Review article

M-Learning in education during COVID-19: A systematic review of sentiment, challenges, and opportunities

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A B S T R A C T

The flexibility and relatively low cost of mobile devices make educational systems more accessible for learners and educators worldwide. When incorporated with the internet, it creates a better learning environment than the conventional classroom lecture. Many studies have been done to shed insight into the existing state of mobile learning (M-learning) studies. However, further research is needed into this topic at a specific time, i.e., during the COVID-19 pandemic. This study aims to retrieve, review, investigate, and critically assess the existing literature on M-learning that was conducted during the COVID-19 concerning our research theme. This study considered publications from four databases, narrowed our initial search results of 4056 articles down to 83 that are relevant to our research questions, and did an in-depth analysis based on the systematic review protocol. The findings explored the major focusing areas of M-learning applications, the regional sentiment of M-learning users, the determinants and perceptions of M-learning, as well as the benefits, challenges, and opportunities associated with M-learning. This systematic literature review (SLR) was performed to apportion a contribution toward an improved understanding of the basic principles that underpin the rethinking of M-learning applications for policymakers, online course designers, and blended learning facilitators.

1. Introduction

Mobile phones as well as smartphones have proliferated at an incredible rate steadily over recent years [1]. As of today, nearly 97 percent of the world's population is now under the umbrella of mobile network connection while about 53.6 % use the Internet [2]. Similar to other domains, the usage of mobile devices (i.e., smartphones) by educational systems, as well as by general students, has risen dramatically in recent years. Concerning this fact, the use of mobile devices for education is particularly and popularly known as mobile learning (M-learning). As the usage of M-learning as a new emergent technological capability is penetrating our educational systems, researchers are increasingly intrigued to explore and understand its influence on training and lifelong learning in general [3].

A substantial number of empirical researches suggest that M-learning may be utilized to facilitate the learning process in the context of special situations such as COVID-19.

Today it is essential to develop emerging skills, specific details, and novel learning methods to learn lifelong and flourish in the modern age education systems and contribute to society [4]. Technological innovations, intelligent apps, and strategies are continuously being used to transform the schooling system, to maximize the adoption or utilization of technology in the education sector [5]. In addition, the extensive spread of COVID-19 has made the global educational systems inclined to use M-learning platforms. Following the onset of COVID-19, most countries in the world have implemented online education programs and made M-learning mandatory to reduce the potential health risks associated with the pandemic.

Although substantial progress has been made, there is still a need to better comprehend the challenges of M-learning applications in education research during COVID-19 [6] that might have future opportunities by uncovering user sentiment, adoption, acceptance, and usage patterns. The identification of challenges and usage patterns or trends of M-learning in different educational domains (e.g., medical), contexts (e.g., countries), and ways (e.g., blended learning) would allow the researchers, academicians, students, and M-learning app developers to consensually develop and integrate M-learning methods and platforms into every day more effectively. Unfortunately, no previous studies have delved into the past and present literature to report how M-learning challenges, user sentiments, innovations, and usages have evolved and emerged over time and their patterns. However, the knowledge of the recent patterns of M-learning applications is significant for M-learning usage to reach its full potential [7,8]. Thus, the main objective of this study is to conduct a systematic review to investigate the recent patterns of M-learning studies and applications reported in education research during the COVID-19 outbreak. This study will provide a better understanding of the usage, perception, and acceptance of M-learning during COVID-19. This study also seeks to comprehend contemporary challenges and success factors in the field of M-learning.

1.1. Background and motivation of the study

M-learning is a term used to represent learning that takes place via the use of a smartphone, along with mobile applications and the Internet. Mobile apps that take advantage of mobile functionalities (e.g., Location tracking, microphone, and camera) provide the audience with a unique and customized interaction needed for learning [2]. Crompton [9] comprehensively defines the term M-learning which includes "learning across multiple contexts, through social and content interactions, using personal electronic devices". Through this description, we may get insight into the educational advantages of M-learning utilizing mobile platforms. The scope of M-learning is unbound and it appears to be an apt medium for learning in a wide range of situations, including time (i.e., the COVID-19 pandemic), topics, participants, and technology [1]. In the recent decade, a substantial number of efforts have been designed to use mobile technology and applications for teaching and learning, with the majority of these programs being funded by the government [10,11].

Numerous SLRs of M-learning have been performed over the past decade [1,4,11]. A dozen of new challenges and opportunities have been demonstrated from the users' frequent usage of mobile devices perspective. The findings provided relevant information that will help researchers better comprehend the usage of mobile devices in academic contexts. However, most of the studies did not cover the research gap in spotting the recent trend of M-learning in the education domain. Especially, specific to COVID-19, the difficulties and use patterns of sophisticated M-learning technologies as well as users' perceptions and constraints are absent during the pandemic. The majority of researchers reported their observations without providing recent patterns of M-learning backgrounds from the technological point of view. For example, Saikat, Dhillon [12] conducted a thorough systematic analysis of the potential and drawbacks of using M-learning for the Science and Technology curriculum during COVID-19 and found that M-learning provides a promising prospect to be a successful platform for teaching and learning. However, the authors did not emphasize the necessity to grasp the expected functionality that should have been incorporated into innovative M-learning platforms. In addition, Lima and Isotani [13] performed a meta-analysis of previously published newspaper and conference articles in the context of Google Classroom as an instructional tool during the COVID-19 outbreak. They concluded that mobile applications make it easier to communicate and connect with other individuals. Moreover, Camilleri [14] also conducted an SLR on M-learning service quality in higher education post-COVID-19 pandemic. They offered the scope of future research to measure the perception of learners. They also encouraged future research that may use a variety of methods, sample frames, and analytical tools to expound on the deployment and success of M-learning.

In contrast, if we look at the recent past in terms of the studies on M-learning, Bano, Zowghi [10] reviewed a study of 49 published articles between the timeframe 2003–2016 and identified the gaps in existing literature for science and math education. Elaish, Shuib [11] represent in their SLR that M-learning has many aspects for both academics and course designers, and it is important to understand how to make optimal use of the current M-learning technology in teaching and learning. More specifically, Papadopoulos, Lazzarino [4] conducted a critical assessment of the studies on the use of Socially Assistive Robots (SARs) in pre-tertiary effective teaching and found that the utilization of SARs in pre-tertiary level education has potential. Several of these researches contribute to the growing body of academic knowledge on the usage of M-learning across specific topics of education. Meanwhile, it might be difficult to differentiate what has been occurring currently in education research in order to comprehend how M-learning apps are assisting learners [1]. In parallel with the urge to comprehend better the usage of smart devices for learning, there is a significant need to better grasp concurrent technical capability. It is fundamental to draw concepts from prior research investigations that have been conducted in this discipline.

