Mobile learning and communication: educational change? – a systematic review

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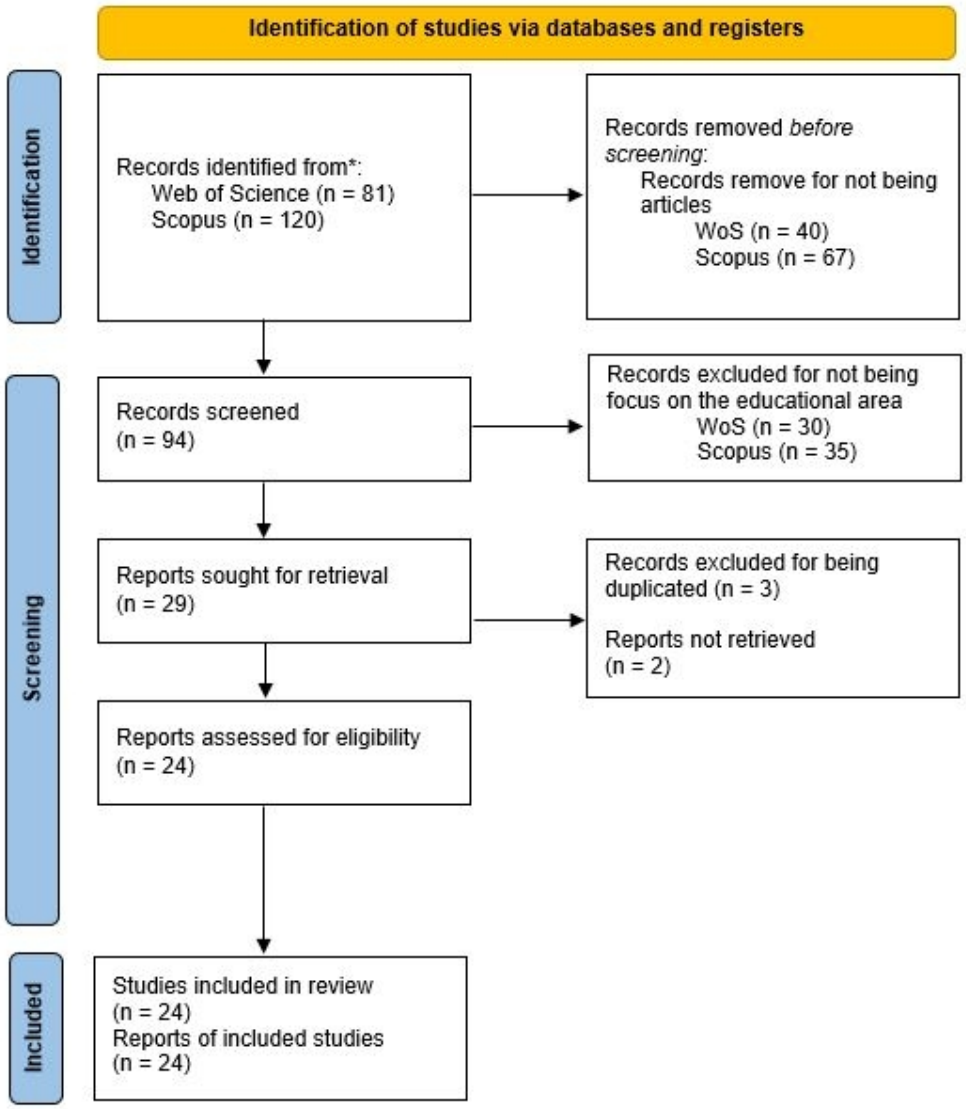

Figure 1. Flowchart of the PRISMA Systematic Review on communication and ML.

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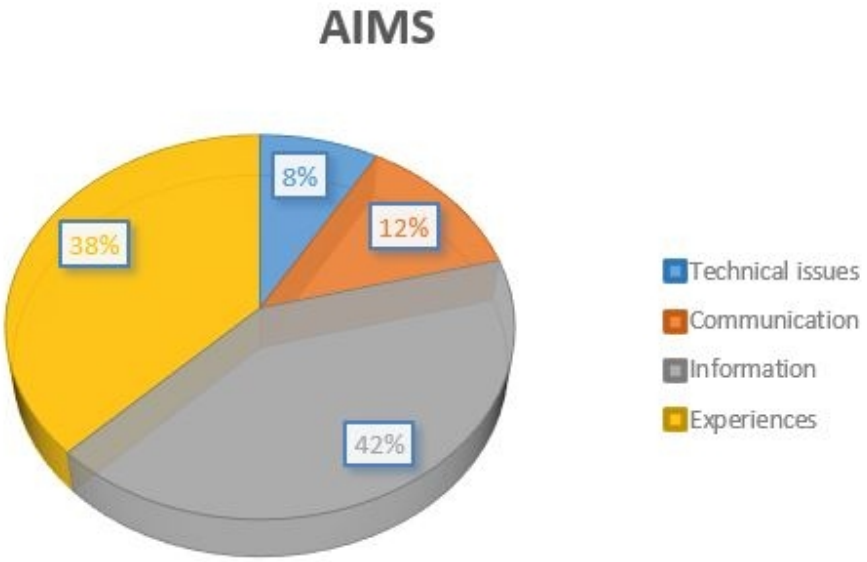

