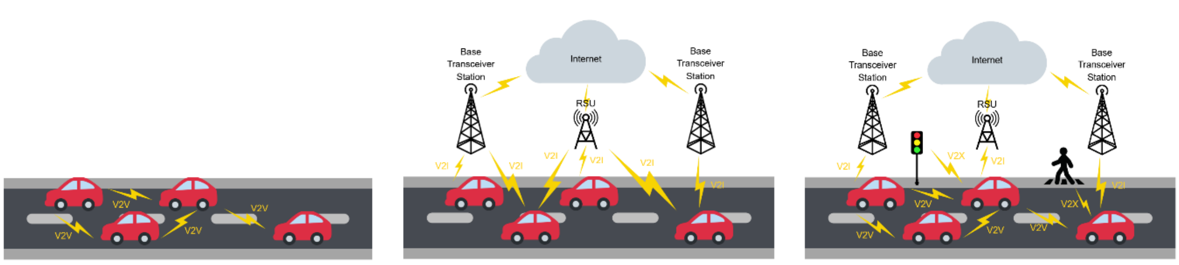

Figure 1. VANET communication strategies.

3. Related Work

Conducting an SLR requires analyzing related secondary works to identify gaps and justify the contribution of the new review. During the planning phase, a search was conducted for other reviews combining the themes of Vehicular Networks and m-Learning. No work was identified that performed the same synthesis proposed by this work. However, reviews addressing each domain in isolation were found.

Tomar et al. [3] conducted an SLR on the challenges and strategies for information dissemination in VANET environments. This work reviews the state of the art in VANETs, addressing several themes in the field. Furthermore, it proposes the deployment of data collection units along roads and the organization of vehicles into groups (i.e., clusters). Such a distribution uses the V2V and V2I communication models as support for message communication and aims to reduce latency in data transmission between vehicles and improve network connectivity. However, the article provides an analysis focused on technical and theoretical concepts of the VANETs area. In contrast, the SLR performed in this work aims to study the works that use VANETs in the educational environment.

Palanci et al. [10] conduct a systematic literature review (SLR) on the use of learning analytics. The objective is to reveal the main trends and findings in the field, analyzing several articles to identify the most studied methods, platforms, and variables. The authors highlight that, despite the benefits of optimizing the teaching process, learning data analysis faces challenges such as high costs and implementation complexity. However, the analysis focuses on optimizing the learning experience through the analysis of data generated on online platforms already connected to the Internet. In contrast, this work does not focus on learning data analysis but rather on the fundamental problem of content access, investigating how VANETs can serve as an alternative communication infrastructure in scenarios where conventional connectivity is a problem.

Lazaro and Duart [11] conduct a systematic literature review (SLR) on the use of m-Learning applications in higher education. The study explores how researchers have documented the impact of mobile learning tools, highlighting that m-Learning strengthens interaction, communication, and collaboration between students and instructors. However, the work is directed towards mobile networks in general and the use of mobile learning tools. In contrast, the proposal of this article is directed towards mobile networks in the domain of VANETs, seeking to understand related works on the theme of m-Learning, starting from the premise of the lack or failure of connectivity in regions with less access to networks, and proposes to investigate an infrastructure solution to enable m-Learning in these challenging contexts.

Benzerogue et al. [12] conduct an SLR on multimedia transmission (streaming) in VANETs. The study focuses on analyzing streaming protocols and resource management, such as bandwidth, to optimize users' Quality of Service (QoS) and Quality of Experience (QoE). It discusses challenges and solutions for media transmission for safety and entertainment. The protocols and resource optimization strategies analyzed are relevant to disseminating educational video content, contributing to the development of a vehicular m-Learning environment.

Therefore, a gap is observed in the literature regarding the systematic investigation of the intersection between these two areas. This work differentiates itself by being the first to focus on analyzing the applicability of VANET mechanisms to mitigate the specific connectivity challenges of m-Learning.

4. Systematic Literature Review Protocol

To achieve the proposed objective, an SLR was conducted, a rigorous method for identifying, evaluating, and interpreting relevant research on a specific question. The protocol [5] of this review was managed with the help of online tools Parsifal and Connected Papers, following the planning, conducting, and synthesizing steps.

4.1. Research Questions

The review process was guided by the following Research Questions (RQs).

