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EDITED BY

Stamatiou Papadakis,
University of Crete, Greece

REVIEWED BY

Hassan A. El-Sabagh,
Mansoura University, Egypt
Efransia Tzagkaraki,
University of Crete, Greece
Alkinoos Ioannis Zourmpakis,
University of Crete, Greece
Michail Kalogiannakis,
University of Crete, Greece

*CORRESPONDENCE

Giovanni Bonaiuti
giovanni.bonaiuti@unica.it

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Educational robotics studies in Italian scientific journals: A systematic review

Giovanni Bonaiuti^{1*}, Lucia Campitiello², Stefano Di Tore² and Arianna Marras²

¹Department of Literature, Languages and Cultural Heritage, University of Cagliari, Cagliari, Italy,

²Department of Humanities, Philosophy and Education, University of Salerno, Salerno, Italy

In recent years, there has been increasing attention to applying educational robotics (ER) in learning settings and, consequently, it has concerned and involved the entire pedagogical field, giving rise to a large amount of experimentation and research. Educational robots are used within the school curriculum and in extra-curricular activities to improve student interest, engagement and academic achievement in various fields, such as STEM and digital literacy, and in many other ways, for example fostering specific cognitive and socio-relational skills. In Italy, as in many other countries, an increasing number of publications are featuring this subject. While there are also some reviews, none of them has been interested in reviewing studies published in Italian journals. The aim of this work is to provide a systematic review of the literature regarding studies investigating educational robotics and provide suggestions for further research and teaching practices. To do this we used the PRISMA statement process. In total, 28 studies published between 2011 and 2021 in 49 Italian journals were analyzed. The main findings from this review provide the current state of the art on research in ER. Furthermore, the paper discusses trends and the vision toward the future and opportunities for further research.

KEYWORDS

educational robotics, Italian journals, social robotics, systematic review, STEM

Introduction

Since from Papert's (1980) work, educational robotics has received global attention from the world of education, which has increasingly invested in this area of practice and research. Interest, which continues to grow to this day, has intensified over the last 10 years, as can be seen from the many literature reviews published on the international scene. These works highlight the breadth of the phenomenon, showing the different aspects and the varied research focuses. Benitti's (2012) review, one of the most cited, pointed out the potential of robotics in schools, highlighting the pedagogical features of projects but also the shortage of more quantitative work. The lack of meta-analysis can also be noted on this side. Mubin et al. (2013), in a review on the applicability of robotics in education, focused on the several practical aspects of using robots in

education, addressing issues such as child-robot interaction and highlighting the added value of robots as stimulating and engaging teaching aids in the classroom.

Some authors have explored the use and teaching of robotics in the school context by highlighting the central role of the teacher who is required to act as a researcher to process new knowledge (Papadakis et al., 2021; Tzagkaraki et al., 2021; Papadakis and Kalogiannakis, 2022). Although the potential of robotic technologies is widely recognized in the school context, some studies have investigated teachers' perceptions about the use of ER in preschools and elementary schools, and how these perceptions may affect the use of robots in educational practices (Papadakis et al., 2021; Papadakis and Kalogiannakis, 2022).

The subjects examined by the researchers ranged from early childhood education (Frison, 2019) to K-12 (Karim et al., 2015; Xia and Zhong, 2018; Kyriazopoulos et al., 2021; Tzagkaraki et al., 2021), as well as young children (Toh et al., 2016; Jung and Won, 2018). Additionally, they examined the learning environments in which such projects have been implemented: from the non-formal and extracurricular associative environment to the formal and curricular environment of school, including primary education (Kyriazopoulos et al., 2021; Tzagkaraki et al., 2021). The richness, heterogeneity, and variety of work is explained by the fact that robots are intrinsically versatile tools. In fact, apparently, only hardware features define the affordance of the device. Many researches demonstrate that the multifaceted nature of robotics fosters the design of countless new multidisciplinary activities in which technical-practical and social arguments coexist (Anwar et al., 2019).

Research shows that robotics has also proved to be an important opportunity in inclusive education, distinguishing itself as a medium capable of providing effective support, in terms of wellbeing, attitude and knowledge, to socio-cultural disadvantage, special educational needs and qualify as a mediator and promoter of gender equality (Daniela and Lytras, 2019; Sullivan and Bers, 2019; Bagattini and Miotti, 2022). In this vein, the synthesis by Pivetti et al. (2020) investigates studies on educational robotics to support children with neurodevelopmental disorders. Beyond the numerous studies that have classified multiple educational robots as particularly effective tools in the STEM disciplines (Benitti, 2012; Toh et al., 2016), few of them have tried to evaluate the potential of robots with social-assistive attributes to foster understanding of scientific concepts (Papadopoulos et al., 2020). In recent years, also in the field of social robotics, numerous studies have been conducted on the use of social robots to promote the development of specific skills in students, particularly for children with Autism Spectrum Disorder (ASD) (Ferrari et al., 2009; Dunst et al., 2013; Conti et al., 2015), with the aim of promoting the development of social skills through verbal or non-verbal feedback. In educational settings, social robots are also used to fill the role of tutors or peers (Belpaeme et al.,

2018), supporting lessons and encouraging students to acquire new skills (Leite et al., 2013), for example learning a second language. Although the use of educational robotics is widespread in each country and a variety of reviews are already available on specific aspects of the topic (see Table 1), we believe it is valuable to analyze specificities existing within a specific cultural context.

This has driven us to undertake this systematic review of the research literature published in Italy over the past decade. This review has multiple purposes: to verify what types of experiences have been documented in Italian journals; to provide educational professionals and researchers with a reasoned summary of the work published to date, in order to understand the direction of research, what types of devices have been most widely tested in which educational settings, for what ages, and for the enhancement of which specific social, cognitive, motor skills; to provide researchers with directions that could facilitate the implementation of new robotics projects, with the intention of prompting new empirical research in order to enrich the scientific landscape¹. Specifically, our research aims to examine the state of research in educational robotics based on the following research questions:

Question 1: For what specific purposes are robots used in educational contexts, and how are these practices implemented (which teaching methods were used most)?

Question 2: What are the general benefits of educational robotics according to the articles reviewed?