Figure 2. Main objectives of the articles analysed

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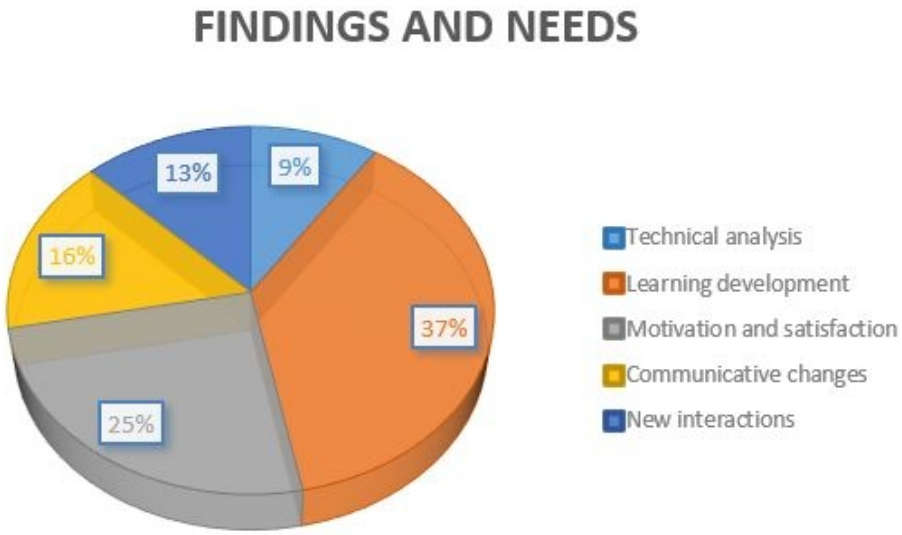

Figure 3. The main results of the articles analyzed

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Mobile learning and communication: educational change? – a systematic review

Abstract

Purpose - The authors of this research present a study on Mobile Learning and the communication processes that are generated in different educational and professional contexts through a systematic review.

Design/methodology/approach - This is descriptive research that analyses a total of 201 results present in Web of Science and SCOPUS, with the criteria established by the PRISMA protocol, giving special relevance to the following categories: country of origin, date of publication, main objectives, methodological design, variables analyzed and considered, size and details of the samples; and their respective scientific contributions in relation to their area of research.

Findings - The results show significant methodological discrepancies with respect to the established criteria. Five blocks of action are apparent: technical issues, influence on learning, impact on satisfaction and motivation, impact on communicative processes, and new forms of interaction.

Originality/value - The value of this research lies on offering a critical view based on an in-depth analysis of the existing scientific production between ML and communication in education.

Keywords Mobile learning, communication, higher education, ICT

Paper type Literature review

1. Introduction

The advent of Information and Communication Technologies (ICTs) has accelerated a society whose paradigms of action and development are far from those of previous human stages (Demidov *et al.*, 2020). Over the last few years, access to and use of technological devices that go beyond being a support for a specific task has become normalized. The development of these new media, so well established that labeling them as "new technologies" is now obsolete, is altering the personal and social development of everyone on the planet. This has been increased by the SARS-Cov-2 pandemic, an exceptional situation that has encouraged the transfer of habits to virtual environments (Lorente *et al.*, 2020). Millions of people have gadgets such as tablets, computers, or phones (Shmakova, 2021) whose characteristics are increasing in record time and are causing a profound new social, political, economic, educational, etc. structure (Vaterlaus *et al.*, 2021). This is most clearly seen in the adult population: from print media to smart fridges. An audiovisual revolution is taking place with new possibilities and needs (Shaway *et al.*, 2015): detecting Fake News (Syam and Nurrahmi, 2020), knowing how to behave in social networks (Soler *et al.*, 2021), etc. Key issues in a 21st-century society whose definitive evolution is not yet in sight.

The educational sphere has not been unaffected by the rise of ICTs. In the case of Spain, the incorporation of technology in didactic contexts has occurred progressively, being regulated by legislative frameworks such as the Organic Law of Education (LOE) of 2006, which meant the definitive acceptance of digital as school support. Digital education is grouped into the so-called Digital Competence (DC), which is made up of five areas: information and information literacy, communication and collaboration, digital content creation, security, and problem-solving. This has been complemented by transversal changes such as the emergence or improvement of active methodologies such as flipped learning, ML (George and Vinay, 2018; Wu *et al.*, 2017), design thinking, project-based learning (PBL), problem-based learning (PBL) or gamification. A good example of this is Vocational Training and Universities, institutions that assiduously use phenomena such as Massive Open Online Courses (MOOCs), holistic systems that can be adjusted to everyday tools such as tablets, computers, or telephones.

Despite its trend during previous years, ML has established itself since 2020 as one of the strongest higher education teaching methodologies (Du *et al.*, 2010; Portilla *et al.*, 2010; Marcos *et al.*, 2009). The pandemic has increased the hybridization of teaching-learning processes (Wang, 2017) and phones have emerged as the core of the procedure (Chen and Zhu, 2021). This is a further step in terms of blended learning (b-learning), more oriented towards devices such as computers, and by delving into issues such as lifelong learning without dependence on timetables or geographical spaces. Two aspects are intrinsically linked to the so-called micro-learning, an approach that subordinates learning through the fragmentation and segmentation of content. This idea is based on what was discussed in previous paragraphs, a current society flooded with information and content 24 hours a day (Arrastia and Tackett, 2020; Al Said, 2020). The impossibility of acquiring everything moves towards very specific and concise content approaches, micro-learning, whose educational linkage can be ideal with ML or b-learning (Lai and Hwang, 2014).

