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Educational Robotics in School Education Focusing on School Distance Education

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ABSTRACT: Technology in nowadays' era has made leaps and bounds in offering a lot to both society and education. Teachers are asked to undertake a new role and respond to the new technology related challenges. The Covid-19 pandemic brought distance education to the surface of the academic world. Educational robotics has infiltrated the field of education recently, but it has not been explored and utilized as it could be, especially in the field of primary education. This study aims to discuss how the combination of educational robotics and school distance education can benefit education in an effective and innovative way. The study employed literature review and a qualitative research approach utilizing a semi-conducted interview as the research tool. Ten (10) experienced teachers in the fields of Distance Education and Educational Robotics participated. The results revealed that Educational Robotics utilizing several tools and platforms can effectively support and enhance school distance education, especially within a framework of blended learning.

KEYWORDS: School Distance Education, Educational Robotics, e-learning

I. INTRODUCTION

With the outbreak of the pandemic Covid19 education was faced with an unprecedented situation. Amid the insecurity and fear that prevailed among the citizens, education at both the school level and universities had to continue. Thus, for the first time in Greece, Distance Education was implemented at all levels, in the context of urgent remote teaching (Trust & Whalen, 2020). The education sector, therefore, was forced to take strict measures worldwide. However, online education has been hampered by emerging issues such as network issues, power supply, inaccessibility as well as lack of digital skills. Therefore, the effects of COVID-19 in the field of education brought the need for all educational institutions to adopt technology and improve their digital skills according to the emerging needs and realities in education (Onyema et al., 2020). Communication with the teacher is of great importance, thus, the teacher must be familiar with new technologies and be present whenever the learner needs him/her. In addition, the teachers' familiarity with Distance Education and new technologies, such as Information and Communication Technologies -ICT- and Educational Robotics, is important (Stavermann ,2025). Educational Robotics has appeared in recent years in the field of education and many teachers utilise it as a teaching tool, but many are not familiar with it. Educational Robotics, despite the perspectives it offers in education, is not so widespread among teachers, especially in primary education (Pasalidou et al., 2021). The enrichment of Distance Education utilizing Educational Robotics and emerging technologies, is necessary in order to meet the continuously increasing needs of the learners, especially the students of primary and secondary school (Ergüzen et al., 2021; Papanikolaou & Manousou, 2019). However, there are many teachers who are not familiar with new technologies and Educational Robotics and they do not feel safe and confident to apply them in their teaching. In addition, a research gap is identified regarding the utilization of Educational Robotics in Distance Education.

For the purposes of this study, educational robotics implemented in a distance learning context is referred to as *Distance Educational Robotics* (DER). This term is used throughout the study to describe robotics-based teaching and learning activities conducted by distance.

II. SCHOOL DISTANCE EDUCATION

Distance education (DE) refers to education provided remotely in all levels of education, focusing mainly on adult education. The methodology of distance learning involves the development and implementation of teaching techniques and educational practices, which "*substitute the physical absence*" of the teacher to limit the difficulties during the learner's studies (Simonson & Zvacek, 2024; Lionarakis, 2006). Distance Education is closely related to self-regulated learning. In convenient teaching and learning settings, self-regulated learning may include teacher assistance for the creation of an effective learning environment. The availability of tools for organization of content and activities, self-assessment through reflection and educational feedback and encouragement, are factors that have a decisive role for a qualitative and effective implementation of Distance education. Distance Education offers many benefits, but requires self-discipline, time management and effective communication skills. However, when implemented effectively, it can significantly contribute to learner's educational journey and widen access to quality education (Martin et al., 2020).

The term "*School Distance Education*" (SDE) refers to flexible learning programs provided remotely by public and private educational organizations to primary and secondary school students, utilizing new technologies and supporting modern educational needs. According to international literature, self-sufficient secondary education provides comprehensive programs that are fully recognized and identical to conventional education with differences in the type of educational material and communication and supplementary secondary education operates in support of and in parallel with conventional schooling (Simonson & Zvacek, 2024). The blended learning model, which combines distance and in-person education, offers several benefits to students. Integrating blended learning equips students with technological literacy and 21st century skills. They gain hands-on experience in new technological tools, robotics kits, programming languages and digital tools. These skills are increasingly in demand, across industries, preparing students for future careers in STEM fields (Cronje, 2020). The role of ICT in the education system provides opportunities for educators to upgrade teaching and enhance overall student performance. The inclusion of ICT in teaching is a complex process that requires proper training and preparation on the part of the teachers but also proper familiarization on the part of the students so that they understand how they can properly utilize ICT in their studies. This increasing use of technology has led educators to rethink their traditional teaching methods and invest in the latest technologies and tools (Zawacki-Richter et al.,2020; Qazi, 2021).

III. EDUCATIONAL ROBOTICS

The presence of robots has revolutionized the industrial environment in just a few decades. Robotics has been applied in many fields and professions in recent years. It has helped to improve, develop and evolve industries as well as science (Gasparetto & Scalera, 2019). But what is an industrial robot and what is included in the science of Robotics, often causes debates and controversies. The dividing line is therefore determined by quality and the complexity of the algorithms that a programmable device can implement. In general, the study of mechanical behaviour and the control of devices do not establish a new science. On the contrary, it derives the individual topics of its methodology from the so-called classical sciences (Niku, 2020). Robotics is not often preferred and it is not applied in school environments and institutions as it is neither intended for young students nor for people who are not specialized in it and do not engage in a similar profession.