In reflection of the above debate, it was revealed that there are a few systematic reviews that have investigated current aspects of the use pattern of M-learning applications. While numerous M-learning studies gave an excellent synthesis of potential problems, Alsharida, Hammood [15] express the need for further exploration not only from an M-learning viewpoint but also from a

non-educational standpoint, to better illuminate the existing findings. In light of this illustrated gap in academic knowledge, the objective of this SLR is to explore the literature on M-learning and to develop a comprehensive insight into the recent patterns of M-learning applications in the education domain during COVID-19 from the perspective of its usage and acceptance. In several areas of research, including the social sciences and education, SLR is a commonly and popularly used technique of the evidence-based paradigm that has achieved growing acceptance in recent years. This SLR is also grounded on the following four extensive research questions related to studies of M-learning apps that have been implemented more recently.

RQ1. What is the discrepancy in student sentiment across different nations throughout the COVID-19 pandemic?

RQ2. What challenges have M-learning systems encountered during COVID-19?

RQ3. What are the determinants (i.e., adoption, acceptance, user perception) of M-learning during COVID-19?

RQ4. which potential future opportunities has the M-learning application during COVID-19 uncovered?

The following is the structure of this study including Section 2 which describes the methods and materials used in the planning and execution of the SLR. Section 3 presents the findings and discussions of the investigation. Finally, Section 4 provides conclusions, limitations, and suggestions for addressing the identified gap for future research.

2. Methods and materials

A systematic literature review (SLR) is a method of selecting, identifying, and summarizing specific research articles to generate a comprehensive and realistic understanding of the case under consideration. Using the customized PRISMA guideline [16] and keeping in mind the four steps of the review process: (i) identification of resources, (ii) study selection, (iii) data extraction and synthesis, and (iv) data analysis, proposed by Kitchenham [17], this systematic review was conducted to answer four research questions above to offer a critical and unbiased synthesis and discussion of the existing findings.
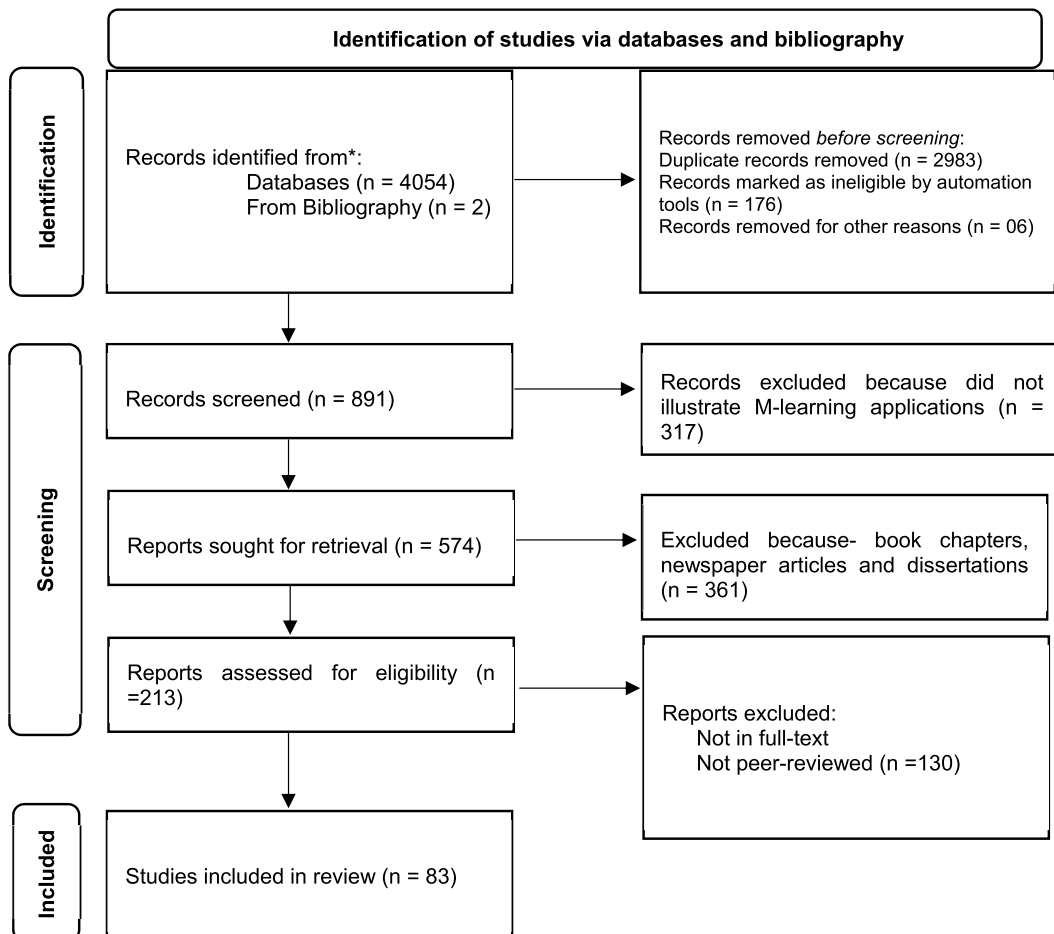

Fig. 1. A graphical interpretation of the literature search and review process [Source [18]].

2.1. Identification of resources

The initial stage in identifying resources was to identify relevant keywords. We applied primarily "mobile learning" to perform a comprehensive search on Google Scholar to find relevant articles. It was demonstrated that "application" was one of the most precise terms for research in education after scanning the first 100 returns of the Google search. Then we objectively used the term "COVID-19" to answer the research questions. A search for peer-reviewed literature was undertaken in major four databases: ScienceDirect, Springer, Welly, and ProQuest from 2020 to 2021 (December) once the keywords were finalized. The databases include an extensive range of academic publications from various fields, giving scholars access to a large collection of material related to the research topic. We took into consideration the timeframe because of the intention to understand the recent pattern of M-learning. When searching each database, the following search terms were entered into the search box:

(Mobile learning), and (application) or (education research), and "COVID-19",

(M-learning), and (application) or (education research), or "COVID-19".