The case of ML is special because it combines all the new digital needs, both in training and personal development (Sun *et al.*, 2018; Rodriguez *et al.*, 2018). Its consideration in higher education, in addition to hindering didactic immobility, exposes a key paradigm shift in the present and towards the future (Lema *et al.*, 2021). With respect to students, almost all of whom have smartphones, facilitating new educational pathways accompanied by digital resources (Maor and Mitchem, 2018) is a clear advantage and difference from previous

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generations (Liu and Liu, 2021). In an age of unlimited access to content, the incorporation of formal education into this paradigm means responding to new and increasingly embedded demands (Guadamuz, 2020; Rau *et al.*, 2008). CD is not a concept but a reality, as can be seen in social movements such as the NFTs or the metaverse. This can also be extrapolated to teachers, whose profession is moving towards the mediation of content due to the informational endowments offered by ICTs (Yumurtaci, 2017). A reality that implies new needs in both cases, students outnumbered by mobile devices (Pete and Chen, 2007) and teachers for whom ICTs have not been provided from birth. This problem is intensified in the case of future teachers (Soler *et al.*, 2020), natives in a digital world of teaching work change.

Technological evolution brings new possibilities (Chee *et al.*, 2016) and new risks. Today the crossroads of the education system responds to a new paradigm, still marked by gaps in access and social status (Shin, 2021). Fake News, fraud and scams exemplify new forms of risky behaviour, more so in the age of social media. For this reason, the field of education needs to consider a profound review and reflection (Mayisela, 2013), especially with regard to new ways of communicating (Berry and Hamilton, 2006). Over the last few years it has become clear, at least in the Spanish context, that the provision of ICT resources is not a major problem. However, their use in the classroom has changed student-teacher interaction. It is the same when talking to someone on the phone instead of face-to-face, in this digital context there are new rules and behavioural patterns that come to encode the message differently for each sender and receiver (Sakkopoulos, 2006).

The relevance of this study lies in the interest of the higher education sector and institutions in incorporating ICTs, which requires global considerations to enable students to develop in the most appropriate way possible. ML and communication cannot be isolated elements. This work focuses on exposing the existing scientific reality between these terms, ML and gamification, in the main scientific databases. A procedure that allows us to know and, even better understand, the current state of communication when didactics are proposed through ML.

2. Method

The development of this systematic review was based on the analysis of the existing literature on the interrelation between communication and ML in educational settings. The reference databases used were Web of Science (WoS) and SCOPUS, two of the world's leading scientific resources. The procedure followed the criteria established and indicated by the Preferred Reporting Items for Systematic Reviews (PRISMA) (Moher *et al.*, 2009; Page *et al.*, 2021), with the aim of answering the questions posed below. In the same way, similar article structures in impact journals have also been taken into account (Jurado *et al.*, 2020), with the aim of following analysis models already validated by experts. The different data of the studies analysed are included, highlighting: country of origin, date of publication, main objectives, methodological design, variables analysed and considered, sample size and details; and their respective scientific contributions in relation to their area of research.

RQ_1 What is the state of scientific production regarding communication in ML educational methodology?
RQ_2 Has the interest in communication processes and ML increased during the last decade?
RQ_3 Do the various studies show a link between communication and ML?

2.1. Search strategy

During the months of January, February, and March 2022, a search was conducted on the relevance of communication and communicative processes in the digital ML methodology. Due to the nature of the research, it was considered to work through an extended search by terms in the Wos and SCOPUS databases. This choice in both databases was determined by their relevance in the global scientific context (Aksnes and Sivertsen, 2019). The terms 'communication' and 'mobile learning' were then established as a search tool, their combination being accompanied by the logical operator AND. Both keywords were selected due to the specific interest in their interaction as a synthesis of the present work. The search was based on English as the main language, due to the international character of the databases used. The initial search yielded 201 files, although the final sample consisted of 24 references.

2.2. Inclusion criteria

The PRISMA protocol (Page *et al.*, 2021) was used as the core for channeling the collection of the final sample. This scientific strategy was used because of its specific design for conducting systematic reviews. The main objective was to analyze those articles whose main focus of interest was reduced to communication and mobile learning methodology. For this reason, such a restrictive search criterion was established. Subsequently, results that were not articles were eliminated from both WoS (n = 40) and SCOPUS (n = 67). Of the remaining 94 articles, results not categorized as 'Education Educational Research' in WoS (n = 30) and 'Social Sciences' in SCOPUS (n = 35) were removed. The remaining 29 references were reduced by removing duplicates as they were part of both databases (n = 3). Once deleted, the availability and information contained in the 26 articles were analyzed and 2 were discarded as they were not found in their entirety. In the end, 24 articles remained as the final reduced sample (FIGURE 1). All of them are articles that incorporate the terms 'communication' and

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'mobile learning' in their title, are cataloged in educational or social areas, are not repeated in both databases and their full text could be accessed.