Educational Robotics adopts elements of robotics such as programming languages, but in a much simpler form and is addressed to school environments, university institutions, teachers and students of all ages (Tzagkaraki et al., 2021; Karatrantou et al., 2025; Klonou et al., 2025). The term "*Educational Robotics*"/ER refers to a field that aims to improve students' learning experiences through the creation and application of robotics-related activities, technologies and objects. In practice, these activities may involve the use of a physical robot, it may be a modular system such as SPIKE Prime by LEGO, or robots custom-built for defined activities (Gubenko et al., 2021). Educational Robotics is an innovative approach to teaching, which harnesses the power of robotic technology to engage students in experiential learning activities. By combining principles of STEM education with robotics, students can learn complex concepts in a fun and interactive way (Zhong & Xia, 2020). Educational Robotics has the potential to revolutionize the way we approach education, giving students the tools and skills they need to succeed in the 21st century. In addition, recently the dynamics of the use of robotic environments in learning, in relation to conventional education environments, have been explored. However, robotics alone is not enough to change and develop the way learners think and lead to high learning outcomes. Robotic platforms should be pedagogically supported and properly configured for both students and teachers to enable them to significantly enhance and improve teaching and learning (Belpaeme et al., 2021; Foti et al, 2024; Foti et al, 2025).

A. Educational Robotics- Skill Development based on Constructivism theory

Educational robotics in schools aim to support the development of 21st century skills deemed necessary in the rapidly evolving employment landscape, where today's students are likely to work in jobs that have not yet been invented.It is important that learners as well as teachers have the opportunity to think and approach robots in a variety of ways and with different ideas in order to develop their critical thinking and expand their creativity (Alimisis, 2020).

Constructivism, constructionism and social constructivism, are widely known and accepted theories of learning. To apply the methods in teaching, activities involving the use of robotic kits are most suitable. They are designed as project-oriented activities in which students work in smaller groups to jointly build a robotic model and program its behaviour (Veselovská et al., 2020). The methods developed with the application of educational robotics are student-centered and usually include inquiry-based learning, project-based learning, problem-based learning, experiential approach to knowledge and collaborative learning (Alimisis, 2021; Klonou et al., 2025). Collaboration between learners during the construction and programming of the robotic objects they create is of great importance as they learn to interact, express what they think in an integrated way and manage problems and tensions more effectively (Alimisis, 2020; Piedade et al., 2020; Foti et al, 2024; Foti et al, 2025). Cultivating critical and computational thinking, collaboration, creativity and metacognition through robotics gives students the opportunity to have more accessible access to their future work environment (Piedade et al., 2020; Tzagkaraki et al., 2021; Yudin et al., 2020). One of the special advantages of educational robotics is that it allows students to apply the concepts that they learn in the classroom on real problems and can immediately see the results of their work. This approach to learning is very interesting and it motivates and encourages students (Tsagaris et al., 2019). Additionally, Educational Robotics provides opportunities for students to cultivate a mindset of development and management of the challenges that arise. While working on robotics projects, students may face challenges, crises and tensions, however, they are encouraged to keep trying and learn from their mistakes (Karatrantou et al., 2025; Sapounidis & Alimisis, 2021). Figure 1 summarizes basic benefits of Educational Robotics.

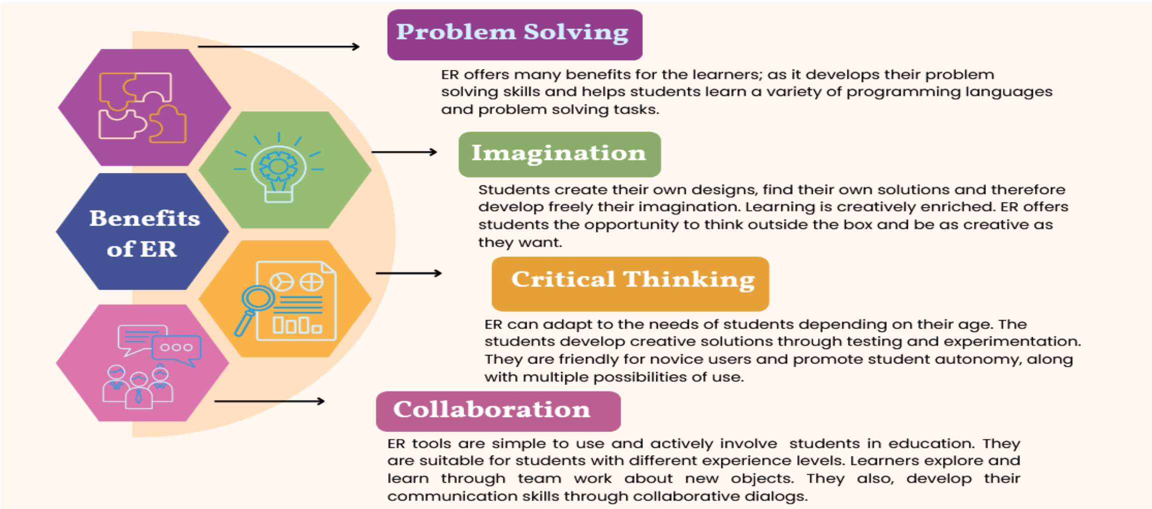

Figure 1. Benefits of Educational Robotics

B. Distance Education and Educational Robotics

Distance Educational Robotics refers to the practice of integrating educational robotics activities into distance learning environments so that learners can engage with robotics-based learning activities, construct knowledge and develop skills without being physically present in a classroom or lab. It combines elements of educational robotics, like the use of robots as pedagogical tools to teach programming and problem-solving, with the principles of distance education. In this context, students may work with robots remotely, use simulations and online resources and participate in collaborative robotics tasks through digital communication channels (Foti et al., 2025; Klonou et al., 2025; Tselegkaridis & Sapounidis, 2022).