A total number of 4056 articles were found after searching for them across several topic areas and numerous languages. Appendix A contains a comprehensive list of databases, topics, and the number of articles available. However, during the search process of our subject areas, we discovered that 2983 publications had been duplicated.

2.2. Selection of the studies

Here the goal is to screen out non-educational research articles from the first list and include only the articles that are relevant to the topic of education research. Fig. 1 depicts a three-stage flow diagram of the procedure based on the pre-defined inclusion and exclusion by the researchers. The first step included scanning databases for relevant keywords and eliminating publications based on duplication of articles and intangible articles generated by automated techniques during the searching stage. Afterward, we manually excluded the articles based on their irrelevant titles, keywords, abstracts, and full texts. Finally, papers that were eliminated from the database matched one or more of the exclusion criteria, which included the following.

- Did not focus on education research
- Did not related to M-learning applications
- Not in the English language
- The contents were either not in the appropriate fields or could not be utilized in the appropriate fields.
- Did not peer-reviewed
- Did not include book chapters, newspaper articles, and dissertations
- No full text is available

A total number of 4054 research articles were revealed. Two (a total of 4056) more were retrieved from bibliographies. The primary reason for receiving a large number of articles is that we looked for articles in the "All Field" category across four databases Following a review of the title, keywords, and abstracts, more than 3165 articles were eliminated on the grounds of the exclusion criteria listed above, as well as the elimination of duplicate entries. Following a further in-depth investigation, even further 817 were ruled out (based on the same exclusion criteria as previously stated). Finally, 83 papers were approved, with all of them originating from peer-reviewed journals (see Appendix A).

2.3. Data extraction and synthesis

There were several phases to the data extraction process. Data were retrieved using full-text publications after the articles had been narrowed down to a final selection. Following the preliminary categorization, subcategories were distributed among the authors following their fields of expertise. The following information was considered from the full-text publications that satisfied our inclusion standards: types of M-learning application, the hardware used in M-learning, method of the study, year of publication, country, authors, study population, level of education, foci of the study and main findings. However, based on the key findings we computed another variable "Sentiment", which was categorized into three: Negative, Neutral, and Positive. We computed this variable because of the investigation of users' sentiments.

2.4. Data analysis techniques

The data for the reviews were retrieved and analyzed using Microsoft Excel 2019 while preserving the procedure of content analysis throughout. Content analysis is a way of investigating qualitative data. It is most often used to describe a collection of texts, i.e., a transcript, an interview, or existing literature. The researchers thoroughly study the data to uncover the content of the existing study, which are subjects to concepts, and patterns of interpretation that appear repeatedly and over in the dataset. We used the deductive technique, which includes pre-determining the themes by researchers, rather than the inductive approach, which requires the data to generate new content or ideas. However, this study applied content analysis suggested by Miah, Gammack [19].

In the coding step, the inclusion and exclusion of the coding criteria were consistent with the study objectives. Subsequently, inter-rater reliability (IRR) was measured to ensure the trustworthiness of the study regarding the coding step, especially when multiple researchers are involved. Therefore, Cohen's kappa coefficient (K) was measured for IRR consisting of three coders, where the K value

of all the codes was above the recommended minimum value of 0.41. There were 82 codes found in the coding step. Then, in searching the main content related to research questions, the researchers identified the patterns among codes to combine the codes into several single themes. In this study, we did not perform the meta-analysis because of the variability of the reviews and the articles that were retrieved.

3. Result and discussion

By identifying the research gap, this study has set its aim to find the recent patterns of M-learning studies regarding user sentiment, challenges, and opportunities in education research during COVID-19. Additionally, this study aims to identify the patterns of the determinants, users' perceptions, challenges, benefits, and opportunities regarding M-learning during COVID-19. In this process, the researchers conducted a content analysis and subsequently answered the research questions that are presented and detailed below.

3.1. Demographic characteristics

The analysis of the studies shows that there were 39.8 % and 60.2 % publications in the year 2020 and 2021 respectively (Fig. 2), which is a 51.51 % year-to-year increase because the volume of publications regarding M-learning has increased due to the emergency caused by COVID-19. When it comes to the number of countries regarding the developed, developing, and underdeveloped county contexts were respectively 33.3 %, 33.7 %, and 33.7 %. Only 1.2 % study from cross-country context. It implies that due to the onset of COVID-19, the researchers focused on all types of country contexts when conducting studies on M-learning almost equally. Further, it was found that the numbers of studies that followed quantitative and mixed methods were respectively 59 % and 14.5 % in comparison to the 26.5 % of studies that followed the qualitative method. The greater number of studies following quantitative and qualitative methods implies that high level of contribution in empirical studies rather than exploratory studies.

3.2. Sentiment towards M-learning (answering RQ1)

The sentiment analysis regarding research findings shows that 24 studies have reported positive findings and 28 studies have reported negative sentiment (Table 1). Additionally, 17 studies reported both positive and negative sentiments, whereas 14 studies demonstrated neutral sentiments. The positive sentiment includes location flexibility, time and effort efficiency [20,21], as well as convenience and ease of access to lecture materials [22]. Regarding the experience of online learning, students opined that M-learning allows cooperative learning [23], flexible learning, and student-centered learning [24], which are positive sentiments. In addition, Ibrahim, Luzinge [25] identified that sense of belongingness, removal of the barrier of physical distances, and opportunity for knowledge sharing in the M-learning medium are linked to positive sentiment. Students also feel positive sentiment about the fact that M-Leaning can save both time and money as well as allow them to not get up early in the morning and have no obligation to go to school physically [26].