Methods

With the goal of capturing a clear picture of what has been published on the topic in the last 10 years in Italy, we have done a systematic literature review using Borrego et al. (2015) four-step process: search, selection, coding, and synthesis. The first two steps correspond to the stages of the PRISMA statement process—search (identification), selection (screening, eligibility, included)—while the other two concern the analysis work (coding and synthesis).

Search method

Since there is no specific database containing all the papers published in Italian journals, to retrieve the best Italian literature on robotics in education, it was necessary to find and search within each journal. Therefore, the first step was to carefully

¹ Although our research includes works published in Italian scientific journals, it is not intended to take a snapshot of the state of the art of educational research in Italy about educational robotics, but rather to detect the interest in the subject on the part of Italian publishers.

TABLE 1 Systematic reviews of robotics in education.

References	Main topic(s)	Period	No. of studies
Benitti (2012)	Use of robotics in schools. Teaching methods implemented in educational robotics activities in schools. An attempt is made to determine which studies demonstrate their teaching effectiveness.	2000–2009	10
Toh et al. (2016)	Use of robotics as an educational tool in early childhood. Children's perceptions and the influence of robots on behavior are analyzed.	2003–2013	27
Spolaôr and Benitti (2017)	Subjects taught with robotics in tertiary education. Learning theories used to support robotics are outlined.	Not specified	15
Xia and Zhong (2018)	Pedagogical-didactic approaches that are effective in implementing robotics in schools. The implications highlighted in the empirical studies reviewed are outlined.	Not specified	22
Jung and Won (2018)	Research findings on children learning robotics. The researchers were interested in how robotics in education is defined and the most commonly used research methodologies.	2006–2017	47
Anwar et al. (2019)	The overall effectiveness of educational robotics in K-12 education: from learning and creativity to student motivation. Teacher professional development is investigated.	2000–2018	147
Frison (2019)	Educational robotics in educational services for children aged 0–6 years; emphasis is placed on design from a play-based learning perspective.	2009–2019	21
Papadopoulos et al. (2020)	Use of socio-assistive robots (SAR) in the teaching mathematics and science in pre-tertiary classrooms. An attempt is made to outline the advantages and disadvantages.	2004–2019	21
Pivetti et al. (2020)	Studies on educational robotics for children with neurodevelopmental disorders. An attempt is made to investigate whether the implementation of robotics activities can improve skills and performance of children with special needs.	From 2006	15
Kyriazopoulos et al. (2021)	Educational robotics in primary education. Multiple factors are analyzed: course topics, designed activities and learning environments.	2012–2019	21

select the journals to be screened. For this purpose, we used the list of Class A journals² accredited by ANVUR, the Italian agency for the evaluation of academic research, selecting, in particular, those in the disciplinary area dealing with didactics, educational technology and educational research methodology (11/D2 sector). Forty-nine Italian journals were selected (see Appendix 1).

Articles were identified by working in two steps. First, using the Google search engine, a limited search was performed with the qualifier “site:journalname.it” (where “journalname.it” means the website of each journal identified). The search string used was the follow:

“(Robot OR Robots OR Robotics OR Robotica) AND (coding OR pensiero computazionale OR computational thinking OR Social OR Sociale OR Student OR studente OR alunno OR School OR Scuola OR Education OR Educational OR Educazione OR Educativa OR inclusione OR inclusion OR Teaching OR Insegnamento OR Learning OR apprendimento OR didattica OR docente OR insegnante OR Formazione).”

Subsequently, in order to check the completeness of the results, a search of each journal's website was executed using the same keywords. The lack of a specialized database for collecting articles published by Italian journals makes the task of compiling a research synthesis even more complicated. The search was performed from the beginning of February 2022 to the end of May 2022. A total of 122 papers were identified through Google search and websites.

² ANVUR (Italian National Agency for the evaluation of universities and research institutes) makes lists of journals for each scientific field in order to assess academic research. We used history, philosophy and pedagogy (area 11). <https://www.anvur.it/en/activities/rating-of-scientific-journals/>.

Selection strategy

In the second phase, according to the PRISMA statement, the retrieved papers were analyzed based on the inclusion and exclusion criteria (Table 2). Two of the authors of this study worked together on deciding to include or exclude a study. As already noted, a total of 122 papers were identified through Google search and websites (Figure 1), of which 3 were reviews of other texts. Of these, 57 studies were discarded because, after reading their abstracts, they did not meet some of the identified inclusion criteria. The remaining 62 papers were independently evaluated by two authors who then compared them with the identified criteria and, after discussion, excluded an additional 34 papers, one of which was excluded because it was in Spanish.

The diagram depicted in Figure 1, based on the PRISMA declaration (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), shows the entire process after which 28 papers were included in this review and subsequently thoroughly viewed and analyzed by the authors of this work. The papers included are listed in the “Results” section (see Table 3) and highlighted with an asterisk in the references.

Coding and synthesis

In the third phase of the process, we collected relevant data and chose criteria to classify all studies. We arranged the 28 papers in a spreadsheet and listed them according to following information and features: (1) research method applied (qualitative, quantitative, mixed methods); (2) data collection