One approach to incorporate educational robotics into Distance Education is through virtual robotics simulations. Some platforms, such as *Robot Virtual Worlds (https://www.robotvirtualworlds.com/)* and *Coder Z* (https://gocoderz.com/) can even allow students to collaborate with their peers in virtual environments. Simulators are part of educational robotics and allow the user to quickly and easily engage virtually in the development and programming of robots through GUI (Graphical user interface). Using a simulator means that instructors do not have to rely exclusively on real robots which can be costly. Therefore, simulators are a useful tool that can save resources and help the educational process (Tselegkaridis & Sapounidis, 2021; Foti et al, 2025; Foti et al, 2024). These simulations allow students to experiment with different robot designs, test various programming concepts and simulate real-world scenarios. Learners have, also, the possibility to share their work with their teachers (Papadakis & Kalogiannakis, 2022; Choi et al., 2021). Another option is to provide students with remote access robotics kits. Companies such as *LEGO Education (https://education.lego.com/el-gr/*) and *VEX Robotics (https://www.vexrobotics.com/vexproducts/overview)* offer robotics kits that can be shipped to students' homes. These kits usually come with online instructions and tutorials and students can use remote access technology to control the robots from their homes. For example, *VEX code VR* allows students to program virtual robots and test their code before running it on a physical robot. Students can use remote access technology to control the robots, code to program them and engage in collaborative activities with their peers (Alimisis, 2020; Barone, 2021). Furthermore, virtual robotics competitions offer students the opportunity to demonstrate their robot programming and building skills in a fun and competitive environment. These competitions can be organized using video conferencing platforms and allow students to compete against each other remotely. In any case the combination of educational robotics and School Distance education requires careful learning activity planning and implementation, combining learning theories, pedagogical approaches, creativity, ingenuity and technological tools.

IV. RESEARCH METHODOLOGY

A. *Aim and Research questions*

The purpose of the study is to discuss the ways Educational Robotics could be utilized in School education with the focus on School Distance Education. Investigating the way ER is already utilized in school education in the physical classroom and remotely or online useful insights would arise on who ER could and should be utilized in School Distance Education that is aiming to be a trend with effective learning benefits supporting school education in different frameworks. So, the research questions aimed at being answered are:

1. In what ways is Educational Robotics utilized in school education?

2. In what ways is Educational Robotics utilized in School Distance Education?

The study aims to highlight the ways in which Educational Robotics can be integrated into School Distance Education to help students to construct their knowledge. The literature review and qualitative research were chosen as research methods.

Initially, Greek and international literature were reviewed. The databases used were *ResearchGate, Scopus, Google Scholar, Springer International Publishing, the National Documentation Center, the journal for Open and Distance Education and Educational Technology, the Institute for Educational Policy (IEP), the Hellenic Scientific Association for Information and Communication Technologies in Education (ETPE) and Education Sciences.* Search filters were mostly limited to the last five years, from 2020 to 2025, that is, with a few exceptions that searches covered mostly the period 2015-2025. Key words used in the search, were Educational Robotics, remote Educational Robotics, Educational Robotics online, Educational Robotics and STEM/STEAM etc.

The qualitative approach was the second part for the research process. The qualitative approach was chosen as through the qualitative method experiences, behavior and opinions of the participant are analyzed and interpreted in real study conditions. To collect the data, interview was used as a research tool. In the present study, some interviews were conducted via a zoom synchronous communication environment. The questions in the interview were seven and are designed to meet the research purpose and research questions.

To conduct the research, teachers of primary and secondary education who have engaged, worked and applied Distance Education and Educational Robotics were selected as participants in the interviews. The participants were 10 teachers, of which 5 were male and 5 were female. They were selected following a convenient and purposive sampling procedure (Mills, Gay & Airasian, 2017).

B. *Research Validity*

In qualitative research, validity refers to the degree to which qualitative data accurately represents what they are intended to measure. To describe validity in qualitative research, two key concepts are used: *reliability* and *credibility*. Reliability refers to the degree to which research data consistently measures what is being measured. Ensuring reliability in qualitative research can be achieved through *credibility*, *transferability*, *dependability* and *confirmability* of both the research process and the researchers' findings. In addition, it is advisable for a researcher to include descriptive accounts of the research field, so that someone can understand the research context. In qualitative methodology, it is important for the researcher to include as many details as possible in order to ensure data *stability*, as well as *neutrality* and *objectivity* of the collected data (Mills, Gay & Airasian, 2017). Two academics, one with expertise in Educational Robotics and one in Distance Education reviewed the interview questions ensuring the validity and reliability of the research tool. A pilot interview was conducted with a qualified teacher and changes and improvements were made before distributing the final interview questions to the participants.

To analyze the research data, thematic analysis by hand was chosen. The code reproducibility test (Krippendorff, 2004) with the participation of two coders was used to verify the reliability of the thematic analysis codes, yielding satisfactory reliability (0.89).