On the other hand, the users showed negative sentiments by relating limited internet access and lack of physical resources with
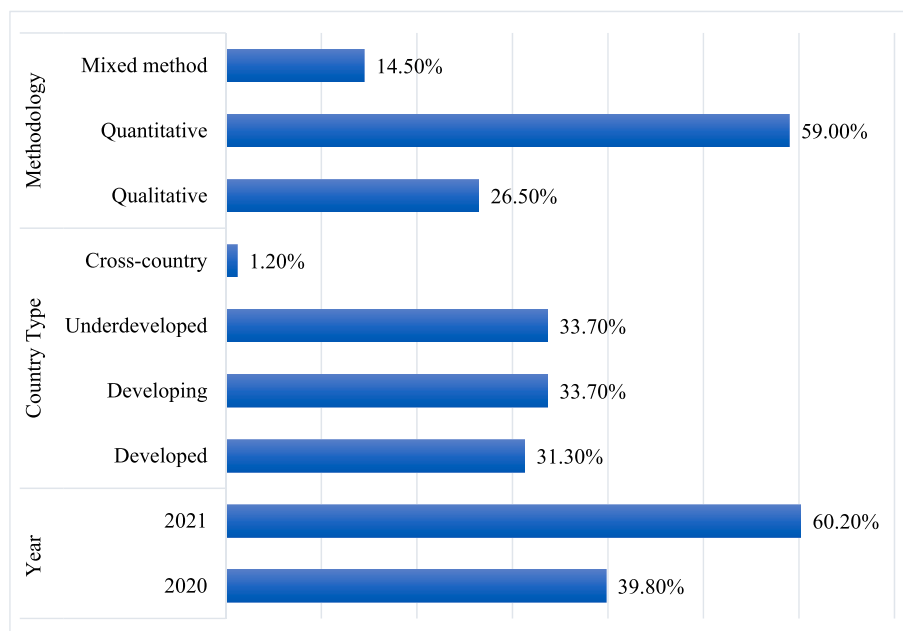

Fig. 2. M-learning studies regarding the years of publication, country type, and methodologies used.

Table 1
Recent patterns of M-Learning studies regarding the sentiment found.

Criteria	Sub-Criteria	Study no./Ref.	Frequency/Distribution
Sentiment	Positive	[22,24,27,28,29,30,31,32,33,34,35,36,37,38,39,40] [41,42,43,44,45,46], [47,48],	24
	Negative	[49,50,51,52,23,53,54,55,56,57,58,58,59,60,61,62,63,64,65,66,67,68,69,70–72]	28
	Both Positive and Negative	[73,74,75,25,76,77,78,79,80,81,82,83,84,85,26,86,87]	17
	Neutral	[21,77,88,89,90,91,92,93,94,95,96,97,98,99]	14

affordability [100,73], as well as slow progress in policy formulation [73], with users' perception. In another study, users showed negative sentiment because of experiencing health issues [49], in addition to facing difficulty in concentration [101], attention, and interest [102], and having a lack of motivation [51], while attending online learning classes. Then the study by Ref. [52], reported negative sentiment by the students due to experience of helplessness, obligations, and exhaustion while expressing the need for social and technical support. When it comes to investigating mental health, students also showed negative sentiment because of anxiety [103], mental stress [104], psychological distress, and fear of loss of academic year [105]. The negative sentiment was also reported due to not having a favorable study environment and poor internet connectivity at home the students who have marginal economic conditions [103], Besides, the issue of socioeconomic status and the digital divide in accessing remote learning have caused negative sentiment among the students [53,106].

Furthermore, in the context of regional sentiment, developing nations have demonstrated the greatest amount of positive sentiment (45.8 %), followed by developed countries (33.3 %), in contrast to underdeveloped countries (16.7 %). Surprisingly, underdeveloped nations have the highest percentage of negative sentiments (46.4 %), followed by developed countries (28.6 %), which is higher than developing countries (25 %). The proportion of people who felt both positive and negative emotions was higher in developed nations (35.3 %) than in developing and underdeveloped countries (23.5 %). Fig. 3 provides further context on regional sentiment.

3.3. Challenges (answering RQ2)

The most common challenges that are reported in the M-learning studies are having difficulty in concentrating, limited interaction, a conducive household environment for online learning [101], and addressing the issues of helplessness, burdens, and burnout through social and technical support [101], as well as the issues of inadequate infrastructure, training, unclear teaching and assessment guidelines, and financial burden [101], The study by Elumalai, Sankar [29] reports that addressing the issues of the digital divide due to different socioeconomic backgrounds, limited interaction and low level of engagement are major challenges. The socioeconomic status and the digital divide in accessing remote learning, significant differences in students' access to remote learning opportunities during the pandemic, and significant differences in access to digital tools between students in government schools and their private school counterparts also contributed to the challenges of access to online education [107]. Then, the challenge of motivation and student-to-instructor interactions were also respectively reported by the studies by Ref. [108], and [57]. On the other hand, the issue of incompatibility is a significant challenge to address in the context of M-learning [109]. Besides, enduring efficiency and time flexibility according to the needs of students are challenging when it comes to online learning [38].

When it comes to the marginalized students from rural areas, the challenge of access to M-learning increases due to lack of electricity and poor internet connectivity [103]. A study by Landa, Zhou [59] of the South African rural student population found that
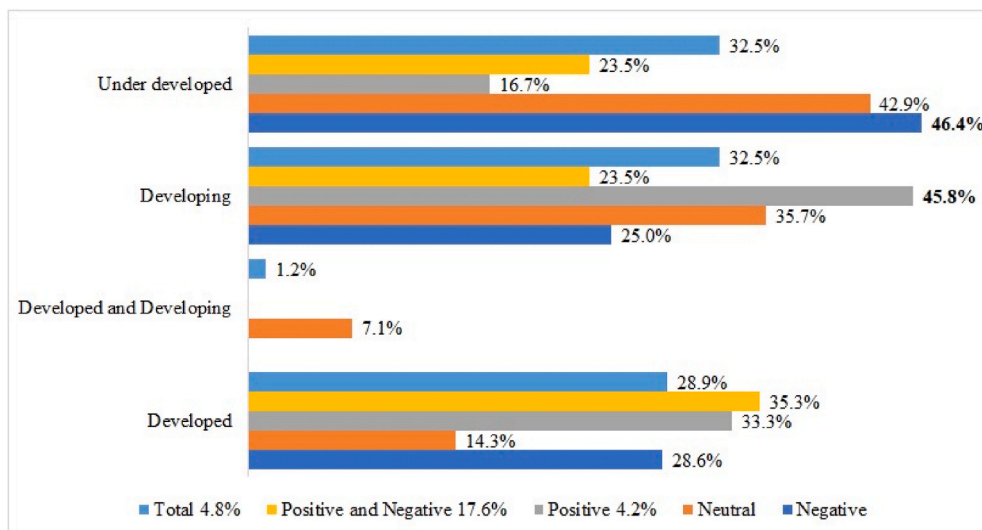

Fig. 3. M-learning user's sentiment by region.

access to online teaching and learning platforms and resources is challenging and that there are gross inequalities in educational outcomes for learners from different socioeconomic backgrounds. Findings also showed that students were not adequately trained in the use of learning technologies and lecturers struggled to deliver content to students since they often found themselves teaching students how to use the technology rather than delivering subject content [59]. Moreover, the challenges of lack of focus due to distractions, lack of engagement, and mental stress are reported in the study by Ref. [87]. Similarly [51], reported the challenges of unsatisfactory internet access, insufficient time due to other familial issues, and inadequate working space at home.