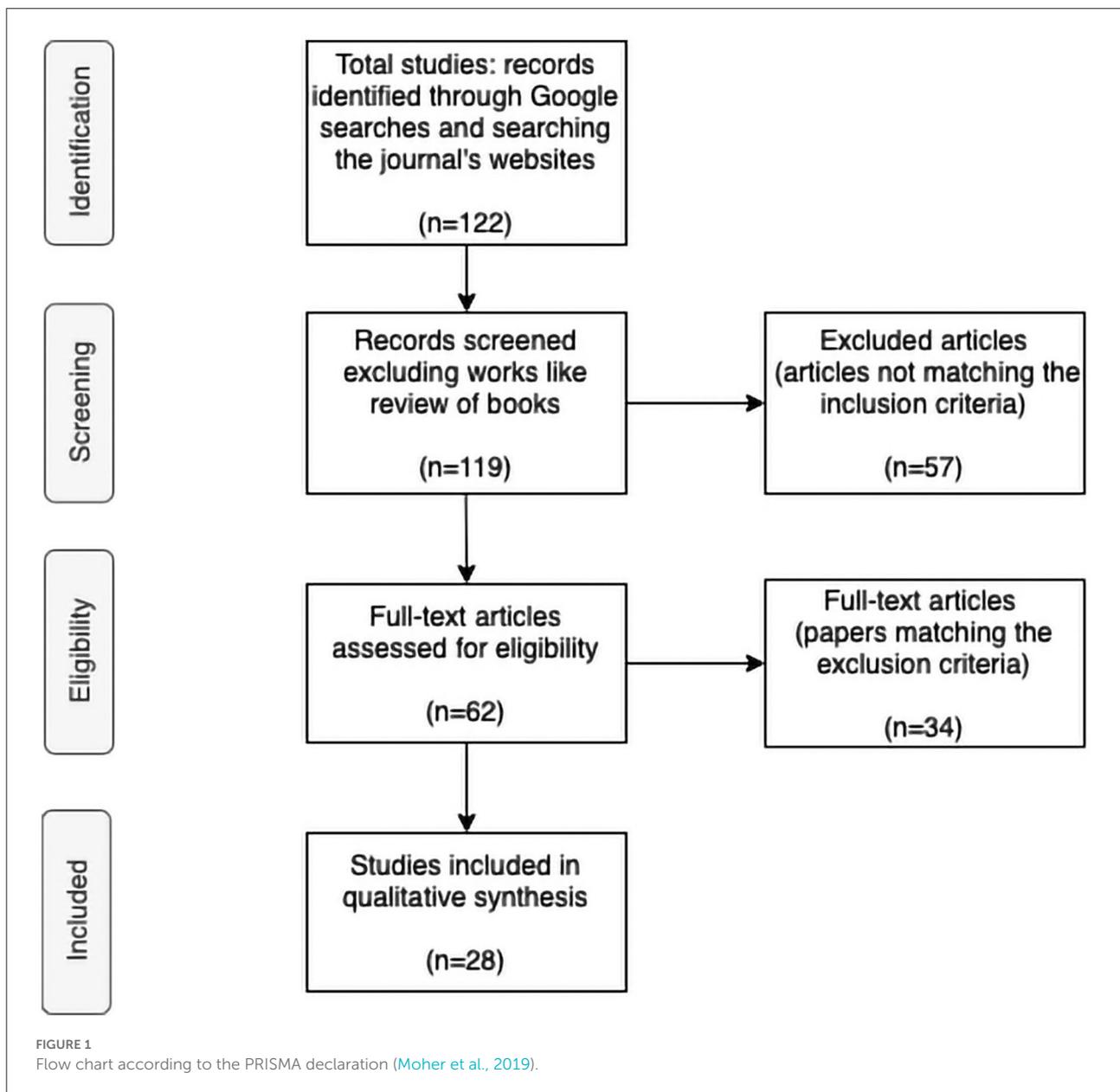
used (observation, interview or focus group, test or assessment, questionnaire, student product evaluation); (3) Goals (education in robotics, education with robotics, teacher training, media education); (4) setting (formal, non-formal); (5) target (children, teenagers, adults); (6) school level (pre-school, primary school, middle school, high school, university); (7) subject (arts or humanities, life skills, inclusion, second language, STEM); (8) robot type (built by student, compact, social); (9) number of participants; (10) duration of empirical research. We then defined other categories, inferring them from reading the articles included and, in part, retrieving and adapting categories from other systematic reviews (Bacca et al., 2014; Jung and Won, 2018). These categories may indicate some of the dimensions presented and analyzed in the research articles. Sometimes the information was not made explicit by the authors. Due to the lack of clarity, some authors’ statements were interpreted. Some papers may provide data categorized into more than one subcategory (in which case, the categorizations in the tables of this paper have an asterisk symbol to the right of the category name). In the last stage, synthesis, we summarized the main findings of the selected articles, answering the research questions.

Results

The papers analyzed were published from 2011 to 2021. Studies published in 2022 were not taken into account due to the publication time of this work. To date, different studies on the topic are “pending publication,” and they are not yet fully available; therefore, in this work, any papers from 2022 have not been evaluated. Figure 2 shows the trend in publications within the time range analyzed. As the graph shows, there

TABLE 2 Criteria for the inclusion and exclusion of studies.

Inclusion principle	Description
Publication date	Articles must have been published between 2011 and 2021 (last 10 years).
Themes	Articles must have “robot” or “robots” or “robotics” or “robotica” in the abstract, title or keywords. Otherwise, the same words must be meaningfully present in the body of the text.
Italian journals	Articles must be published in Italian ANVUR Class A journals, sector 11/D2.
Language	Articles must be published in Italian or English.
Exclusion principle	Description
Scope of article	Articles that do not have robotics educational research as their primary aim (e.g., articles that aim to design a robot or develop computational logic for implementing a robot).
Nature of article	Articles that do not present an empirical study. Papers excluded could be those that propose visions, models or theories on educational robotics as well as expert interviews, editor’s notes, or reviews of other works (books or articles). Research still at the design or planning stage is also excluded.
Secondary or tertiary source	Articles that do not present a primary study. They could be syntheses that have compared and contrasted primary research work or have attempted to extrapolate findings from other studies.



is a publication spike in 2019. This variation is due to the publication of a special issue of the journal *Form@re* on the topic of robotics.

Our search, which considered 49 Italian journals, led to identify 122 papers in 23 journals and, after the analysis and evaluation phases, to select 28 papers from 11 different journals (see Table 3). Remarkably, in 26 Italian journals, educational robotics issues it seems that are never considered.

In the Table 4 we summarize main design features of 28 papers included.

Table 5 reports the main features that characterize the selected research papers.

Based on the data summarized by the table above, we can state that:

- the preferred type of research design was qualitative (54%);
- the preferred type of data collection was observation (30%);
- the average duration of the research analyzed was around 6 months;
- 75% of the research has focused on the goal of education with robotics;
- 75% of the research has preferred a formal setting;
- most of research was conducted with students attending primary school;
- the average sample was composed of 49 subjects.

TABLE 3 Papers identified and included in each Journal.