- RQ1: What are the main mechanisms and protocols for data dissemination in VANETs (e.g., critical events and traffic information), considering efficiency, latency, and range?
- RQ2: How are multi-hop communication and RSU infrastructure used to ensure coverage and reliability in information delivery within vehicular environments?
- RQ3: What are the main connectivity and content access challenges faced by m-Learning platforms, especially in mobility contexts and areas with low Internet coverage?
- RQ4: In what way can the data dissemination and storage capabilities of VANETs be applied to mitigate the connectivity challenges of m-Learning?
- RQ5: What are the main research gaps and directions for future work at the intersection of VANETs and educational technologies?

4.2. Data Source and Search Strategy

The search for primary studies, through the Parsifal tool, was conducted in the following digital databases: Association for Computing Machinery (ACM), Institute of Electrical and Electronics Engineers (IEEE), and ScienceDirect. The search string was built based on Population, Intervention, Comparison, Outcomes, and Context (PICOC) terms, combining keywords from the VANETs and m-Learning domains with the logical operators AND and OR.

The keywords and synonyms used for each related topic were:

- Comparison: 3G, 4G, 5G, Cellular Networks, Wi-Fi, and Conventional Internet Connectivity.
- Outcome: Continuous content access, content availability, latency reduction, learning continuity, and packet delivery ratio.
- Population: Distance Education, Educational Content, m-Learning Users, and Mobile Devices.
- Intervention: RSU, Roadside Units, V2I, V2V, VANET, Vehicular Ad Hoc Networks, Data Dissemination, Multi-Hop Communication, and Vehicular Content Dissemination.

4.3. Study Selection Criteria

After the initial search, the articles were evaluated using specific Inclusion Criteria (ICs) and Exclusion Criteria (ECs) to ensure that only relevant, high-quality, and current primary studies aligned with the research questions (RQs). The ICs guarantee that the selected articles address the core technical elements of this work, including VANETs, data dissemination mechanisms, and m-Learning challenges. Conversely, the ECs serve as filters for quality and scope, removing duplicates, incomplete, or inaccessible works. Additionally, specific ECs were established to maintain technological currency by limiting works to 2020 onwards and to restrict the scope to network and application domains, intentionally excluding purely pedagogical studies (EC3) or focused solely on hardware and physical layers (EC5). Therefore, the study selection was guided by these criteria.

- IC1: The article is available for reading.

- IC2: The article discusses m-Learning challenges.
- IC3: The article discusses mechanisms, protocols, or strategies for data dissemination.
- IC4: The article is a primary study.
- IC5: The article addresses VANETs or vehicular communication as its main theme.
- EC1: The article is a duplicate.
- EC2: The article is not written in English.
- EC3: The article discusses m-Learning solely from a pedagogical perspective, without proposing or analyzing computing artifacts such as software, hardware, or protocols related to vehicular environments.
- EC4: The article is an abstract, an editorial, or has less than 4 pages.
- EC5: The article focuses exclusively on the physical layer.
- EC6: The article was published before 2020.

4.4. Search String

To perform the search for the studies, the following search string was used: ("VANET" OR "Vehicular Network") AND ("V2V" OR "Multi-Hop Communication" OR "V2I" OR "RSU") AND ("Mobile Learning" OR "Electronic Learning" OR "Education").

4.5. Quality Assessment and Data Extraction

The studies that met the selection criteria were subjected to a quality assessment using a checklist.

- Are the research objectives or questions clearly defined?
- Is the study context (e.g., application domain and environment) well defined?
- Is the research methodology (e.g., simulation setup and experimental procedure) described with sufficient detail to allow replication?
- Are the results presented clearly, and are they a logical consequence of the methodology?
- Are the conclusions and contributions of the article supported by the results presented?

For the approved studies, data were extracted using a standardized form designed to collect information on:

- Publication Year.
- Study Type.
- Dissemination strategy.
- Use of RSUs.
- Role of RSUs.
- Evaluation Method.
- Simulation tools used.
- Actual Implementation.
- Evaluation Metrics.
- Main Contribution.
- Mentioned Limitations.
- Proposed Future Work.

5. Review Results

The initial search with the Parsifal tool in the databases, using the defined search string, returned a total of 834 articles, as shown in Table 1.