V. FINDINGS

A. *Educational Robotics Tools*

In recent years, rapid technological advancements have significantly transformed educational systems worldwide, leading to changes in both teaching methodologies and learning environments. The increasing integration of digital technologies in education has become a central component of teaching and learning, particularly in response to global challenges such as the COVID-19 pandemic. This unprecedented situation accelerated the adoption of Distance Education and highlighted the need for flexible, technology-enhanced instructional approaches that can support learning beyond traditional classroom settings. Within this evolving educational context, Educational Robotics has emerged as an innovative pedagogical approach that combines technology with experiential learning. It enables students to actively engage with concepts through hands-on activities, promoting problem-solving, critical thinking and collaboration. At the same time, Educational Robotics supports teachers in implementing modern instructional practices that align with the educational demands of the 21st century, making it a valuable component of contemporary education. Robotics tools and kits provide an interconnected approach to programming and construction, often used as creativity-enhancing interventions in the school setting. While working with the kits, learners can practice engineering skills and creative solutions to a

huge range of problems, starting with making a robot move from point A to B. In addition, principles such as problem-based learning and gamification, guide the implementation of Educational Robotics interventions (Gubenkoet al., 2021).
In table 1 below, are presented some worldwide familiar tools and kits with their characteristics and some useful information. The educational robotics tools presented in the tables are suitable for elementary school students but also middle school and high school students. The teacher can adjust the level of difficulty in most learning activities by changing the learning objectives and learning outcomes of the activities according to the level of the students and their needs.

Table 1: Some worldwide familiar tools and kits:

ER TOOLS	CHARACTERISTICS	CODING ENVIRONMENT
Micro:bit https://microbit.org/ https://makecode.microbit.org/	Electronics platform with programmable microcontroller boards. Users work based on websites and videos with step-by-step instructions; separate materials for students and teachers; free PDFs, Word files, presentations and source code; teacher notes with extra info, code examples, short extensions; curriculum learning outcomes and timetable estimates.	Python, blocks, Scratch
Arduino https://www.arduino.cc/	Open-source electronics platform with programmable microcontroller boards; coded via free software; connects sensors, LEDs, motors, displays for interactive projects; simple, affordable, widely supported for education; available materials from various sources/creators.	Programming languages C++, Python etc.
Raspberry Pi https://www.raspberrypi.org/	Arduino and Raspberry Pi can be used in distance education through online simulators such as Tinkercad, allowing students to program and test circuits without physical hardware. Learners can build virtual breadboards, connect components and run code directly in the browser.	Programming languages C++, Python etc.
LEGO Education https://education.lego.com	Offers educational robotics tools with learning objectives, optional additional materials, indicative timetables, lesson plans, theoretical coverage of computational thinking, teacher organization/planning materials, discussion questions/answers and assessment support.	Block of icons
Sphero https://www.sphero.com/	Programmable robot controlled via app for coding/STEM; simulators/coding platforms mimic functionality; Sphero Edu app has virtual environments for block-based or JavaScript coding without physical device; alternatives like Tinkercad, Scratch, Code.org for similar experiences.	Python, blocks
Ozobot https://ozobot.com/	Small robot programmed via color codes or block-based coding for younger students; screen-free (color lines) or digital (Ozobot Blockly); simulator for virtual practice replicating behaviors; fosters creativity, problem-solving, STEM skills remotely.	Color codes - block-based coding
Dash and Dot https://www.makewonder.com/	Introduces kids to coding via mobile apps (e.g., Blockly); students with robots use apps for challenges, share videos; without robots, use Scratch or run code on teacher's physical robots in live/recorded sessions; collaborative projects via Google Classroom.	Blocks, Wonder app, Python
HYPERLINK	Programmable robot for all grades with lesson plans/activities; affordable/versatile; apps like EdBlocks, EdScratch, Python; share lessons online, submit challenge videos; Robot Simulator for virtual coding practice.	EdBlocks, EdScratch or Python
Shield-Bot https://www.parallax.com/shield-bot-for-arduino/	Arduino-compatible mobile robot kit; uses motor shield for drive control; supports sensors for line-following, obstacle avoidance; includes tutorials for programming navigation, autonomy; ideal for intermediate Arduino projects.	C
Cyber:bot https://www.parallax.com/cyberbot/	Propeller Activity Board-powered robot; PS2 gamepad option; lessons on encoders; beginner-friendly with strong educational guides.	Python
ActivityBot https://www.parallax.com/activitybot-360/	360° robot with tri-drive wheels; Propeller microcontroller-based; expandable with sensors; focuses on mapping, localization, advanced mobility.	BlocklyProp, Propeller C
Boe-Bot https://www.parallax.com/boe-bot-robot/	Classic two-wheeled robot with BASIC Stamp or Propeller brain; continuous rotation servos; extensive IR sensor integration for whiskers/line-following	PBASIC

Scribbler https://www.parallax.com/scribbler-s3/	Programmable drawing robot; Bluetooth/WiFi connectivity; camera vision system; supports Propeller Spin, Python; activities include art generation, color tracking, maze solving.	BlocklyProp
ELEV-8 https://learn.parallax.com/tutorials/robot/elev-8	Quadcopter drone kit; rotor blades, flight controller; Arduino-compatible; tutorials cover stabilization, flight modes, sensors; emphasizes aerial robotics and autonomy.	C
Thymio https://www.thymio.org	Educational robot with visual/text-based coding (Blockly, Python); uses sensors/actuators; Simulator for virtual code writing/testing without physical robot; supports interactive remote lessons/challenges/feedback.	Blockly or Python
Open Roberta Labs https://lab.open-roberta.org/	Online platform by Open Roberta Foundation; visual programming (Blockly/Python) for various robots; easy for beginners, educators, students, hobbyists exploring robotics/programming.	Python, Java, Blocks
Sparkfun, www.sparkfun.com	A platform/online seller that can promote Educational Robotics in school education. There are materials for many platforms such as Arduino, micro: bit, Raspberry Pi, Paper Circuits as well as programming languages. The material is presented in many formats such as pdf, video and web pages.	Programming languages C++, Python etc.
Carnegie Mellon Robotics Academy, www.cmu.edu/roboticsacademy	A series of programs that cover many robotics platforms such as VEX IQ, VEX CORTEX, VEX V5 and Parallax. Pdf, videos and websites are available and provide guidance to both teachers and learners. Parts of the content are free and there are tips for class preparation, optional activities, written reflection questions, worksheets and additional leaflets.	Programming languages C++, Python etc.
Parallax, www.parallax.com.	The material covers a wide range of programming languages and robotics platforms such as ActivityBot, Cyber:bot, Boe-Bot, Scribbler 3, Shield-Bot and ELEV-8. It is aimed for elementary and high school students and content is separated by platform and programming language.	Programming languages C++, Python etc.