Journals	Retrieved (identified) papers	Selected (included) papers
Annali online della didattica e della formazione docente	1	1
CQIA Rivista—FORPERLAV	1	0
Education sciences & society	1	1
Form@re	29	9
Formazione & Insegnamento	12	2
Giornale italiano della ricerca educativa	2	0
Giornale italiano di educazione alla salute, sport e didattica inclusiva	1	1
JE-LKS. Journal of e-learning and knowledge society	11	4
Journal of educational, cultural and psychological studies—ECPS	1	0
L'integrazione scolastica e sociale	4	1
Nuova secondaria	1	0
Orientamenti pedagogici	2	0
Pedagogia più didattica	2	0
Qwerty	2	0
REM	6	5
RicercaAzione	1	1
Ricerche di pedagogia e didattica	9	1
Ricerche di psicologia	1	0
Ricerche pedagogiche	3	0
Scuola democratica	8	0
Studi sulla formazione	4	0
Studium educationis	1	0
TD—tecnologie didattiche—Italian journal of educational technology	19	2
Tot	122 papers identified in 23 journals	28 papers included in 11 journals

The samples retrieved from the analyzed research broken down in Table 6.

According to the data shown in the table above, the sample size varies greatly, as summarized by the variation coefficient (1,2). This variation is partially due to the type of research, with the case studies on inclusion and disabilities having small samples. It is also interesting that two studies (7% of total analyzed studies) do not give any information about their samples. With respect to subjects, most of the research was aimed at fostering the development of STEM competencies, as Table 7 illustrates.

To answer the second research question, aimed at identifying the general benefits of educational robotics, we attempted to isolate and summarize the main educational objectives of the works through a categorization of the dimensions analyzed (see Table 8). Such dimensions (problem-solving, motivation, inclusion, etc.) point out the authors' interest in some aspects related to specific expected benefits through the practice of educational robotics. However, as we shall see in the discussion, in several cases the data stop at mere statements of principle without adequately supporting them with empirical data or arguments.

As Table 8 illustrates, most of the studies were conducted with the aim of fostering the development of computational thinking (16%), while only 4% of studies were conducted with the aim of evaluating the technology from a usability, effectiveness, acceptability, or sustainability point of view. Two researchers independently coded the papers in order to categorize them. The rules were developed through discussions between the authors of this paper. Interrater reliability (Cohen's Kappa) was strong ($k = 0.89$), and disagreements between raters were all resolved through discussion.

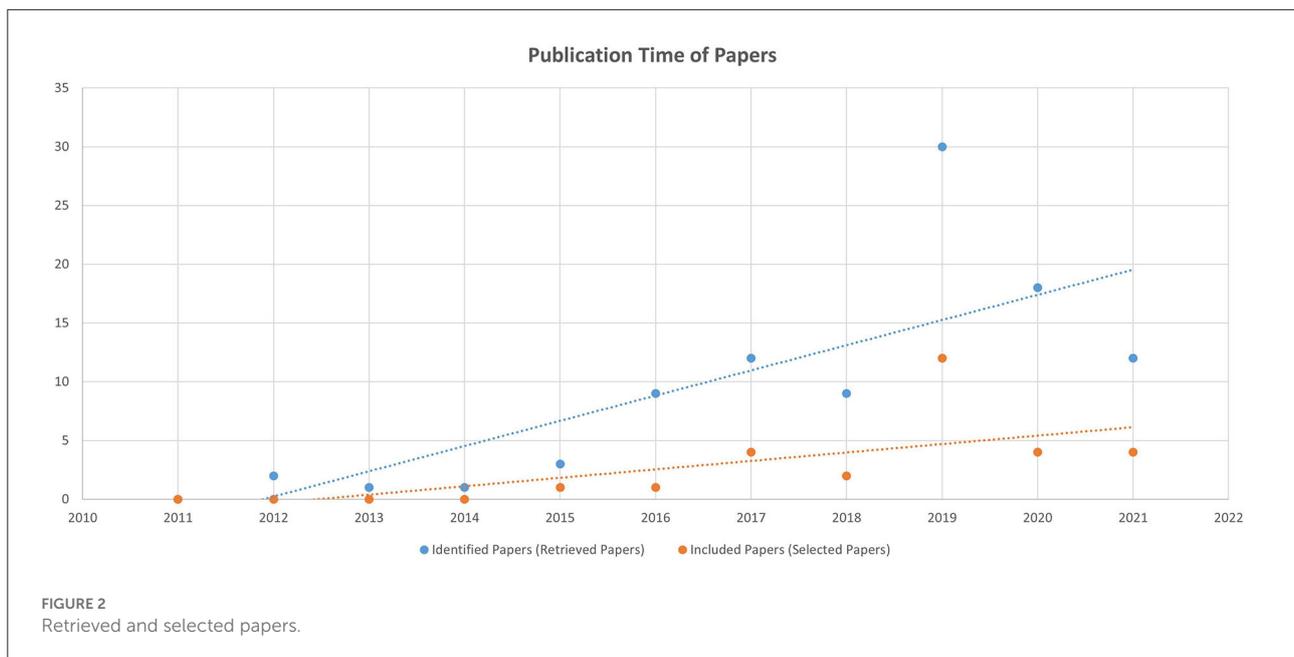
Aggregating the data from Table 8 we can see that 45% of the analyzed papers focused on fostering the development of metacognition processes and 26% were related to inclusion and social topics. Only 7% of the studies were conducted to foster teachers' professional development.

As Table 9 shows, most of the studies (28%) were conducted using a project-based approach as teaching method, while only 7% of the studies were conducted using a free-play-approach. Most of them were organized as group work.

Table 10 shows that most of the studies (82%) used robotic hardware. Of the total studies included, 17 (61%) used an educational robot, within that number, 3 studies used built and compact robots, and for this reason they were calculated twice within the subcategory. Only 6 researches (21%) used a social robot, and 5 researches (18%) did not use any robotic devices.

Discussion

Based on the research questions that guided our investigation, we must point out the limitations of this work and suggest new frontiers of research on educational robotics. Of the 28 papers accepted published between 2011 and 2021, 26 were published in the last 5 years and 12 in 2019 alone. These data allow us to surmise that, also in Italy (see Figure 2), there has been growing interest in robotics, confirmed by the scientific literature. This is in line with the references of several researchers (Sullivan and Bers, 2019; Ching et al., 2019; Kyriazopoulos et al., 2021) regarding the lack of research on robotics (before 2017), a trend that does not reflect the growth observed in recent years.