Table 1. Primary search results in Parsifal by database.

Search source	Articles Found
ScienceDirect	443
ACM Digital Library	234
IEEE Digital Library	157
Raw Total	834

From this amount, articles were selected using the ECs and ICs defined in the SLR protocol. Among the works, duplicate articles (EC1) and works not written in English (EC2) were identified and removed. Next, works that were abstracts, editorials, or had fewer than 4 pages (EC4), and those published before 2020 (EC6), were removed to maintain technological currency.

Finally, purely pedagogical works that did not address computing artifacts, such as software or hardware related to VANETs (EC3), and those focused exclusively on the physical layer (EC5), were removed.

Five articles were selected that, although they do not deal directly with education, provide the necessary infrastructure for caching, data dissemination, and technologies in VANETs to support applications aimed at the educational area with m-Learning. Due to the scarcity of articles explicitly uniting VANETs and m-Learning in traditional databases, the Connected Papers tool was used in an exploratory manner. According to the defined keywords, the tool returned a series of connected works, from which the 7 articles most adherent to the educational theme were selected to compose the SLR analysis. In the end, 12 primary studies were selected for data extraction. Table 2 details the article selection process.

Table 2. Article selection process.

Step	Applied Criteria	Articles
Initial Search (Raw Total)	-	834
Removal of Duplicates and Language	EC1, EC2	-114
Filtering by Type and Year	EC4, EC6	-450
Screening by Title and Abstract	EC3, EC5	-265
Selected Technical Articles	IC1, IC3, IC4, IC5	5*
Educational Articles (Complementary Search)	IC1, IC2, IC4, IC5	7**
Final Total of Articles	-	12

Note: *Selected for infrastructure support. **Selected via Connected Papers.

Table 3 presents the synthesis of 12 selected works (5 technical and 7 educational), relating them to the publication year, the main focus of the approach, and which RQs they help answer.

Table 3. Synthesis of the selected primary studies and their relationship with the RQs.

References	Year	Main focus of the approach	Related RQs
Hu, et al. [13]	2020	Data security and authentication in VANETs.	RQ1, RQ2, RQ5
Jiang, et al. [14]	2021	Use of Deep Learning to optimize large-scale data delivery.	RQ1, RQ2
Kadhim, et al. [15]	2022	Efficient multicasting using parked vehicles and Fog Computing (Fog).	RQ2, RQ4
Nguyen, et al. [16]	2025	Edge caching for video transmission.	RQ3, RQ4
Noman and Atkison [17]	2023	Network attack mitigation techniques in VANETs.	RQ2, RQ3, RQ5
Qiao, et al. [18]	2023	Public education on autonomous vehicles via simulation.	RQ5
Hayes, et al. [19]	2021	University curricula for electric vehicle technology.	RQ5
Rother, et al. [20]	2023	Scaled vehicle for teaching and research in autonomous control.	RQ1, RQ5
Vilas Samak, et al. [21]	2021	Simulation platform for education in V2X.	RQ5
Trúchly, et al. [22]	2024	A tool for simplified teaching of vehicular networks.	RQ5
Sangi, et al. [23]	2023	Redundancy control in Information-Centric Networking (ICN) for vehicular Internet of Things (IoT).	RQ1, RQ2
Tang, et al. [24]	2020	Cooperative content download in VANETs.	RQ3, RQ4

5.1. Identified Mechanisms and Protocols (RQ1 and RQ2)

To answer which mechanisms support dissemination in VANETs, the SLR extracted vehicular communication and security techniques from the articles. The results were categorized into three main topics.

- Information Security: Hu et al. [13] and Noman and Atkison [17] identified that data integrity is of utmost importance. Techniques were mapped for Aggregate Signature to efficiently authenticate and protect the integrity of data transmitted by multiple terminals, and Intrusion Detection Systems to mitigate Sybil, Jamming, and Timing attacks that interrupt the connection.
- Delivery Optimization and Redundancy: Jiang et al. [14] propose the use of Deep Learning (DL) to optimize the data flow to be delivered. Sangi et al. [23] introduce a redundant transmission control algorithm based on network coding in Information-Centric Networking (ICN) architectures, aiming to reduce data redundancy and accelerate transmission.
- Topology and Support Infrastructure: Kadhim et al. [15] present a multicasting approach that uses parked vehicles as Fog Nodes and Software Defined Networks (SDNs).