While the majority of educational robotics platforms remain active and supported, some individual robot models within these ecosystems have been discontinued as part of normal product evolution, without affecting the overall viability of the platforms for distance and classroom-based education.

B. Educational Robotics combined with Augmented and Virtual Reality

Augmented Reality is a growing field of study in recent years. A variety of AR applications have been designed and built, mostly using mobile devices. In the field of education, several studies have been conducted, using an augmented or mixed reality system and a robot, with the aim of achieving learning goals by enhancing student motivation. Systems using augmented or mixed reality technology and robots can have positive effects, influence students' motivation and learning performance (Pasalidou & Fachantidis, 2021; Pozzi et al., 2021). Literature describes several ways in which Educational Robotics can be combined with Augmented Reality in education. For example, *an augmented reality application can be used to simulate the operation of a robot and allow students to interact with it in a virtual environment*. This can help students better understand the operation and functionality of the robot without requiring access to physical hardware. Additionally, augmented reality can be used to *create virtual labs where students can conduct experiments and test their understanding of robotics-related concepts.* This can provide a safe and cost-effective way for students to learn and experiment with robotics, especially in situations where physical laboratories may not be available or feasible (Pasalidou & Fachantidis, 2021). Such applications can be used for Distance Education and are suitable for students of different ages and skill levels. They provide a fun and engaging way for students to learn about robotics using augmented reality technology. Table 2 below lists indicative AR tools.

Table 2: Indicative AR Tools supporting ER

AR TOOLS	DESCRIPTION
CoSpaces Edu https://cospaces.io/edu/	This platform allows students to create and interact with virtual 3D models. Students can build their own robots and test their designs.
Robotify https://www.robotify.com/	This platform provides an AR experience for students to visualize and program robots in a 3D environment. The app includes robotics and coding courses and can be used for DE.
Merge Cube https://mergeedu.com/cube	This application uses a physical cube to create an AR experience for students to learn about robotics and programming. It includes lessons and challenges to help students develop their skills.
Zapworks https://zap.works/	AR platform that combines many tools and features. Teachers can find instructions for the tool they choose to use on the platform through videos. They can make videos and images as well as design, plan or select the objects and tools most appropriate for their lesson
JigSpace www.jig.space	This application provides 3D presentations of how everyday things work. It can be used alongside educational robotics for interactive learning experiences, visualizing complex concepts in AR.

Virtual Reality (VR) can be combined with Educational Robotics in Distance Education to enhance the learning experience of students. VR technology provides a fully immersive experience that allows students to interact with virtual robots and environments, providing a more realistic and engaging learning experience. There are several ways in which virtual reality can be used to enhance educational robotics in Distance Education. Virtual Reality can be used to simulate real-life scenarios and challenges that students may face when working with robots. For example, students can be presented with a virtual scenario where they must deal with and repair a malfunctioning robot. This can offer a valuable learning experience that is difficult to replicate in a physical laboratory (Radianti et al., 2020). VR can also be used to create virtual labs where students can conduct experiments and test their understanding of robotics-related concepts. This can provide a more affordable and accessible way for students to learn and experiment with robotics, especially in situations where physical laboratories may not be available (Mystakidis et al., 2021; Foti et al, 2025; Foti et al, 2024). Table 3 below lists the AR tools with details.

Table 3: Indicative VR Tools supporting ER

VR TOOLS	DESCRIPTION
RoboCo https://roboco.co/	This VR application allows students to design, build and program robots to complete various tasks and challenges in a virtual environment. The app can be used to teach coding and robotics concepts to students of all ages.
VR Robotics Simulator https://store.steampowered.com/app/683880/VR_Robotics_Simulator/	This application provides a virtual environment where students can practice programming and controlling robots in a 3D space. The application is suitable for students with different levels of experience.
Virtual Robotics Toolkit https://www.virtualroboticstoolkit.com/	This platform provides a virtual environment where students can design and test robots using realistic simulations. The application is suitable for students with different levels of experience.
ARLOOPA https://www.arloopa.com/	This application is designed for young learners and allows them to explore and see different objects using augmented and virtual reality. The app includes several challenges to enhance student learning and interest.
Robotics VR https://store.steampowered.com/app/1774930/Robotics_in_VR/	This application is a virtual lab where students can experiment with different types of robots and learn about programming and robotics concepts in a more immersive and interactive way. The app includes lessons and challenges to help students develop their skills

C. Interview Findings

The responses provided during the interviews confirmed many of the findings reported in existing literature, both in terms of pedagogical approaches and the educational tools used. Participants' views were largely consistent with previous research regarding the role of Educational Robotics in enhancing student engagement, supporting experiential and discovery-based learning and promoting creativity and innovation. In addition, the tools and platforms mentioned by the participants align with those most frequently reported in the literature as suitable for both face-to-face and distance learning contexts. Below, some indicative interview questions are presented, along with representative responses, to illustrate the convergence between the empirical findings of the present study and the relevant literature and to describe the situation in Greece as well.