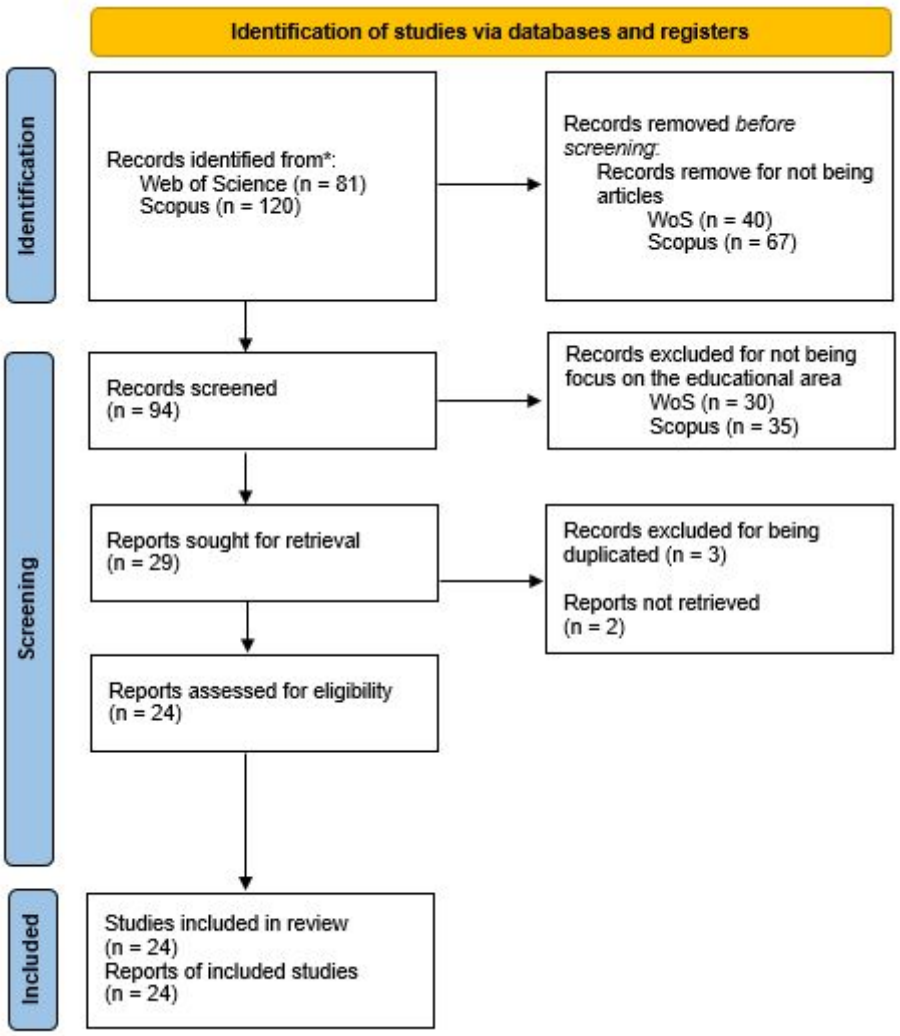

Figure 1. Flowchart of the PRISMA Systematic Review on communication and ML.

3. Findings

This section presents the analyses of the articles that, after going through the PRISMA methodology, have ended up making up this systematic review. In order to facilitate their understanding, they have been sequenced and organized according to different variables, a total of nine, which will be developed in their respective sections. An appendix at the end of the work is included, consisting of two tables, Table A1 and Table A2, which present all the data studied and whose separation corresponds to the diversity of scientific approaches found. The result is the incorporation of articles with clear empirical approaches in Table A1, while those whose research design has been based more on theoretical background have been included in Table A2. The disparity of designs used in the articles belonging to Table A1 stands out, with quantitative (n= 9), mixed (n= 6), and qualitative (n= 5) approaches.

3.1. Country

The nationalities of the authors of the papers analyzed a total of 14 countries, including several cases (n= 4) in which the articles include authors from different countries. The greatest presence is found in countries such as China and Taiwan, contributing papers from a single country (n= 3) and also jointly (n= 2). The United States also includes several articles on the subject, with both single (n= 2) and shared (n= 2) sources. Malaysia, Spain, and Australia add more papers, with one being single-sourced and one joint-sourced. The other countries adding research in the area are Turkey, Costa Rica, United Arab Emirates, Colombia, India, South Africa,

Greece, and Etopia. By continents, the distribution is led by Asia with 15 articles, North America with 5 articles, Europe with 3, Australia and Africa with 2, and South America with 1 paper submitted.

3.2. Language

Almost all of the articles analyzed and which formed part of this systematic review were written in English (n= 21), with three cases written in Spanish (n= 3). This shows the international nature of the two databases considered, WoS and Scopus, as well as the independence of the country of publication in relation to the final language of publication.

3.3. Dates

The articles analysed are framed within a time period that covers from 2006 to 2021, with no papers published in 2011 and 2012. Despite the limited number of papers, it is possible to appreciate a permanent interest in the subject, the increase being more significant during the last five years. The number of studies, except in 2006 and 2015, is reduced to one per year until 2017, when the number increases. Since 2017, the average number of articles per year has risen to three, with the year 2020 being the year with the highest scientific production, with four papers.

3.4. Objectives

Despite the existence of different methodological designs, three objectives can be defined that encompass the hypotheses of the articles observed: technical technological developments, theoretical and descriptive developments, and the development of experiences (Figure 2). The technical technological developments focus their objectives on the analysis and improvement of software and accessibility; the importance lies in understanding the problems associated with the digital systems themselves. Technical values such as transmission power, reception levels or the complete development of applications are estimated. Theoretical developments are oriented towards establishing theoretical frameworks and close knowledge that allow for a significant deepening of the application of ML and its communication. In this sense, the focus is usually on the opinions or habits of students in cases of interaction with ICTs. Another pattern is developed through the analysis of experiences developed, based on trial-and-error strategies in contexts of ML application and its repercussions on aspects such as the effectiveness of collaborative learning, learning management, language teaching or communication.