Main findings

Our work, the main aim of which was to retrieve and analyze articles published in Italian Class A journals on the subject of educational robotics over the last 10 years (2011–2021), sought to answer two main research questions that guided the investigation from the outset. Regarding the first question, namely “For what specific purposes are robots used in educational contexts, and how are these practices implemented (which teaching methods were used most)?”, we can state that we are in line with what has been reported in the international literature (e.g., Benitti, 2012; Anwar et al., 2019; Kyriazopoulos et al., 2021), i.e., that the main reason for its adoption is related to the promotion of STEAM skills. A series of Italian works have stated the potential of robotics in educational competitions to promote the development of problem-solving skills and computational thinking (Balestra, 2018; Luccio, 2019; Mortari et al., 2020; Scippo and Ardolino, 2021), soft skills (Rubinacci et al., 2017) and disciplinary topics (Cortiana and Rigotto, 2019; Torre, 2019). Torre (2019) introduces math reasoning in high school in an interdisciplinary way through examination of dilemmas in a literary tale. The proposed story involves different time trajectories for the various protagonists to be achieved through problem solving and robot programming. Educational robots are also used to promote the development of scientific thinking (investigating the ability to intuit the behavior of a robot) and the use of scientific method (Tzagkaraki et al., 2021) using an inquiry-based approach (Datteri et al., 2015; Datteri and Zecca, 2017). A type of robot called “MoveCare,” on the other hand, has been used to improve the autonomy of elderly people (Zannini et al.,

2019), confirming that the potential purposes of robotics are multiple and ever-expanding.

Social robots are also present in the literature investigated in the field of special education, either to help children with ASD in social interactions by observing behavior and using human-robot imitative modeling to support the development of basic social skills (Pennazio, 2017; Campitiello et al., 2021), or as in the case of Iromec and Zora (Van Den Heuvel et al., 2016), to support play in children with severe motor disabilities. Robots with social features have taken on the role of tutors in teaching a second language (De Carolis et al., 2019; Gasparini, 2019; Arar et al., 2021). De Carolis et al. (2019) explore how social robots (specifically NAO) can be used in teaching a second language to unaccompanied migrant children. The overall aim of this research is to support the cultural processes of inclusion. The work has given ample space to the cultural aspect of the gestures required to enable social inclusion. Gasparini (2019) presents a preliminary study on the use of the social robot NAO for teaching L2 vocabulary through the selection of gestures that can accompany comprehension. However, the work does not yet provide direct evidence. Lehmann and Svarny (2021) were interested in probing students’ thoughts and opinions on the role of Pepper, a humanoid social robot, in providing learning support during university lectures. The authors also wondered which type of feedback from the robot was most productive.

Some work focused on technology evaluation and measured whether the robotic technologies designed and implemented were sustainable and/or accepted by teachers and students. Two examples are works on the alpha and beta testing phases of designed and 3D-printed artifacts: a built robot (Di Tore et al., 2019) to develop digital skills in high school and a social

TABLE 4 Articles selected and study type.

References	Topic	Methodology	Data collection method	Participants	Robots
Alimisis et al. (2019)	The eCraft2Learn project in which children create their own robotic artifacts through learning by doing	Qualitative	Observation	24 students	Pepper
Arar et al. (2021)	Social robots as a support to facilitate learning a second language in children	Mixed methods	Knowledge test	54 children	Emys
Balestra (2018)	Use of small robots for the development of computational thinking	Qualitative	Observation student product	Not specified	Sphero Lego WeDo Bee Bot Little Bits Not specified
Bruni and Nisdeo (2017)	A preliminary investigation of the idea of robots through the analysis of the drawings of primary school children	Mixed methods	Observation Student product	44 students	Not specified
Campitiello et al. (2021)	Creation of a robot prototype through 3D printing to promote the development of social skills in children with ASD	Qualitative	Observation	1 child with ASD	ASD-Robot
Castro et al. (2019)	Educational robotics to enhance executive cognitive processes	Mixed methods	Test	11 children with neurodevelopmental disorders	BeeBot
Cicognini et al. (2019)	Educational robotics workshops to promote active learning in kindergarten	Mixed methods	Observation Interviews Questionnaire	45 teachers	Lego WeDo Mindstorms
Cortiana and Rigotto (2019)	Educational robotics as a tool to promote the teaching of literature in children	Quantitative	Questionnaire	25 children	BlueBot
Datteri and Zecca (2017)	Describe the behavior of a preprogrammed Braitenberg-like vehicle in primary school	Qualitative	Observation	23 students	Coderbot
Datteri et al. (2015)	The “scientist’s game,” children trying to understand how a robot was programmed to learn the scientific method	Qualitative	Observation Interviews	24 students	Lego Mindstorms
De Carolis et al. (2019)	The use of social robots to teach a second language to minor migrants to support their integration into a new culture	Qualitative	Questionnaire	4 children and 6 adults	Nao
Di Tore et al. (2019)	Design of an educational robot to foster digital skills in upper secondary school students	Qualitative	Observation	37 teenagers	Disuffo
Ferrari et al. (2020)	A first exploratory survey aimed at acquiring specific information on the use of robots in reference to AI education	Qualitative	Interviews	6 teachers	Not specified
Gasparini (2019)	Social robots and L2 teaching for children	Qualitative	Observation	32 children	Not specified
Giannandrea et al. (2020)	Documentation of a teacher training course on design, robotics and coding	Mixed methods	Knowledge test Questionnaire	41 teachers	BeeBot
Gramigna (2018)	Reflections on the use of educational robotics to analyze the cognitive field of students and activate a metacognitive approach to school knowledge	Qualitative	Interviews	127 teachers	Not specified
Lehmann and Svarny (2021)	Using the Pepper robot to collect student feedback during university lectures	Qualitative	Questionnaire	155 students	Pepper

(Continued)

TABLE 4 (Continued)