Also, specific to the context of developing countries, Zarei and Mohammadi [110] found that students face multiple challenges with the transition to online education such as incompatibility of their gadgets with educational platforms, lack of sufficient and efficient internet connection, unsuitable home environment for education because students may get distracted by other family members or pets and lack of interaction with instructors and fellow students. Additionally, the class size, the online experience of students and instructors in using technology, and student reluctance to ask questions and participate are the other significant challenges for students [60]. Likewise [71], in their study of university students found that challenges facing the usage of e-learning systems are not only limited to the infrastructure issues as mentioned in the previous studies but also include other such as e-learning system technical issues, change management issues, course design issues, computer self-efficacy, and financial support issues. Then [64], reported that infrastructure factors, cultural factors, digital inequality, and the threat to digital privacy influence student engagement in online learning.

Regarding motivation for engagement, a study of college students in the USA found that a major challenge is the internet and technology access. Most students felt their academic success was inhibited by feeling unmotivated, distracted, and/or anxious due to COVID-19. The majority also reported feeling less motivated due to mental health concerns and having trouble sleeping. Almost all students felt less motivated due to not meeting in person. This challenge can be addressed by incorporating structured opportunities for connecting with peers [23]. Similarly, a study on online science education during COVID-19 in Saudia Arabia identified that the biggest challenge was the university, the student curriculum, and the last faculty members [111]. In another country context, another study has reported the challenges faced by Jordanian university students are as follows: teaching methods, social aspects, infrastructure, computer skills, and coordination all showed a high degree of challenge, and assessment methods, motivation & willingness came with a moderate degree of challenge [67].

In this phase of SLR, to address research question 3 (RQ3), we have classified the comprehensive evidence into three distinct subsections: study focus, determinants, and users' perceptions.

3.4. Major study focus

Fig. 4 shows that the top five focus areas in the studies regarding M-learning were users' experience (n = 16), users' perception (n = 14), M-learning challenges (n = 10), users' attitudes (n = 7), and influencing factors (n = 6). When it comes to studying focusing on users' perception, the studies reveal that the common issues are related to limited internet access, lack of acceptability due to physical resources [100], mental health [105], lack of human interface [22], flexibility in the learning process [21], disruptions in online learning due to disturbance home [56], information quality and system quality [91], an opportunity to recover study gap during this COVID-19 [112], inhibition in academic success due to COVID-19 [48], motivation to learn [85], and course satisfaction [95,99]. Additionally, the most common factors related to users' experience are feeling a lack of motivation and concentration issues [51], need for social and technical support [52], student-centered learning [24], lack of engagement, and mental stress [104], and scope of cooperative learning [23].
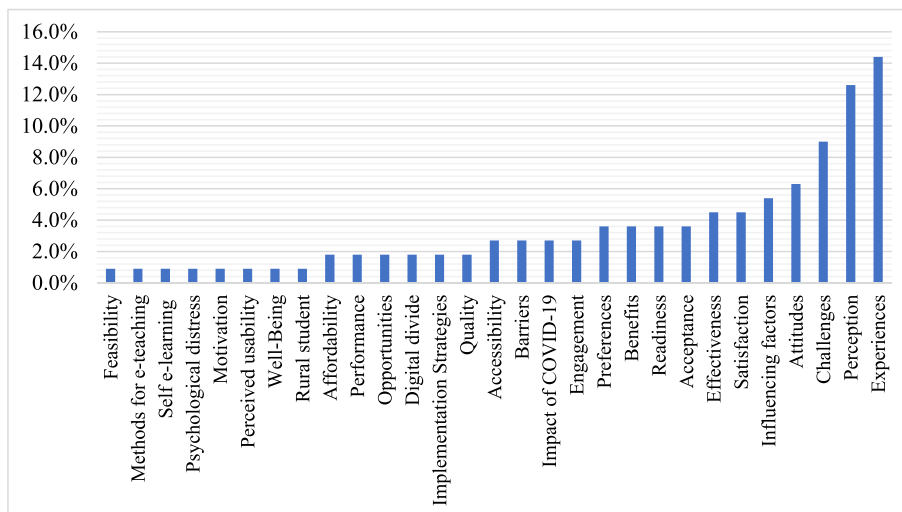

Fig. 4. The recent trend of major studies focuses on M-learning.

It was also found that users' experience is related to having access to online resources [106], learners' satisfaction [77], technological challenges [32], having comfortable educational environments [90], difficulty in understanding the information [63], lack of interaction and participants [83], and home environment [66]. On the other hand, the researcher also focused on the challenges regarding M-learning. The common challenges that are reported are creating motivation and willingness to participate [108], and ensuring access to the learning system. [66], lack of interaction and poor internet connections [45], self-motivation [57], difficulty in concentrating [101], limited engagement [29], and financial burden of buying technological devices as well as family distractions during online class hours [24]. The other major factors that can affect the users' attitude are improved information and communication [49], lack of motivation [51], time and effort efficiency [20], sufficient technological skills [79], learning experience [85], and online learning readiness [113]. Then another major study focus was finding the influencing factors that may affect M-learning. With that regard, ease of use [42], performance expectancy, content quality [54], emotional engagement, cognitive engagement [88], course design, self-efficacy, financial support [89], teacher characteristics, internal motivation, infrastructure and system quality [34], administrative support, social support, and technical support [97] were found be significant influencing factors.

3.5. Determinants of M-learning usage (answering RQ3)

This theme primarily summarizes the positive and negative factors that can influence the adoption, acceptance, and use behaviors of M-learning. The positive factors include self-efficacy [88,107,58,48], users' satisfaction [25,88,59,81,82], readiness [114,62,65, 113], ease of use, engagement, accessibility [42], ICT literacy, performance expectancy, and content quality [54], perceived usefulness [88], enjoyment [58], administrative, social, and technical supports [97] as well as synchronized learning [80]. On the other hand, the negative factors that can significantly affect the use behaviors of M-learning of M-learning are psychological distress [105], computer anxiety [80,58], privacy issues [61], and financial issues [89], Similarly, the lack of affordability of internet access hinders students from achieving effective e-learning. Also, the lack of availability of digital resources could not only negatively affect M-learning but also create a social divide [100].