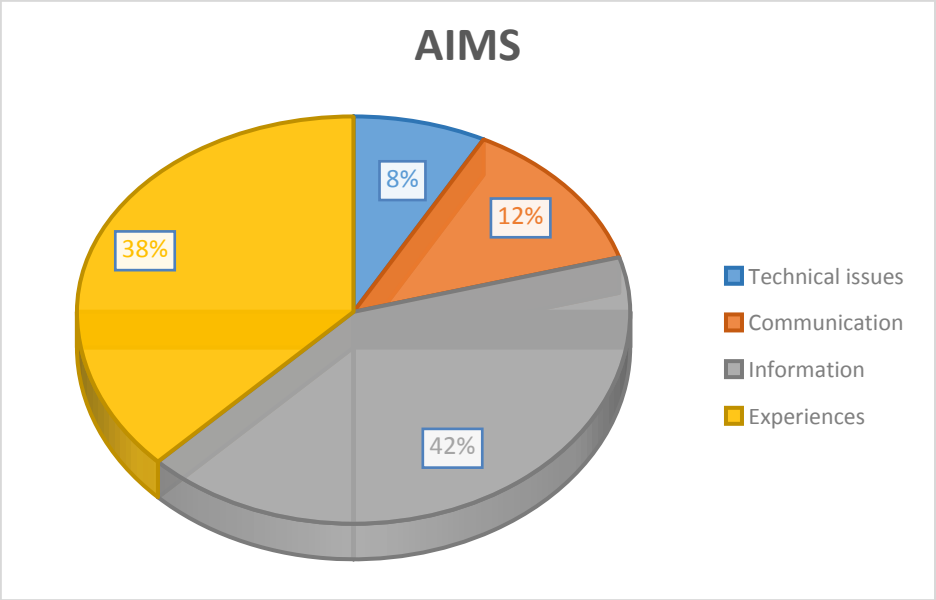

Figure 2. Main objectives of the articles analysed

3.5. Methodological design

There are two clear methodological designs, with more empirical articles (n= 20) than theoretical ones (n= 4). In the first case, there is a diversity of approaches between purely quantitative (n= 9), qualitative (n= 5) and mixed (n= 6). In this sense, quantitative approaches also show subdivisions in their methodological application, such as experimental (n= 6) or quasi-experimental (n= 1) approaches. As for the more theoretical ones, their developments have been established through systematic review processes (n= 2) and documentary reviews (n= 2).

3.6. Sample

From the articles analysed, it can be taken into consideration that the main object of study is the student body (n=12), although there are differences and uncertainties regarding ages and educational stages. There is also disparity in the sample sizes, the quantitative breadth ranging from works with samples of 17 students to others with sample sizes of 606 students. Similarly, interest in students is encompassed in broader contexts, such as family and hospital conditions, and is related to other educational agents such as teachers (n= 2). In this sense, one case focuses particularly on teachers as the only object of study (n= 1).

3.7. Variables

The variables analyzed by the articles included in the work are diverse. The empirical methodological approaches are based on three main variables: technical, communicative, and informative. The technical variables, in relation to the objectives already mentioned, focus on issues associated with digital developments or software such as power or similar. The variables more associated with communicative issues refer to modified elements of the communicative process when using ML, such as the resolution of queries or established rules. On the other hand, there are several variables more oriented towards informative issues, generating interest in aspects such as ICT habits or the predisposition towards ICTs from the student's experience.

3.8. Instruments

The instruments used in the articles analyzed cover quantitative, mixed, and qualitative perspectives. Ad-hoc questionnaires emerge as the main working tool, being used in up to 12 articles. Structured or semi-structured interviews are the most commonly used strategy in more qualitative approaches or as a complement to quantitative approaches. Focus groups also emerge as a technique for gathering information, both established as the sole means and as a complementary tool for interviews of different types.

3.9. Main findings

The main results synthesized from the articles studied can be categorized into five blocks (Figure 3): technical issues (n= 3), influence on learning (n= 12), impact on satisfaction and motivation (n= 8), impact on communicative processes (n= 5) and new forms of interaction (n= 4). One line of results is very limited to evaluations of components and technical aspects linked to software, such as the power or speed of applications. A notable number of studies deal with results relating to the influence of ML on teaching-learning processes, with some disparity in their effectiveness in educational contexts. The repercussion of ICTs, specifically ML, on motivational aspects has also been a clear source of results, and there is a positive trend in terms of its application in didactic environments. The consideration of ML in communicative processes has also been dealt with in several articles, and more in-depth studies are needed. Finally, the interaction between agents during the use of ML has also been considered, being oriented more towards the educational than the technical and accessibility side of the interface.