References	Topic	Methodology	Data collection method	Participants	Robots
Luccio (2019)	Use of a robot to promote the learning of algorithms through the learning by doing approach	Quantitative	Knowledge test Questionnaire Student product	26 + 47 students	Lego Mindstorms EV3 mBot
Mortari et al. (2020)	“Resolving Robots” educational robotics project to promote teaching and thinking skills in prospective teachers	Qualitative	Observation	15 students	Lego WeDo 2.0
Negrini and Giang (2019)	Investigation of how students perceive educational robotics to enhance their creativity and promote interest in STEM disciplines	Quantitative	Questionnaire	91 children	Thymio II
Negrini (2020)	Analyze teachers’ attitudes toward educational robotics	Mixed methods	Questionnaire	174 teachers	Not specified
Passalacqua and Zecca (2019)	Project robotics laboratories at the EXPLORA Museum: evaluation of methods and learning”	Qualitative	Observation Interviews	Not specified	Lego NXT 2.0 Bee-bot
Pennazio (2017)	Social robots to help children with autism in their interactions through imitation	Qualitative	Observation Questionnaire	1 child with ASD	IROME C
Rubinacci et al. (2017)	Robotics for the training of soft skills in an non-formal context	Quantitative	Questionnaire student product	128 children	Lego Mindstorms
Scippo and Ardolino (2021)	The use of technological material in Montessori primary school to encourage the development of computational thinking	Mixed methods	Observation Knowledge test Student product	19 students	Ozobot Lego WeDo
Torre (2019)	Use of educational robotics to facilitate the learning of abstract scientific concepts	Qualitative	Test/assessment	35 teenagers	Ozobot
Van Den Heuvel et al. (2016)	Robots to support play in children with severe physical disabilities	Mixed Methods	Focus group	11 children with a physical disability 33 children with a degree of physical disability.	Iromec Zora
Zannini et al. (2019)	Robotics project to analyze the use of ICT as a potential to promote socialization in older people	Qualitative	Questionnaire	16 elderlies	MoveCare

robot (Campitiello et al., 2021) to foster the development of social skills in children with ASD. A considerable number of studies analyzed the aspect of teacher and student perceptions of robotics resulting from the use and implementation of this practice at school. In general, this type of research has been conducted through the use of questionnaires or interviews. There are at least five papers (Gramigna, 2018; Cicognini et al., 2019; Ferrari et al., 2020; Giannandrea et al., 2020; Negrini, 2020) that, overall, show that teachers have a strong interest in robotics. Regarding students’ perceptions of educational robotics, Negrini and Giang (2019) investigated its pedagogical value in formal education. Following a semester of workshops with Thymio II, four dimensions were investigated

through a questionnaire: creativity, collaboration, computer skills (computational thinking), and promotion of interest in STEM. The work of Rubinacci et al. (2017) also aims to investigate the expectations and opinions of students and teachers with respect to the development of soft skills, teamwork, understanding and problem solving.

Overall, based on our findings, we can state that the research published in Italian journals is moving in different directions, but the environment in which the experience takes place, in most of the works, appears to be formal. This finding helps us answer the second part of the question, which aims to examine which teaching methods were used when the research involved students. The results show a variety of methodological

TABLE 5 Summary of research data.

Category	Sub-category	Number of studies	Percentage (%)
Design of research	Qualitative	15	54
	Mixed methods	9	32
	Quantitative	4	14
Data collection*	Observation	13	30
	Questionnaire	12	27
	Interviews/focus group	8	18
	Test/assessment	6	14
	Student product evaluation	5	11
Duration of research*	Between 2 and 6 months	11	39
	Less than a month	6	21
	Not specified	5	18
	Between 7 and 12 months	3	11
	More than a year (longitudinal studies)	3	11
Goals	Education with robotics	21	75
	Education in robotics	3	11
	Teacher training	3	11
	Media education	1	4
Setting	Formal education	21	75
	Non-formal education	7	25
Target*	Children	16	50
	Adults	10	31
	Teenagers	6	19
School level*	Primary school	13	41
	Middle school	7	22
	University	5	16
	Pre-school	4	13
	High school	3	9
Sample size*	Students	20	68
	Teachers	6	31
	People	1	1
	Not specified	2	/

TABLE 6 Descriptive sample statistics.

Tot. subjects involved	Average	Standard deviation	Median	Mode	Variation coefficient	Min	Max	Range
1,421	49	62.4	25	24	1.2	1	278	277

approaches (see [Table 9](#)) in the implementation of these practices, aimed at making the role of the student active and the teacher a facilitator (Tzagkaraki et al., 2021). Often, the teaching method was not explained in the articles, so it was difficult for the authors to determine which method accompanied these experiences. When the child-robot interaction was free and there was no instructional approach, the authors interpreted it as free play. In many works, however, it seems possible to interpret an eclectic use of multiple methodologies. Many

educational robotics activities for students are supported by collaborative architectures. In 10% of them, working in pairs was preferred (Pennazio, 2017; Rubinacci et al., 2017; Scippo and Ardolino, 2021), while in 13% the working in a group was open (Balestra, 2018; Giannandrea et al., 2020; Arar et al., 2021; Lehmann and Svarny, 2021), even to different age groups, which may mean the coexistence of other methodologies such as peer tutoring. Indeed, it would seem that the collaborative approach can be put into practice in different ways and is

sometimes supported by other methodologies and, in particular, exploratory architectures.

The second research question in this review seeks to define the general benefits of robotics in the educational environment and the evidence on which they are based. Arar et al. (2021), in the social robotic area, have provided reliable results indicating that the use of a social robot in children's L2 learning increases the effectiveness of the educational process and significantly improves learning gains. De Carolis et al. (2019), in a preliminary study, show the effectiveness of the proposed approach in learning gestures using a social robot as well. The interaction was found to be engaging and quite spontaneous. Pennazio (2017) pilot study notes the robot's ability to promote the acquisition of social skills through imitation and interaction. The author reports an increase in different measures (e.g., eye contact and attention) and a smooth transition in communication aspects. The child moves from seeking contact (e.g., caresses, hugs) from the robot to contact with the teacher