5.2. Mapped Connectivity Challenges (RQ3 and RQ4)

The data extracted from the primary articles indicate high latency and intermittent connectivity as the main challenges for applications with high data consumption, such as educational videos in m-Learning. The identified solutions focus on reducing dependence on centralized infrastructure.

- Caching and Cooperation Strategies: Nguyen, et al. [16] propose a hybrid caching model (deterministic and probabilistic) at the network edges, minimizing service time in cooperative video transmission. Tang et al. [24] address cooperative content downloading to select the best cooperating nodes, overcoming bandwidth scarcity in direct connections.

5.3. Classification of Educational Approaches (RQ5)

When analyzing the intersection between VANETs and education, the selected articles were classified according to their teaching objectives. The quantitative analysis of this category reveals a division in research focuses.

1. Teaching Tools: Vilas Samak, et al. [21]; Trúchly et al. [22] and Rother et al. [20] present the development of simulators and scaled vehicles as tools for teaching engineering and networks.
2. Technical Education: Hu et al. [13] and Noman and Atkison [17] address security issues in VANETs and propose mechanisms for data authentication and protection, with practical methods for fixing vulnerabilities and attack mitigation techniques.
3. Curriculum Development: Hayes et al. [19] describe university course structures and training programs focused on training the workforce for the automotive industry.
4. Public Awareness: Qiao et al. [18] report the use of simulation to educate laypeople about the safety and acceptance of autonomous vehicles.

The absence of articles classifying vehicles and traffic infrastructures as channels for content delivery from other areas of knowledge is noted, focusing almost exclusively on teaching vehicular technology itself.

6. Discussion

The analysis of the selected studies enables answering the research questions defined in this work. This section discusses the synthesis of the answered questions, organizing them according to each RQ.

6.1. Mechanisms and Protocols for Data Dissemination (RQ1 and RQ2)

In response to RQ1 and RQ2, the analyzed studies indicate that data dissemination mechanisms in VANETs are directed towards network performance. The works by Hu et al. [13] and Noman and Atkison [17] address the necessary security issues in VANETs to ensure efficient performance, providing a secure network capable of delivering information. The works by Jiang et al. [14], Kadhim et al. [15], and Sangi et al. [23] demonstrate that the use of DL and Fog Computing techniques is a new option to traditional protocols. The use of parked vehicles and deep learning algorithms suggests a trend towards more predictive and resilient networks, essential to support educational data traffic.

6.2. Mitigation of m-Learning Challenges (RQ3 and RQ4)

In response to RQ3 and RQ4, the analyzed studies confirm the m-Learning challenge related to dependence on continuous connectivity and low latency. The works by Nguyen, et al. [16] and Tang et al. [24] validate that the use of proactive caching in RSUs and cooperative sharing among vehicles are viable mechanisms to enable streaming of classes and heavy content, mitigating dependence on a constant cellular connection.

6.3. Gaps and Future Directions at the Intersection of VANETs and Education (RQ5)

In response to RQ5, the analyzed studies reveal the main gap and directions for future work. The works by Hayes et al. [19]; Hu et al. [13]; Noman and Atkison [17]; Rother et al. [20]; Vilas Samak et al. [21], and Trúchly et al. [22] propose simulators, security techniques, hardware platforms, and curricular programs to teach the public or future engineers about autonomous and electric vehicles and their technologies.

Most studies that connect "vehicles" and "education" do not focus on disseminating m-Learning content through vehicular networks. Instead, they emphasize education about vehicular technology. The primary gap is the lack of studies that develop, implement, and validate complete systems for delivering m-Learning content via VANETs.

6.4. Future Research

For future research in m-Learning with VANETs, it is proposed to build simulation environments that allow the validation of real scenarios of educational content dissemination in VANETs. To this end, there are tools already established in the literature, namely: a computer network simulator (Network Simulator 3 (NS-3) [25]), a mobility simulator (Simulation of Urban Mobility (SUMO) [26]), the project that mapped the city of Luxembourg (Luxembourg SUMO Traffic (LuST) [27]), enabling the use of a real environment, and a simulation framework (Monitoring and Dissemination of Urban Events (MINUET)) [7]).