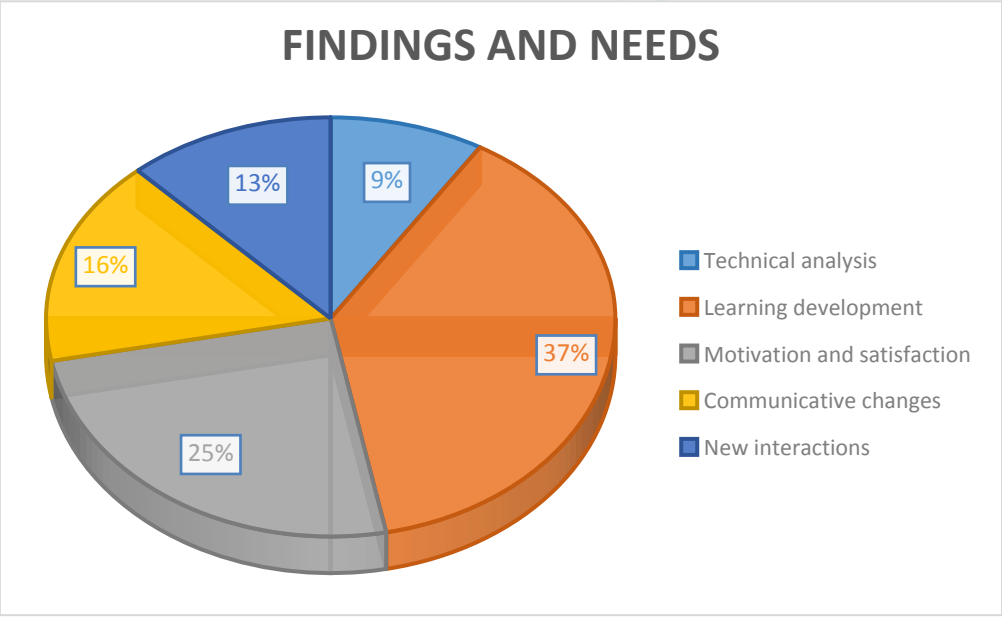

Figure 3. The main results of the articles analyzed

4. Discussion

ICTs have altered the face of an increasingly digitally-driven population. This new paradigm affects how to be an active part of society (Demidov *et al.*, 2020) and exposes vulnerabilities such as phone addiction, cyber-bullying, fraud, or questionable behavior on social networks (Soler *et al.*, 2021). Habits enhanced by SARS-Cov-2 and the total digital gamble (Lorente *et al.*, 2020). The educational sphere is within these parameters and has been legislatively aware of this since 2006. There are new channels and messages in didactic processes, different from classic approaches, exemplified by the use of smartphones or Augmented Reality. This forces a profound reconsideration of an already controversial environment, especially regarding the role of teachers (Shaway *et al.*, 2015). Under the framework of CD, new educational demands and possibilities arise whose repercussions extend to any member of the community: students and their early access to the Internet, intergenerational families whose relationship with ICTs is not linear, teachers whose training in the digital sphere is far from their work reality or other members managing educational institutions regulated by legislation and bureaucracy. This situation is exemplified in higher institutions such as vocational training and universities, two pillars whose characteristics reflect the technological fabric of the beginning of the century.

The analysis of the articles that form part of this systematic review reveals some relevant aspects. Asia is the continent with the highest scientific production in this area, contributing a total of 15 papers, both with a single nationality and shared between countries. Almost all the papers have been published in English, which reflects the international nature of the databases used and the independence of the country of publication with respect to the final language. The interest in the subject dates back to 2006, when the oldest article was found, and continues to be valid until 2021. However, it is worth noting the scarcity of works until 2017, when there was a significant increase. There are different methodological designs used, but the main objectives of the research are framed in three areas: technique, theory and experience. These three aspects are supported by empirical and theoretical designs, with the first case being the most numerous (n= 20). In this respect, there is a diversity of approaches, with quantitative, qualitative and mixed research being found in close numbers.

The samples analysed are defined in three agents: pupils, teachers and family contexts. Despite this, greater specific interest can be seen in the pupils, although the sample sizes are irregular and make it difficult to extrapolate knowledge. The same is true of the variables considered, which are very specific in technical terms and very generic in personal or experiential terms. Ad-hoc questionnaires are the main research instruments, while interviews or discussion groups are individual qualitative resources or integrated into the former. The results observed from the articles analysed reflect different avenues of research. Five blocks of ideas could be defined: technical analysis, learning development, motivation and satisfaction with the use of ML, changes in communicative processes and new interactions arising from ML. These contributions suggest undefined interests in the subject, being considered more in the theoretical contribution of ICT habits of students or educational agents; or the elaboration of conclusions through trial and error. It is noteworthy that changes in the communication process when applying ML only form part of 20% of the results of the articles, especially when other blocks refer to the development of learning or the interactions derived from it.

5. Conclusion

The results show that the study of communication and the application of ML in educational contexts is still an undefined field of study. Despite the fact that it is a subject whose first works date back more than 15 years, there is still no scientific framework of reference. The disparity of objectives and results, the latter being more extensive than the former, reflects the fact that it is an increasingly relevant object of study in society but without theoretical depth. This is all the more striking given that it is a key methodology in society, increasingly used in the personal sphere and in higher educational institutions such as vocational training and universities. This is a significant shortcoming if one considers its specific consideration in CD, especially CD. This reflects a profound problem, which is the application of ICTs in the classroom without prior analysis and reflection on their didactic repercussions. The communicative process, the axis of teaching and learning, takes on great importance in the training of students, teachers and future teachers. The purpose of education, especially formal education, must continue to be to foster the development and work orientation of students who are increasingly familiar with the Internet, asynchrony and ubiquity when accessing information (Shmakova, 2021).

With regard to the starting hypotheses, some considerations will be developed below. Firstly, we can define the state of scientific production on the subject, communication in ML, which is still in an initial phase. The figures and knowledge developed to date do not provide well-defined lines of research, just as the methodological designs are not sufficiently validated to be extrapolated to other contexts as there are large disparities in samples and instruments. Scientific production started to be significant in 2017, with very low numbers since 2006.