and then with peers. Van Den Heuvel et al. (2016) evaluated the usability and playfulness of the Zora and Iromec robots with children with severe disabilities and found a significant and promising contribution in supporting free play and achievement of predetermined goals in rehabilitation and special education. Regarding teachers' perceptions, Negrini's (2020) results show an interest and propensity to use robots for soft skills development. The study highlights factors that teachers believe limit the implementation of robotics in the classroom (e.g., cost and instructional design time). However, they prefer to use robots as educational technology tools to be programmed rather than as social robots that function as tutors or assistants. Rubinacci et al. (2017) also noted that teachers see robotics as a useful tool for promoting soft skills, although, it is unclear whether it is the laboratory as an experience rather than the use of robots that develops these skills. The research also reports that students rated the lab positively in terms of promoting technical skills. In terms of enhancing soft skills, it emerges that students have high expectations for teamwork, understanding and problem solving. Importantly, for students in the post-test, the perceived effectiveness of robotics in supporting teamwork skills decreases. Negrini and Giang (2019) showed that students were generally interested in working with the robot and believed that educational robotics enhanced twenty-first century skills. However, the greatest perceived improvements were found in the two dimensions of soft skills (i.e., collaboration and creativity) and not in the two dimensions of technical skills (i.e., computational thinking and computer science). The study on children's imagery by Bruni and Nisdeo (2017) shows as overall results a strong prevalence of an anthropomorphic view of the robot. Scippo and Ardolino (2021), through a longitudinal study and a mixed-method approach, observed an increase in creativity, sense of community, good self-efficacy, and low error pervasiveness after a course with the robot Ozobot. Cortiana and Rigotto (2019), on the other hand, noted the usefulness of ER in encouraging readers' identification with characters proposed by literary texts. In an experiment conducted in a primary school, through pre-post administration of an adaptation of a validated questionnaire, they showed that robotics supports the development of affective-emotional dimensions by making the student more engaged and motivated. Significant change was shown in the area related to pleasure associated with reading. Two works (Datteri et al., 2015; Datteri and Zecca, 2017) were interested in understanding the development of students' scientific thinking through the use of robots. The authors, analyzing student transcripts, found a category-structured taxonomy for assessing children's modes of explanation, useful for teachers to make an analysis of the cognitive skills employed during robotics activities. Castro et al. (2019) have also experimented with educational robotics in school settings. Various tests were administered before and after the workshops, which showed improvement in executive functions (e.g., inhibition). Luccio

TABLE 7 Area of knowledge/subjects.

Sub-category*	Number of studies	Percentage (%)
STEM	13	45
Life skills (SKILLS)	6	21
Inclusion (INC)	3	11
Second language (L2)	3	11
Art and humanities (HUM)	3	11

TABLE 8 Dimensions analyzed.

Sub-category*	Number of studies	Percentage (%)
Problem solving, computational thinking	12	16
Learning	9	12
Inclusion (special education, difference, gender)	8	11
Self-efficacy, metacognition	7	10
Teamwork, collaboration	7	10
Attention, memory	5	7
Motivation, enjoyment	5	7
Teacher professional development	5	7
Creativity, design	4	5
Social abilities	4	5
Motor skills, spatial skills	3	4
Technology evaluation	3	4
Planning	1	1

TABLE 9 Classroom work.

Category	Sub-category	Number of studies	Percentage (%)
Teaching method*	Project-based approach	13	28
	Narrative)-based approach	8	17
	Hands-on approach	7	15
	Instructive approach	6	13
	Collaborative approach	5	11
	Problem/inquiry-based approach	4	9
	Free-play approach	3	7
Organization*	Group work	16	59
	Individual work	8	30
	Work in pairs	3	11

TABLE 10 Robot types.

Category	Number of studies	Percentage (%)	Sub-category	Number of studies	Percentage (%)
Educational robot	17	61	Built*	10	30.5
			Compact*	10	30.5
Social robot	6	21			
Not defined	5	18			

(2019) focused on performance, showing that the hands-on robot programming project significantly improved exam performance. From the test results on student performance, it was argued that, in general, educational robotics supported by an instructional methodology, such as the project-based approach, can support the learning process by making it more interesting, increasing collaboration skills and also the very knowledge of theoretical concepts.

Limitations

This study has several limitations. Primarily, although a thorough search strategy was used, some empirical studies on the use of ER may not have been found for several reasons: the lack of a single, reliable search engine capable of indexing all Italian journals; the fact that not all publishers publish articles online in digital format (or that they must be paid for); the fact that some journals have changed publishers over time, leaving the repositories partially incomplete. The search for studies also did not cover either chapter in volumes of texts on robotics or conference proceedings. Secondly, several of the included studies showed, on one hand, a lack of information and data clarifying the implemented research design and, on the other, methodological weaknesses. In fact, very few studies presented a strict experimental-type structure. The methodological nature, therefore, included the possibility of being able to trace the evidence on the effectiveness of the experiments presented.

Thirdly, many of the included studies took place in poorly controlled settings or with small sample sizes, which does not allow for generalization of the reported results.

Conclusion and future directions

This study presents a review of the literature recently published in Italian Class A journals on educational robotics. The review conducted suggests, as Benitti (2012) reported 10 years ago, the limited number of experimental and quantitative studies regarding learning through the use of robotics in education, which would seem to be a general trend in educational research in Italy. Regarding the work on teachers and students' perceptions, questionnaires implemented by the authors and not validated were used (in some cases, only Cronbach's alpha was calculated). This criticality also involves international work, which could be explained by the skills and timing required for statistical validation of an instrument. Interestingly, around 21% of the articles included in this work were written by international academics. This implies a general openness of the journals to research conducted outside national borders and the consequences of the Italian academic community being fully integrated into the international scientific debate. We can also conclude the need to conduct more longitudinal and long-term studies to investigate the impact of ER over time. In fact, only three articles reported experiences longer than 1 year. Two had adults,

school teachers and computer science undergraduates as targets (Cicognini et al., 2019; Luccio, 2019), and only one investigated a primary school class during the entire 5-year cycle (Scippo and Ardolino, 2021). Most of the studies were conducted in a formal environment, which is in line with other systematic reviews (e.g., Kyriazopoulos et al., 2021), indicating a propensity to include robotics practice at an institutional setting. It should be emphasized that, despite general encouragement by institutions and growing interest on the part of teachers, robotics at school has not been systematically integrated into curricula (Alimisis, 2013; Mubin et al., 2013; Tzagkaraki et al., 2021). ER practice is often characterized as an optional or extracurricular activity. As pointed out by Tzagkaraki et al. (2021), the analysis of the selected articles in this study does not reveal a link between ER and STEAM (which also sees an interconnection with Art) and there is not enough information on the role of teachers in the implementation of the practice itself. From this systematic research, one can see, in line with Kyriazopoulos et al. (2021) but in contrast to Benitti (2012), a decline in the use of LEGO robots in favor of new devices, which are cheaper, in step with technological advances and driven by open-source and maker logic. There is, however, an increase in studies using social robots, although these are very expensive devices. Finally, despite the positive effect of ER attested by the authors on cognitive, social-affective and learning dimension outcomes, there are several cases where the results are not clearly defined and no data were found to support them, thus creating the need for further investigation. Among future prospects, it is interesting to see whether the project proposals included in the review will be realized in quantitative works. Such types of research could enrich the international landscape of empirical research on robotics in education and could be included in a meta-analysis.