A study by Ref. [52] identified 12 factors that greatly impact students' utilization of e-learning facilities. The findings reveal that 100 % of the participants believed that technology-related factors such as ease of use, speed and accessibility, and service delivery influence their usage of the e-learning facilities, while 93 % of the participants indicated that organization-related factors such as training support and diversity shape their use of e-learning facilities. Another study found the impact of performance expectancy (degree of usefulness, expected outcome, relative advantage), content quality (quality of e-content), platform quality (quality in terms of usability), university management (management issues inside the university), and lecturers' behavior on the level of use of M-learning platforms [58]. Likewise, a study of Chinese university students revealed that students' satisfaction with online learning platforms is directly and indirectly impacted by their computer self-efficacy and the perceived ease of use and usefulness of the platforms [33].

Besides, the barriers that can negatively influence M-Leaning are lack of conducive space for studying, platform reliability and responsiveness [82], poor communication between educators and learners, mental health difficulties [78,63], lack of social interactions, lack of ICT tools, internet, and electricity, lack of infrastructural support [31], and not having adequate knowledge, skill, and training of teachers for conducting in M-learning programs [46]. Further, the barriers also include the lack of structure, technological difficulties, and financial support [46]. It is also reported that users' motivation is a significant determinant of M-Leaning [51,115,76,57]. Another study by Ref. [61] investigated barriers to online education among medical students. The most frequently encountered barriers were difficulty adjusting learning styles, having to perform responsibilities at home, and poor communication between educators and learners. Lack of physical space conducive to studying and mental health difficulties was also common. A study by Ref. [85] shows it is a significant barrier for students to pay attention for a long time facing the screen followed by a lack of effective communication compared to face-to-face. Students are found to face difficulty in understanding the information which affects their motivation.

As well, student and teachers' characteristics and the quality of information, infrastructure, system, course, and learning environment can determine the efficiency and success of M-learning [34]. Additionally, users' attitude significantly influences M-learning [49,51,20,60,85,113,40]. It was found that the attitudes of the users were linked to the environment and this accounted for 53 % of the views of the participants, while the impact-related factors such as learning experience, skill development, academic performance, and degree of engagement accounted for 93 % of the participant's views. In contrast [91], found that student's use and acceptance of online learning during COVID-19 in Mexico, Peru, Turkey, and the USA are determined by the technological infrastructure and socioeconomic context of each country. In addition, a study of Indian university students found that factors such as assurance, reliability, responsiveness, and website content have a positive significant impact on e-learning quality, confirming previous similar investigations and, in turn, found to be having a strong relationship with learners' satisfaction [93].

3.6. Users' perception

When the users' perception is concerned, the majority of students agreed with the negative impact of digital learning on their well-being and identified it as a major contributor to their low academic performance. The users often perceive problems such as confusion, frustration, anxiety, and nervousness as a result of online learning and digital enables assessments and do not recommend continuing with the online learning model because it is socially and psychologically unhealthy [70]. Also, the feeling of psychological distress is perceived by students to be due to psychological distress and fear of academic year loss when finding online learning challenging [105]. The study [55] reported that in third-world countries like India, the students who stayed in rural remote areas had been

disrupted by their internet connectivity and power outages that rely on mobile learning applications. Also, implied that the problem policy paralysis had damaged technical infrastructure, academic incompetency, and lack of resources that draw the major setback as financially crippled. Then, the students of South Pacific University showed high levels of e-preparedness, indicating that they would be expected to be somewhat ready for the transition from face-to-face to online learning. Students perceived that online learning connected them more with their peers and facilitators, gave them access to a wider range of learning materials, made the learning process more creative, and enabled self-paced learning. Though technology-enabled learning has been well received by most students and but may require support with their digital literacy [45].

Further, the users perceive that virtual conferences have become an integral part of neurosurgical education since the COVID-19 pandemic. In the United States, residents and faculty report a preference for the continued use of virtual conferencing, especially virtual case conferences and board preparation [20]. Another study of Indonesian students found that students enrolled in the English for Engineers course using Gagne's Nine Events of Instruction, speaking activity in an online learning classroom, achieved satisfactory results. The students opined that designing online learning following both synchronous and asynchronous methods for speaking is as effective as face-to-face [28]. Also, a study of school students in Cyprus found that students had an overall negative perception of their experience in online education and the factors responsible for negative perceptions include: students felt disconnected from their peers and teachers and they experienced technical difficulties; technical difficulties seemed to be most influential; and the overall lack of satisfaction with reactive online education may in part be due to a lack of prior experience with online education [116].

As well as, in another study, students reported a positive perception of online learning due to positive team working activities, improvement in digital skills, and improved problem-solving through cooperative learning [31]. Besides, a study of medical and dental undergraduates of a college in Pakistan revealed that students believe e-learning has increased their motivation and made them more engaged with the course content. Students found e-learning to be flexible time-saving and easy accessibility to well-organized online lectures. It was found that students participate more actively in class and show better performance in the assessment of core knowledge [47].

Another study found an overall positive perception of online learning experience with perceived social interaction, self-management, and learner satisfaction. Students are also satisfied with their teachers' online teaching methods and the assistance they receive from their parents. The participants who used computers or a mix of devices reported more satisfying online learning experiences as compared to students who used televisions as they suffered from poor social interaction and self-management and reported the lowest levels of satisfaction with their online learning experiences [117]. Additionally, a study of students in Ghana found that lack of social interactions, poor communication, and poor student outcomes were associated with the perceived ineffectiveness of e-learning. The students cited a lack of ICT tools, the internet, and electricity as some of the barriers to online learning [118]. A study by Armstrong-Mensah, Ramsey-White, Yankey, and Self-Brown (2020) also reported benefits perceived by students about online learning at Georgia State University. Not having to commute to school and subsequently saving money was reported by more than a third of students. Some students also reported having more time to work on assignments and to be with family and friends [24]. Another study shows that often earning environment is not conducive due to all family members staying at home and limited space to do revision and perform course assessment tasks. Besides, technical destruction such as computers failing to run smoothly, limited Internet data, and a single device being used by many family members to perform work tasks are the issues raised frequently [86]. The study by Ref. [32] also confirms that remote learning is significantly more challenging and a reason for their chance to succeed. Then, concerning using online learning platforms, the students perceive that there is a need for practice and required training and time to prepare for using online learning platforms efficiently [35]. The students, in addition, perceive the issues that include lack of interest and attention during online classes, and therefore, they think of the need to develop soft skills, especially listening skills, distracting online activities during study time, affordability of data plans, and difficulty to keep up with the teacher teaching speed [102]. Finally, the students also perceive that information quality and system quality have direct relationships with user satisfaction [91].