The limitations of the study are associated with the risk of loss of information. This is considered by the strategy defined and applied in terms of the selection of descriptors. The search was based on specific terms such as "mobile learning" and "communication", which were established to delimit educational issues and were complemented by specific screening in the area. On the other hand, the final number of 24 articles analysed is a clear conditioning factor with regard to the elaboration and extrapolation of evaluations on the subject.

Some of the lines of research that could be developed in this area could focus on studies or research that contribute to defining how communication processes influence, transform and evolve when using ML in

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educational contexts. Especially in vocational training processes, the didactic application of ML can improve the encoding and decoding of information in didactic interaction processes, especially in applications, workshops, or other professional practices.

The value of this work in terms of education lies mainly in the introduction of a methodological change that allows students to participate in an active, participatory and social learning process; with personal responsibility that results in an increase in communication and enhancement of interpersonal relationships and a reinterpretation of the didactic processes. In an environment of the constant digital revolution, it is essential to reflect on the real changes and implications introduced by resources such as ICTs in issues as necessary in the 21st century as is the field of education, especially in higher education stages linked to the world of work such as Vocational Training.

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Appendice

TABLE A1. Empirical design

Country	Language	Date	Aim	Methodology	Sample	Variables	Measurement	Main Findings
Ethiopia	English	2021	To increase the secrecy capacity of the wireless networks when there are moving cooperative communication devices.	Quantitative research	—-	The transmit parameters, the interaction of the transmitter, receiver, relay-node, and the eavesdropper devices	Reinforcement learning. Q-learning	The proposed technique has enhanced the secrecy level of the legitimate receiver.
China	English	2021	To study the addition of intelligent algorithms to wireless network communications to optimize and build autonomous mobile learning for cloud education.	Quantitative research	550 students	Transmission delay of wireless network communication system, the energy consumption	Questionnaire survey	This wireless network communication system has a 10% lower packet loss rate and less wireless network data transmission errors, than the other two methods, thereby improving the data transmission power of the wireless communication network.
China	English	2021	To design an English mobile learning platform based on the GSM-R wireless network communication system	Experimental research	—-	The platform encryption technology, and learning recommendation algorithm to create the English mobile learning platform.	Deep learning and method based in similarity measure	The application of the designed platform can improve student satisfaction and learning efficiency.
Costa Rica	Spanish	2020	To know students' opinion on the educational use of mobile devices, and the implementation of mobile	Qualitative research	67 students	Usefulness of the application as a communication tool	Questionnaire	There are conditions for mobile learning in the Costa Rica university classroom, and

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			learning in university classroom using Whatsapp					its implementation brings benefits in the teaching and learning process.
Australia United States	English	2020	To explore the use of mobile technologies to connect hospitalized adolescents students to their schools, classmates, and families to reduce their isolation and disrupted schooling experiences.	Qualitative research	18 hospitalized adolescents, 29 teachers, and 4 parents	Technology related to learning; to communication with school and wellbeing	In-depth interviews QSR Nvivo	Mobile technology should be used as a therapeutic tool to overcome hospitalized adolescents' social isolation and improve their well-being
United Arab Emirates	English	2020	To analyze how do students use technology in their educational processes and why do they use some technologie	Qualitative research	100 students, 2 specialists of the university and 10 instructors from college	Funcionality, intuitiveness, progress tracking, relation with studies, user-friendly interface	semi - structured interviews, focus group	In an informal setting, they prefer to use mobile technology because of its accessibility, flexibility, connectivity and interactivity
China United States	English	2018	To analyze the efficiency of collaborative learning comparing learning-related uses of an online discussion forum against such use of a mobile instant-messaging app	Qualitative research	78 upper-division undergraduate pre-service teachers	Learning interaction, network density, cliques, usefulness, ease of use	Ad-hoc Questionnaire	Online discussion forum enhanced knowledge construction. The mobile instant-messaging app social interactions.
Colombia	Spanish	2018	To develop a communicative mediation tool that allows deaf people and listeners to communicate.	Experimental research	—-	Sign generation speed, translation validity and system performance	System development through mathematical processing	A communicative mediation system was obtained through an interface on a mobile device, which allows a message to be entered aloud and converted to text by the application, translated into GLOSA and sign language.

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India	English	2018	To propose a mobile application which can be used to access the University Learning Management System with the mobile and the mobile digital book with augmentation system	Qualitative and experimental research	200 teachers and 500 students 280 students	the effectiveness of existing technologies in teaching and learning process. Effectiveness analysis of the application	Questionnaires	The teacher module allows the teacher to adjust the e-assessment, access the students' performance and learning pattern. The student accesses different and tools for the learning process.
Taiwan	English	2017	To propose a context-aware mobile Japanese conversation learning system (CAMJAL) for Taiwanese students.	Quantitative research	86 university students	Perceived convenience, ease of use, and usefulness	Ad-hoc questionnaire	Perceived convenience, perceived ease of use, and perceived usefulness were antecedent factors that affect acceptance of CAMJAL
Taiwan	English	2017	To analyze how the mobile Computer-Supported Collaborative Learning (mCSCL) contexts help learners improve their learning	Quasi-experimental approach	199 students (three groups)	Communication and coopetition, Examination scores, learning satisfaction level,	Questionnaires & Artefact analysis	The students in mCSCL contexts significantly outperformed those in face-to face collaborative learning (CL) contexts in terms of examination scores. No significant difference was found between the groups regarding perceived learning satisfaction.