All research participants appeared to have extensive, experience with the implementation of Distance Education. Responses to the question, *"What is your experience with distance teaching in school education?"*, showed that 8 out of the 10 participants had significant experience in Distance Education at the school level. The other 2 became familiar with Distance Education during and after the pandemic period. Indicative responses include: *"My experience with distance teaching in school education is extensive," "I have been involved for many years in distance teaching, specifically in supplementary mode,"* and *"I implemented distance teaching for the first time during the COVID-19 pandemic."*

Responses to question: *"In what ways do you utilize Educational Robotics during your teaching?"*, show that most educators, specifically 9 out of 10, use Educational Robotics: as a supplementary tool to enrich and enhance their teaching, to make lessons more enjoyable, creative, individualized and practical and to engage students in exploratory and hands-on learning experiences. Indicative statements include: *"I usually use ER to enrich my teaching and make the lesson more enjoyable," "In my classroom, I use Educational Robotics to engage students in hands-on learning experiences", "Sometimes I use it as a supplementary tool in the lesson… other times within the framework of discovery learning", "I have used Educational Robotics several times in order to improve understanding of the teaching subjects."* One participant stated that he uses Educational Robotics through project-based learning activities and integrates it into STEM activities. Indicative answers include: *"I integrate robotics into the STEM (Science, Technology, Engineering and Mathematics) curriculum"* and *"I use robotics as a means to promote creativity and innovation."*

Question concerning the educational robotics tools used by the participants. *"What educational robotics tools have you used and consider suitable for students?"* revealed that nine out of the ten participants used and worked with LEGO Education kits. Indicatively, one participant stated: *"I have used Lego kits, which are very useful and enjoyable to implement in the lesson."* Seven out of ten reported using Arduino, while five out of ten reported using Raspberry Pi. Indicative answers include: *"I have used Arduino, which is quite easy and affordable tool and students enjoy it… I have also used Raspberry Pi, which is like Arduino,"* and *"Some popular tools I use include… Arduino and Raspberry Pi."* One participant mentioned using VEX Robotics: *"Some popular tools I use include VEX Robotics''.* Five out of ten participants also emphasized the importance of selecting tools appropriate to students' age, access and needs.

Answers to the questions *"How would you implement Educational Robotics remotely with synchronous communication?"* and *"How would you implement Educational Robotics remotely with asynchronous communication? Please mention any tools you would choose to use."* showed that the most frequently mentioned tools and platforms for synchronous distance teaching were Arduino (mentioned by 5 out of 10 participants) and LEGO Education (3 out of 10). Indicative answers were ''*I would use an online programming environment, for example the LEGO Education platform,"* and *''would utilize tools such as Arduino''.* These platforms enable students to design, code and simulate robotic systems in real time for synchronous distance teaching of educational robotics.

To facilitate synchronous communication during sessions, educators primarily used video conferencing platforms: Zoom (4 out of 10 participants), Cisco Webex and Microsoft Teams (each mentioned by 3 out of 10 participants). These platforms allow teachers to present robot constructions, guide coding activities and provide real-time feedback to learners. For synchronous robotics instruction without requiring physical hardware, educators can leverage online Arduino simulators such as Tinkercad Circuits (free, browser-based tools supporting multiple Arduino boards with real-time code compilation). Indicative responses included: *"I would use a platform such as Teams, Webex, or Zoom…* and *"You can implement Educational Robotics remotely using synchronous communication platforms such as Webex, etc.."* Another teacher noted that *"Tools such as video conferencing platforms (e.g., Zoom, Microsoft Teams) allow me to present robot constructions,"* while one participant highlighted that *"We could utilize various simulation tools for Arduino,"* enabling hands-on learning experiences without access to physical components.

For asynchronous distance learning, educators primarily utilized learning management systems and educational platforms to deliver robotics activities for independent student completion. The platforms e-me and e-class were mentioned by 3 participants each, Moodle by 4 participants, the MIT platform for Scratch programming environment (scratch.mit.edu) by 3 participants and Google Docs by 3 participants. Indicative responses included: *"For asynchronous communication, I often use e-me or e-class, where I assign activities that students can complete at home,"* and *"I would use platforms such as e-me, e-class, or Moodle to deliver activities to students."* Responses indicated that some tools can be used for both synchronous and asynchronous communication, depending on how each teacher chooses to utilize them. For example, Moodle and Google Docs can support both real-time collaborative coding sessions and asynchronous assignment submission and feedback. Similarly, Arduino simulators and LEGO Education platforms can be deployed within both communication framework, allowing teachers to adapt their instructional approach based on learner needs and institutional constraints.

Participants effectively utilized robotics kits such as LEGO Education, Arduino and Raspberry Pi by combining them with online platforms like Moodle, e-me and e-class to enhance lesson delivery and student engagement. They shared project instructions, code examples and progress updates through these platforms, enabling asynchronous access and collaboration beyond classroom hours. For instance, teachers uploaded LEGO building guides and Arduino simulations to Moodle for homework assignments, while using e-class forums for troubleshooting and peer feedback. This approach ensured age-appropriate tool selection, accommodating students' access levels and fostering hands-on learning despite varying resources. Furthermore, teachers utilised platforms like Moodle and e-class to distribute Raspberry Pi code libraries, allowing students to experiment independently at home. Through e-me forums, participants posted VEX Robotics challenge videos for peer review, promoting collaborative problem-solving and iterative design improvements.