Nevertheless, to adequately address Research Question 4 (RQ4), it is imperative to dig deeply into the subsequent sub-sections, namely Section 3.7 and Section 3.8.

3.7. Benefits

The benefits of the introduction of M-learning include convenience and ease of access to lecture materials [22], feeling a sense of belonging to the learning community, removal of the barrier of physical distances [25], saving money, students having more time to work on assignments and to be with family and friends [47]. The other benefits include the inclusion of rural and marginalized students in M-learning [29], experiencing an alternative way of learning, and the opportunity to catch up due to COVID-19 [65]. Also, study shows that students have a feeling that distance learning has been enhancing their effectiveness and productivity; their self-efficacy with distance learning is also medium; students consider distance learning IT tools to be very intuitive, and they are generally comfortable with using computers and the internet; they plan to use distance learning often during the semester [39]. Online learning was reported to be beneficial during the COVID-19 pandemic, especially for educational institutions and students with heterogeneous infrastructure and internet access like in Indonesia [37]. Another study highlighted the significance of satisfaction of basic psychological needs such as experienced competence and relatedness for positive emotion and the relevance of autonomy and self-regulated learning for intrinsic learning motivation [96]. Also [22], found that it might be beneficial in decreasing the level of anxiety related to online learning if synchronized learning is offered.

It was also found that before COVID-19, students used to spend less than 4 h, whereas coming to the number of hours of online learning during COVID-19 increased to more than 4 h per day. This indicates that students are engaged in online learning and self-

motivated to improve themselves. It is also observed that most of the students became self-conscious and caring about their careers as they focused on the progress of their learning and made learning a habit. This survey also indicates that most of the students have a healthy learning environment with support and students are connected with the outside world synchronously or asynchronously [98]. Another study proved that, in the e-learning context, students' participation in and control of the teaching process, their high closeness with teachers, and their mutual recognition and behavioral referents with peers will make students feel satisfied and thus produce learning-related well-being that results in learning engagement [112]. Similarly, the findings of the study revealed that using Facebook as a medium for language learning was very effective in increasing the confidence of the participants of the study engaging them in a motivating way, and consolidating the points discussed previously in the class sessions. The learners favored the chatting section, which provides them the means to interact with other users. Tutorials, vocabulary training, and language reminder were the other activities the learners used frequently to boost their knowledge of the language [46].

3.8. Opportunities (answering RQ4)

Online learning through the M-Leaning medium has created many opportunities. The most common opportunities, as reported in multiple studies, are affordability regarding low cost [100,53], minimizing the digital divide [53], and scope to continue learning during COVID-19 [50]. Therefore [90], reported that online learning can improve interpersonal interactions and the quality and dynamic of the online content which could improve the effectiveness of online learning. As a result, educational institutes should maintain ongoing awareness of the e-capabilities of the student cohorts to be best prepared for future challenges to the educational sector [45]. On the other hand, considering the opportunities, stakeholders in education are willing to integrate ICT in education in Ghana and implement realistic and rigorous ICT policies to ensure effective online learning where the needs of both urban, urban poor, and rural students are taken into consideration [118]. Thus, schools should provide teachers with brief training courses on how to grant students more control over their learning, provide a more active online teaching atmosphere, add relevant applied technologies, and enhance students' sense of participation and control in class in the e-learning environment. Moreover, providing more interfaces and functions for interaction and communication among students can also be introduced to the online teaching platform [112].

Also, by understanding the opportunities provided by online learning, researchers have recommended undertaking the significant responsibilities of serving and satisfying students. Hence, online learning platforms need more simplified interfaces and registration and login systems to make them approachable to students. For that, the developers can also develop more useful features or learning support services to make them more beneficial to students. It is also necessary to publish relevant and better-designed guidebooks and manuals, with the help of which students will be able to use online learning platforms more easily and obtain more benefits from them. Besides, course developers can also cooperate with platform designers to develop more accessible and beneficial programs that target specific teaching content. It is also worth mentioning that governments, universities, and service providers can create social media for interactive communication with users which can help improve platform services [33].

In another study, to avail the opportunities, the researchers have emphasized facilitating and improving the efforts made by instructors, modulation of assessment methods to better accommodate the workload, and preparing contingency plans and other alternative learning activities or resources to supplement the inadequacy [48]. Also, to grab the opportunities, a study has recommended that the nursing educational system should use programs for improving e-learning that are more user-friendly and technically sound, where virtual experiences of practical sessions can also be carried out effectively and efficiently. Subsequently, E-learning programs with proper strategies need to be developed based on existing evidence to enhance the nursing student's clinical skills, knowledge, and attitudes to preparedness for an emergency like COVID-19 [82].

Moreover, the policymaker, as well as the educational institutions, should consider the opportunity to incorporate mobile learning technology for the whole education system where social media may enhance the process of teaching and learning [38]. For that, the development of e-learning by the universities needs to be made so that all students and lecturers can be facilitated and have the same e-learning standards. Also, to solve problems in e-learning, teachers should consider two phases of teaching, the offline self-learning phase, and the online teaching phase. In the self-learning phase, students should read the subject-specific reading materials before joining the class. In the online teaching phase, teachers should discuss with the students about their understanding and clear their misconceptions [119].

In the study by Ref. [106], it is reported that to achieve high-quality online learning, five high-impact teaching practice principles for online education are essential, which are: (a) appropriate relevance between online instructional design and student learning, (b) effective delivery of online instructional information, (c) adequate support by faculty and teaching assistants to students including timely feedback, tutoring and email guidance after class; (d) high-quality participation to improve the breadth and depth of student learning, and (e) contingency plan to deal with unexpected incidents of online education platforms.