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Malasya	English	2016	To develop and design an android application namely MobileLearning Communication Aid (MOLECOMAID) based on social constructivism theory	Experimental research	—-	—-	Application use	The novelty and originality of this app canbe assured since there are no any similar app currentlythat can be noticeable in the MOLECOMAID's GooglePlay Store Page.
Taiwan	English	2014	To investigate the effects of mobile learning participation time on students' conception of collaboration, communication, complex problem-solving, meta-cognitive awareness and creativity	Quantitative research	606 students	Namely collaboration, communication, complex problem-solving, meta-cognitive awareness, and creativity	Ad-hoc Questionnaire	The students' complex problem-solving abilities could also be improved by engaging for longer periods of time in mobile learning activities.
South Africa	English	2013	To establish how the use of mobile technology could enhance accessibility and communication in a b-learning course.	Mixed research	30 students	Need for use of ICT, Access to ICT, Frequency of use and Use of ICT for communication and collaboration	Questionnaire likert scale and open ended questions	Findings revealed that social networks such as Facebook improved online communication and increased participation and collaboration beyond the computer centre.

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Chine	English	2010	To evaluate the use of mobile information and communication technology in a large- sized undergraduate class, where the effectiveness of multilearner participation and prompt learner-instructor interaction is often challenged.	Mixed research	232 students	Age Gender, Prior usage of PDA Prior learning and experience Course information	Ad-hoc Questionnaire and focus group	Their results suggested that richness of a "lean" medium could be increased in certain socially constructed conditions, thus extending existing notions of computer-aided instruction towards a techno-social learning model.
Spain	English	2015	To present a project-based learning experience to teach mobile communications courses, carried out at Alcalá University, Madrid, Spain	Qualitative and experimental research	50 students	The work in groups under a group's leader, the competition process and rules established and motivation in the course	Opinion Questionnaire	The competition aspect of the method helps to maintain the students' interest in the process, and integrates them in the learning process.
Spain	Spanish	2009	To evaluate the use of mobile learning (m-lear- ning) as a tool for the development of discussion skills in asynchronous communication forums is proposed.	Qualitative and experimental research	80 students	Student evidence left in the forums	Focus group and rubric	Given the results observed in this study, the use of the mobile learning tool could be recommended in activities where reading comprehension is assessed like PBL (problem-based learning).
Chine Taiwan	English	2008	Analyze the effectiveness of mobile communication to stimulate teacher-student communication and improve learning efficiency.	Quantitative research	176 senior high school students	The independent variable: use of individual media in instruction process. The dependent variables were student pressure, motivation and performance of learning.	Ad-hoc questionnaire and coding with ANOVA	When combined with Internet communication media, it can significantly increase student extrinsic motivation without causing higher pressure.
Australia	English	2006	To analyze the influence that Tablet PCs have had on the way multimedia students learn concepts and approach their design development work through their communicative ecology	Qualitative research	17 students	Tablet PCs in Everyday Work Practices, Drawing With the Tablet PC, Communication and Tablet PCs.	Survey, structured interviews and focus groups.	Introducing Tablet PCs in a creative computing programhas influenced the ways students learn conceptual development and reflective

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								practice within the design process.
Greece	English	2006	The proposed environment attempts to enhance the information flow among the members of a department and, furthermore, to provide a test-bed mobile Web application for students undertaking Internet technologies courses.	Mixed research	43 students	Student-Specific Functionality, Academics Using the Mobile Web Services and Management of the Mobile Web Services	Ad-hoc Questionnaire and foc group	Technological evaluation and students' feedback indicate that the proposed solution is both efficient in communication perspective and effective for student involvement in the mobile Web initiative.

TABLE A2. Theoretical design

Country	Language	Date	Aim	Methodology	Main Findings
United States	English	2020	To support mobile applications (apps) use for classroom management, communication with parents, and student learning.	Descriptive analytics based on documentary review and empirical inquiry	Although teachers have acknowledged an unfamiliarity with tools to support their selection of apps for effective use with students, they have welcomed guidance for such evaluations. Mobile technology (apps) has been reviewed from a sociocultural perspective, evidence-based research has been synthesized, and directions for future research have been offered.
Turkey	English	2017	To provide a theoretical framework about connectivist learning	Descriptive documentary methodology based	A combination of two-pronged approach of Technology Acceptance Model and Media Naturalness Theory proposed in this study introduces a method for evaluating technology in a way that will help us understand the opportunities, benefits, and shortcomings of the

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			focused in how to evaluate our perception of mobile communication technology	on a systematic review	technology we seek to grasp and utilize in learning.
Malasya	English	2015	To present a mobile learning framework to develop a Malay language learning application using near field communication (NFC) technology.	methodology based on a systematic review	The system allows Malay language learning using mobile devices and NFC technology to achieve several learning theories such as Ubiquitous, immerse learning, context and tangible interface. Users learn the language using their mobile devices to enrich their learning process. NFC helps the learning process as it requires touch on tag or other NFC devices to work; therefore students interact with object directly.
USA, Taiwan	English	2007	To discuss a general framework to depict the interaction of the knowledge contents and the components of communication tools that are involved in their delivery.	Descriptive documentary	A cross-discipline approach may help us to reach the goal of better learning/teaching, and an incremental, modular approach may allow this collaboration to take place. We can be certain that because of the diverse economic and social structures, the dimension and magnitude of 3G impact will be different among different countries and geographic areas.

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