Answers to the question *"How would you incorporate ICT tools with distance Educational Robotics?"*, revealed that most participants would use simulations, augmented reality applications and videos. Specifically, 7 out of 10 proposed simulation and augmented reality applications, such as: *"I would use augmented reality applications, meaning students could scan an image, for example and the object would be displayed interactively in front of them… so that they can familiarize themselves and get an idea of what they will learn through Educational Robotics"* and *"I would use online resources, interactive simulations and virtual environments."* Four out of ten proposed videos, with indicative statements such as: *"ICT tools suitable for Educational Robotics include videos, as they can combine rich content and instructions for students in an engaging way", "I would therefore use a video that explains step-by-step and provides clear instructions on what students should carry out the corresponding activities"* and *"Online video platforms, such as YouTube, to create and share educational videos."* Teachers use YouTube to produce instructional content on robot assembly, coding demonstrations and troubleshooting procedures. These videos allow students to access and review robotic instructions at their own pace. Two participants also proposed the online Scratch programming environment: *"Various programming environments such as Scratch…"*. Scratch provides a block-based visual coding environment where students develop computational thinking skills applicable to robot control programming. This accessible approach enables students to design algorithms and logic sequences that translate directly to robotics applications. In Figure 2 some indicative tools to support Distance Educational Robotics are presented.

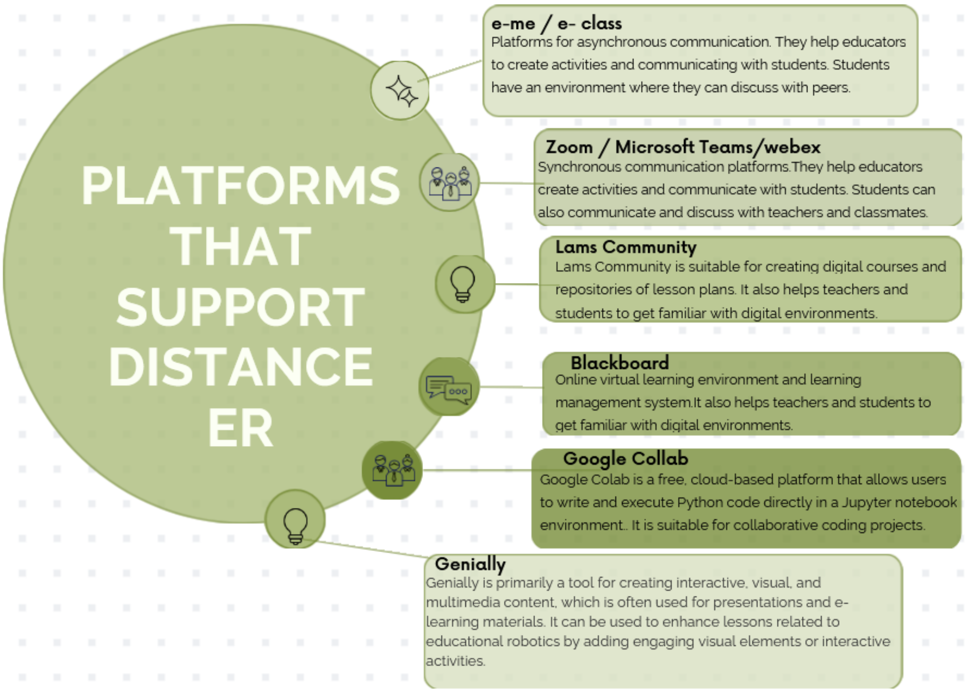

Figure 1: Platforms teachers in the study used to support Distance Educational Robotics

VI. DISCUSSION AND CONCLUSION

The findings of this research clearly demonstrate that Distance Education can be creatively and innovatively enriched by the utilization of Educational Robotics and complementary ICT tools. This integration enables teachers to design learning activities where students actively construct knowledge through experiential engagement with technology and robotics-based learning experiences.

Regarding the first research question, "*In what ways is Educational Robotics applied in school education?*", the findings reveal that Educational Robotics can be integrated successfully into contemporary school environments. Educational Robotics is important for teaching because it creates unique methods and develops essential skills necessary for success in the 21st century. One of the key advantages of educational robotics is that it empowers learners to apply what they have learned in practice, transforming abstract concepts into tangible learning outcomes. Moreover, educational robotics supports the development of critical thinking, creativity and collaboration; competencies recognized as foundational in modern education. It also enhances student motivation and engagement by transforming abstract concepts into concrete, interactive learning experiences. As a result, Educational Robotics has emerged as a valuable instructional tool that aligns with contemporary educational demands and technological advancements.

Regarding the second research question, *"In what ways is Educational Robotics used in School Distance Education?"*, the findings demonstrate that Educational Robotics can be effectively deployed through diverse tools and methods during distance education. The COVID-19 pandemic catalyzed both the widespread adoption of Distance Education and accelerated technological development in educational contexts. As Distance Education became more prevalent at the school level, it simultaneously opened pathways for the implementation and development of Educational Robotics in teaching. Using virtual and augmented reality, robotics kits and instructional videos, educators can provide learners with engaging and interactive learning experiences that encourage critical thinking, collaboration and creativity (Tselegkaridis & Sapounidis, 2022).