Again, to make use of the opportunities derived from online learning, teachers could design different pedagogical approaches to cater to learners with different personalities. For those with strong neuroticism, teachers could design some interesting content to release their negative emotions, reduce their stress, and relax them. For those with strong extroversion traits, teachers could provide them with opportunities for interpersonal communication and design interactive academic activities for them. And, for those with strong personalities such as agreeableness, conscientiousness, and openness to a new experience, teachers could increase the amount of knowledge using updated technologies, raise the level of difficulty of knowledge, and establish a higher learning goal than those with traits of neuroticism and extroversion [90].

4. Implications, limitations, and future directions

This research has implications that are both theoretical and practical. This SLR contributes to the existing research gap in academia alongside education policy-makers on M-learning. Specifically, it addresses the dearth of studies that explore user sentiment, challenges, and potential, especially in the context of the COVID-19 pandemic. This SLR also provides valuable insights to researchers by highlighting emerging trends, existing challenges, and potential possibilities for future study in the field of M-learning systems.

From a practical perspective, this SLR will assist relevant stakeholders in developing M-learning systems that have the capacity to significantly transform the field of education and learning.

These systems provide novel prospects for people to get information and develop skills via methods that are characterized by enhanced flexibility, personalization, and engagement. However, it is necessary to engage in thoughtful planning and continual evaluation to successfully use these advantages while also tackling the accompanying challenges. However, one of the notable implications of M-learning is its ability to provide students with geographical restrictions the opportunity to access educational material and tools in their personalized time, liberating them from the limitations of conventional time limits. The aforementioned flexibility confers significant advantages to both educators and learners.

This comprehensive SLR demonstrates the current state of the art by analyzing reliable research. It is a synopsis of studies that have been referred to in four different databases during the preceding years (COVID-19 periods). Therefore, the first drawback may be that this analysis only looked at the articles from these four specific data sets; as a result, not all of the previous research on the topic areas were analyzed. Second, the purpose of this research was to explore current trends in M-learning, and it is important to note that the time frame for this investigation was restricted to the years 2020 and 2021 (December), which may be considered a limitation. Furthermore, we searched for articles in four important databases, which is also a limitation. Exploring more databases or repositories might have included additional pertinent studies. Future studies should broaden the search scope to include more databases, potentially resulting in a more in-depth evaluation. Third, because of the search terms, there is a possibility that any crucial documents were overlooked. Thus, an improved version of the search term might be developed and run once again to eliminate any remaining risks. Last but not least, the fact that research conducted in languages other than English was not included in our analysis makes the possibility of publication bias more likely.

The advantages and drawbacks of using M-learning have been covered up to this point. Additionally, there have been some recommendations made to enhance the quality of education that is associated with M-learning. First, educational institutions should have a heightened sense of the technological infrastructure to enhance interpersonal interactions as well as the effectiveness and dynamism of online materials. This will allow them to be sufficiently skilled for the challenges of the future. Second, the government should implement stringent ICT policies to enable effective M-learning that considers the requirements of students in urban, urban poor, rural, and hard-to-reach areas, as well as to improve the way risk management is handled in educational systems. Thus, educators should have sufficient training in blended learning approaches not only for the provision of M-learning but also to comprehend the sentiments of the students. Additionally, this SLR proposes potential avenues for future study in light of the results presented in the preceding section.

Proposition 1. *During the design process of M-learning, developers of mobile learning applications may take into consideration the incorporation of emotionally intelligent agents. Examine the incorporation of emotionally intelligent virtual agents or chatbots inside mobile learning (M-learning) systems. These agents have the ability to connect with learners in a way that is characterized by empathy and emotional responsiveness, hence augmenting their level of engagement and motivation.*

Proposition 2. *One significant challenge that has been highlighted in this SLR pertains to the issue of insufficient interaction with instructors through M-learning systems. The potential of metaverse education using virtual reality (VR) and augmented reality (AR) technology may be investigated in remote regions by adequately training educators to address challenges related to interactivity.*

Proposition 3. *While this SLR identified many factors influencing M-learning, this study suggests the inclusion of a generative artificial intelligence (AI)–based M-learning approach. This technique has the capability to construct adaptive learning pathways by analyzing a learner's progress and performance.*

Proposition 4. *The study is primarily grounded in a comprehensive analysis of existing literature, with a notable absence of empirical data to substantiate its conclusions. Future research may involve the collection of primary data, such as conducting surveys or interviews with users or educators of M-learning, to obtain a more comprehensive understanding of their experiences and perspectives.*

5. Conclusion

Education is a nation's most important resource, and technological advancements help educational institutions leapfrog to new levels of effectiveness. While the COVID-19 pandemic has had a considerable detrimental influence on the education system, government and policy-makers need to continue developing appropriate approaches to guarantee that teaching and learning activities may continue without much obstruction. Therefore, they must comprehend the emerging pattern of educational challenges and opportunities. The findings of the SLR on understanding the emerging patterns of M-learning applications are presented in this study. The SLR helps scholars in this area accumulate a considerable amount of information. An SLR covering the time from 2020 to 2021 (December) was carried out concerning previous studies of M-learning applications. The findings gave valuable new insights into information about the setting that was employed in this investigation. This SLR explored the focusing area of M-learning applications, the regional sentiment of the M-learning users, the determinants and perceptions of M-learning adoption, as well as the benefits,

challenges, and opportunities associated with M-learning. This particular SLR is intended to contribute to a better understanding of the underlying ideas that underlie the rethinking of M-learning applications for policy-makers. The findings of this recent study are very important for those working in the fields of education and online course development, especially those who specialize in M-learning, virtual education, and blended learning.

Funding

Ethical approval

The research incorporates previously published literature data. The inquiry does not include collecting personal inquiries or clinical trial outcomes and hence does not need ethics committee approval.

Data availability statement

The data can be found in the manuscript. Please see Appendix A: List of Retrieved Articles for Review.

CRediT authorship contribution statement

Atika Qazi: Conceptualization. **Javaria Qazi:** Investigation. **Khulla Naseer:** Data curation. **Najmul Hasan:** Methodology. **Glenn Hadaker:** Funding acquisition. **Dat Bao:** Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A: List of retrieved articles for review

[3], [20–25,27–29,41–43,49–54,73–76,100–106,114,115], [30–32,44,47,55–59,77–81,88,89,107,109,120], [45,60–62,90], [33, 48,62–64,82–84,91,92,112], [26,34–36,46,65–67,93–95], [6], [113,121,122].

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