6.4.1. Network Simulator 3

NS-3 is an open-source computer network simulator widely used by the academic and scientific community for research and development in the area of data communication networks [25]. The simulator is equipped with several libraries that implement protocols of the physical, link, network, and transport layers, being essential for communication in vehicular networks, allowing a realistic simulation environment for the exchange of messages between vehicles and infrastructure.

6.4.2. Simulation of Urban Mobility

SUMO is an open-source network traffic simulator widely used for studies in vehicular networks [26]. The simulator allows modeling complex road topologies, including urban streets and highways, representing the individual behavior of each vehicle. It can simulate routes, speed, and interactions with traffic infrastructure such as traffic lights and intersections, enabling the extraction of realistic mobility data.

6.4.3. Luxembourg SUMO Traffic

LuST is a large-scale, realistic traffic scenario developed for use in the SUMO simulator [27]. It models the mobility of Luxembourg based on real mobility data. Figure 2 shows the topology of the Luxembourg city scenario. LuST adds realism and credibility to experiments, ensuring m-Learning systems in VANETs work in realistic environments.

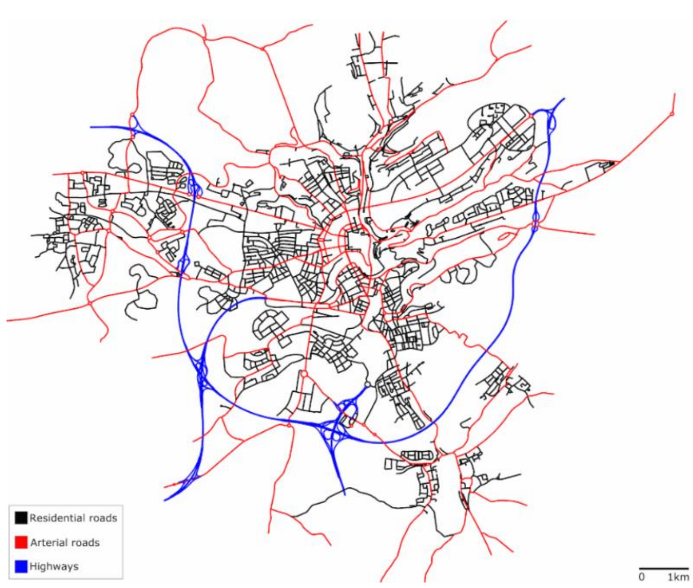

Figure 2. Topology of the LuST scenario.

Source: Codeca et al. [27].

6.4.4. Monitoring and Dissemination of Urban Events

MINUET is a VANETs simulation framework aimed at detecting and disseminating critical urban events in VANETs [7]. It manages the creation of network nodes in NS-3, corresponding to vehicles in SUMO, updates their positions, and allows the execution of network applications in vehicles and simulated infrastructures, enabling full configuration of the experimentation environment.

7. Conclusion

The modeling of network systems for disseminating educational content in VANETs is a recent research area that emerged alongside VANETs in the 2000s, aiming to improve communication, traffic safety, and information dissemination by utilizing vehicles' ability for spontaneous formation of communication networks and traffic infrastructures dynamically.

Several research challenges remain open regarding the formation of educational content dissemination networks using V2V, V2I, and V2X communication in VANETs. The number of studies on this topic remains limited, considering the importance and impact of successfully disseminating educational information to areas with limited access. The problem addresses aspects ranging from developing and implementing new technologies to make this approach viable, ensuring the safety of drivers and pedestrians due to the type of vehicular network established by VANETs, and establishing environments conducive to disseminating educational content.

VANETs are a promising field, especially in urban contexts and large cities, where the exchange of information between vehicles and traffic infrastructures occurs frequently and must be reliable and efficient to ensure the dissemination of information. Research on the propagation of educational content in VANETs provides an innovative approach to using this network model. Thus, the SLR conducted in this work succeeded in evaluating the current efforts in the research area regarding the dissemination of educational content in VANETs. Despite the current advances in research within the VANETs area, further theoretical and practical investigation into the subject is necessary, with the creation of practical and more consolidated approaches to provide a suitable and effective educational environment. As future work, the development of primary studies, with proposals for content dissemination algorithms, is necessary.

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