The qualitative findings from interviewed teachers identified corresponding tools and methods that support distance robotics instruction. Essential tools include Arduino, LEGO Education, Thymio, Edison and Raspberry Pi. Teachers also identified communication and management platforms suitable for Distance Education Robotics: Zoom, Microsoft Teams, Webex, Moodle, e-me and e-class. They emphasized that tool selection must be guided by appropriateness criteria including student age, accessibility and individual learning needs. For both synchronous and asynchronous robotics instruction without requiring physical hardware, teachers can leverage online Arduino simulators such as Tinkercad Circuits, which are free, browser-based tools supporting multiple Arduino boards with real-time code compilation.

Beyond these core platforms, educators utilize supplementary asynchronous tools to enhance robotics instruction. Teachers noted that Genially is a valuable tool for creating interactive, visual and multimedia content, including presentations, infographics, e-learning materials and interactive storytelling, which can enrich lessons and projects related to educational robotics by adding engaging visual elements and interactive activities. Moreover, educators consistently emphasized that tool selection must prioritize appropriateness based on student age, accessibility and specific needs. It is also essential that ICT integration be grounded in pedagogical approaches rather than relying on technological means and tools. In general, teachers indicated that ICT tools combined with Distance Educational Robotics can constitute a valuable educational tool with future applicability in their learning (Pasalidou & Fachantidis, 2021).

Teachers utilize Educational Robotics to enhance exploratory and hands-on learning experiences, making teaching more engaging and personalized while adapting instruction to individual student needs. Additionally, teachers use Educational Robotics as a complementary tool to enrich their lessons. Another benefit, is that Educational Robotics empowers learners to develop enhanced creativity and innovation (Tsagaris et al., 2019; Gubenko et al., 2021). Educational Robotics creates unique and stimulating conditions in education that foster creativity, critical thinking, collaboration and problem-solving.

Tools such as Tinkercad and Arduino, have become mainstream, enabling students to engage with hands-on STEM learning remotely. These advancements have not only increased accessibility but also fostered innovation and practical skill development globally. This shift has contributed to educational globalization, allowing learners from different regions to access identical, cutting-edge tools and resources. Furthermore, these advancements support sustainability by promoting efficient, resource-conscious educational practices that prepare students to collaboratively address global challenges.

Educational Robotics positively impacts students' self-efficacy and interest in the STEAM field, thereby supporting experiential learning. Educational robots serve as powerful tools that encourage students to think scientifically and develop solutions to presented problems. Educational Robotics represents an innovative teaching approach that harnesses robotic technology to engage students in experiential learning activities. By integrating STEAM education principles with robotics, students can learn complex concepts in engaging and interactive ways (Alimisis, 2020). Furthermore, Educational Robotics cultivates fundamental cognitive and social competencies including metacognition, computational thinking, critical thinking, problem-solving, creativity, collaboration and decision-making (Piedade et al., 2020).

One approach to incorporating educational robotics into distance education is through virtual robotics simulations. Platforms such as Robot Virtual Worlds enable learners to collaborate with classmates in virtual environments, experimenting with different robot designs and simulating real-world scenarios (Tselegkaridis & Sapounidis, 2022). Another effective approach is through remote access kits, where companies such as LEGO Education and VEX Robotics provide either physical equipment distributed to schools and homes, or online platforms simulating various educational robotics tools. Optimal implementation requires that educational robotics platforms be properly used for both learners and teachers, ensuring that technology enhances and strengthens teaching effectiveness and learning outcomes. Educational Robotics serves as an educational tool that stimulates student interest and enriches the learning experience (Belpaeme et al., 2021).

The research clearly indicates that appropriate equipment is essential for teachers and students to work effectively without technological barriers. Reliable internet connectivity and flexible, accessible hardware, is particularly critical during distance educational robotics implementation to ensure smooth instructional delivery. Significant challenges require obstruct implementation of distance Educational Robotics, including unstable internet connections, high equipment costs and limited institutional support. Therefore, schools, universities and the state should prioritize facilitating access by providing sufficient, flexible equipment that enables all students to engage with educational robotics easily and equitably (Tzagkaraki et al., 2021). However, teachers themselves, through appropriate professional development and deliberate effort, must work actively to overcome these challenges and implement innovative practices.

Teachers must develop their professional roles and adapt to technological and pedagogical developments. They must function as researchers, continuously updating their knowledge as new information emerges. Teachers should familiarize themselves with emerging technologies and confidently implement Educational Robotics in their teaching practice. By doing so, they provide substantial benefits to students, including the development of critical thinking, problem-solving skills, creativity and collaborative competencies. Pedagogically supported technology use has prompted teachers to reconsider traditional instructional approaches and adopt contemporary and emerging technologies and tools (Zawacki-Richter et al., 2020; Qazi, 2021). The inclusion of ICT in teaching enhances the capabilities and skills of both educators and learners, creating conditions for meaningful and comprehensive learning. Technology has become integral to contemporary social and educational life. Technological fluency and adoption are therefore essential for individuals, particularly teachers and students, to develop the competencies and adaptability necessary for future workforce participation and societal engagement. Ultimately, new technologies and digital tools provide learners unprecedented opportunities to actively construct knowledge gradually, creatively and innovatively.

Greek educational institutions must adapt to global demands where technological competence and innovation are critical for students' success and international competitiveness. By embracing Educational Robotics and ICT-integrated approaches, Greek schools can narrow educational gaps and ensure that students access the same quality and caliber of learning experiences as their international peers. Through committed integration of Educational Robotics in distance education, educational institutions can prepare learners to address the complex challenges of the 21st century. Educational Robotics, when combined with appropriately chosen ICT tools and pedagogically sound instructional design, represents a powerful approach to transforming distance education and fostering students' development as critical thinkers, creative problem-solvers and collaborative learners prepared for success in an increasingly interconnected world.

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