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Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

The authors have conceived together the overall structure of the paper. The work is the result of a collaborative commitment. Nevertheless section # 1 (Introduction) was edited by LC and AM, section # 2 (Methods) was edited by GB, section # 3 (Results) was edited by SD and LC, and section # 4 (Discussion) was edited by AM. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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* Studies included in the Systematic Review.

Appendix

TABLE A1 Class A Italian journals.

Nr.	Journal title	Website
1	Annali di storia dell'educazione e delle istituzioni scolastiche	https://www.morcelliana.net/204-annali-di-storia-dell-educazione
2	Annali online della didattica e della formazione docente	http://annali.unife.it/adfd
3	Bollettino Cirse	https://new.cirse.it
4	Cadmo	http://www.francoangeli.it/riviste/sommario.asp?idRivista=117
5	CQIA Rivista—FORPERLAV	https://forperlav.unibg.it/index.php/fpl
6	Dirigenti scuola	https://riviste.gruppstudium.it/content/dirigenti-scuola
7	Educational reflective practices	https://www.francoangeli.it/Riviste/sommario.aspx?IDRivista=172&lingua=EN
8	Education sciences & society	https://journals.francoangeli.it/index.php/ess/index
9	Educazione	http://www.giornaledipedagogiacritica.it/index.php/gdpc
10	Educazione linguistica, language education (EL.LE)	https://edizionicafoscari.unive.it/it/edizioni4/riviste/elle/
11	Encyclopaedia	https://encp.unibo.it/
12	Excellence and innovation in teaching and learning	https://journals.francoangeli.it/index.php/exioa
13	Form@re	https://oaj.fupress.net/index.php/formare/index
14	Formazione & Insegnamento	https://ojs.pensamultimedia.it/index.php/siref
15	Giornale italiano dei disturbi del neurosviluppo	https://www.vanniniscientifica.it/it/prodotti/riviste/giornale-italiano-del-neurosviluppo-detail
16	Giornale italiano della ricerca educativa	http://ojs.pensamultimedia.it/index.php/sird
17	Giornale italiano di educazione alla salute, sport e didattica inclusiva	https://ojs.gsdjournal.it/index.php/gsdj
18	History of education & Children's literature	http://www.hecl.it
19	I problemi della pedagogia	http://www.problemidellapedagogia.it/index.php?option=com_content&view=category&layout=blog&id=10&Itemid=114
20	Italian Journal of special education for inclusion	https://ojs.pensamultimedia.it/index.php/sipes/index
21	JE-LKS. Journal of e-learning and knowledge society	https://www.je-lks.org/ojs/index.php/Je-LKS_EN
22	Journal of educational, cultural and psychological studies—ECPS	http://www.ledonline.it/index.php/ECPS-Journal/
23	La famiglia	https://riviste.gruppstudium.it/la-famiglia/archivio
24	L'integrazione scolastica e sociale	https://rivistedigitali.erickson.it/integrazione-scolastica-sociale/archivio/
25	Lifelong, lifewide learning—LLL	http://www.edaforum.it/ojs/index.php/LLL
26	Maltrattamento e abuso all'infanzia	http://www.francoangeli.it/riviste/sommario.asp?IDRivista=76
27	MEDIC. metodologia didattica e innovazione clinica	https://www.pacinimedicina.it/prodotto/medic-metodologia-didattica-innovazione-clinica-nuova-serie/
28	Metis	http://www.metisjournal.it/index.php/metis/issue/archive
29	Nuova secondaria	http://nuovasecondaria.lascuola.it/
30	Nuovo bollettino cirse	http://www.edizioniets.com/riviste.asp
31	Orientamenti pedagogici	http://www.erickson.it/Riviste/Pagine/Scheda-Rivista.aspx?ItemId=38474
32	Paideutika	https://www.paideutika.it/rivista-3/
33	Pedagogia e vita	https://riviste.gruppstudium.it/content/pedagogia-e-vita
34	Pedagogia oggi	http://www.siped.it/rivista-pedagogia-oggi/presentazione/
35	Pedagogia più didattica	http://rivistedigitali.erickson.it/pedagogia-piu-didattica/
36	QDS. Quaderni di didattica della scrittura	http://www.carocci.it/index.php?option=com_carocci&task=schedarivista&Itemid=262&id_rivista=42

(Continued)

TABLE A1 (Continued)

Nr.	Journal title	Website
37	Qwerty	http://www.ckbg.org/qwerty/index.php/qwerty
38	Rassegna di pedagogia	http://www.libraweb.net/riviste.php?chiave=21&h=438&w=300
39	REM	http://www.degruyter.com/view/j/rem
40	RicercaAzione	http://www.iprase.tn.it/pubblicazioni/ricercaazione/
41	Ricerche di pedagogia e didattica	https://rpd.unibo.it/
42	Ricerche di psicologia	http://www.francoangeli.it/riviste/sommario.asp?IDRivista=41
43	Ricerche pedagogiche	https://www.edizionianicia.it/ricerche-pedagogiche/
44	Rivista di storia dell'educazione	http://www.edizioniets.com/view-collana.asp?col=Rivista%20di%20storia%20dell%27educazione
45	Rivista italiana di educazione familiare	https://oaj.fupress.net/index.php/rief/index
46	Scuola democratica	https://www.mulino.it/riviste/issn/1129-731X
47	Studi sulla formazione	https://oajournals.fupress.net/index.php/sf
48	Studium educationis	http://ojs.pensamultimedia.it/index.php/studium
49	TD—tecnologie didattiche—Italian journal of educational technology	http://www.tdjournal.itd.cnr.it/