UNIVERSITAT ROVIRA i VIRGILI

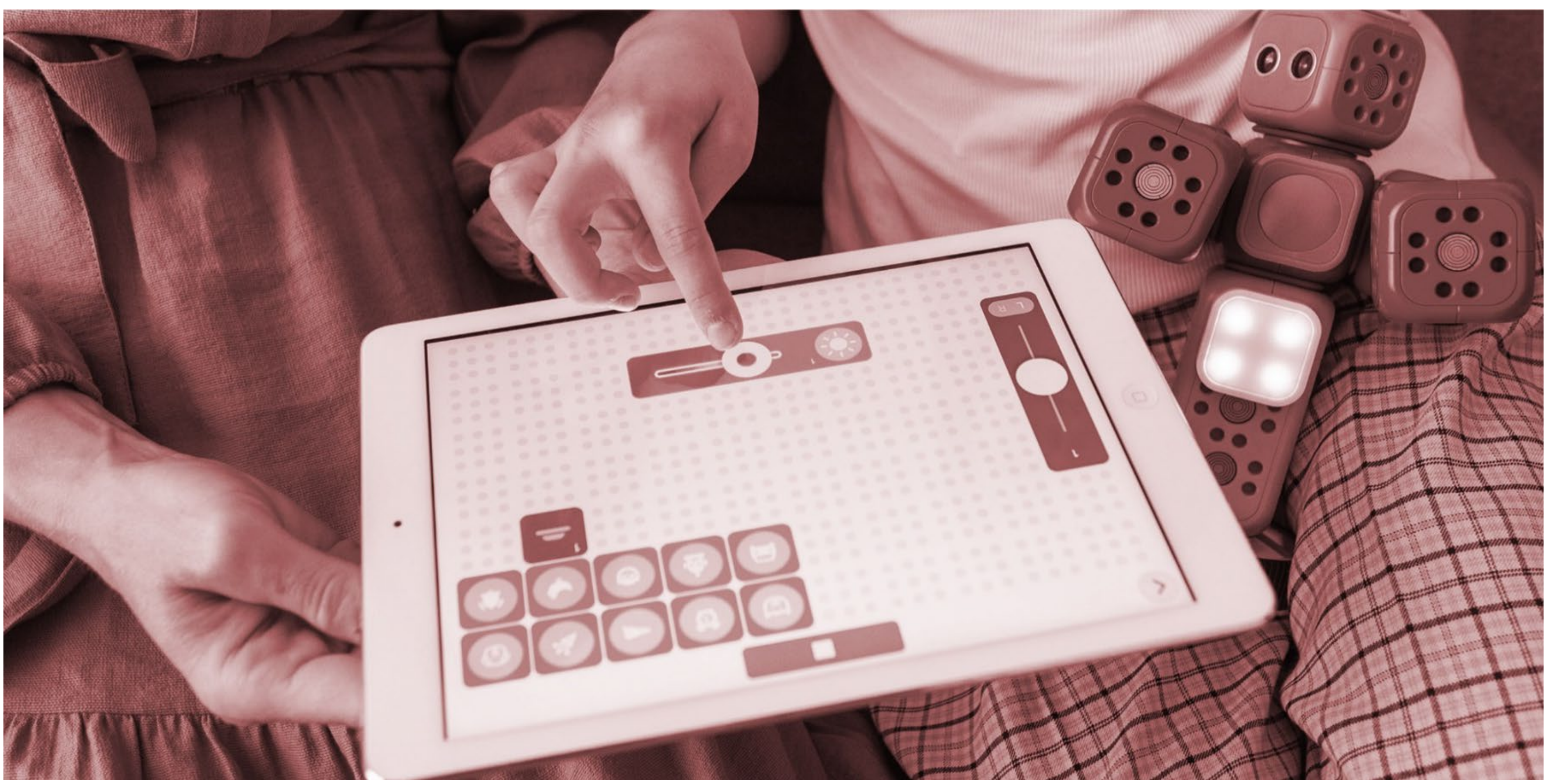
Doctoral Thesis

Teacher Training in Educational Robotics: participants' learning and perceptions

Despoina Schina

Department of Pedagogy

Tarragona 2021



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Teacher Training in Educational Robotics: participants' learning and perceptions

Despoina Schina

Supervised by

Dr Vanessa Esteve González & Dr Mireia Usart

Department of Pedagogy

Tarragona

2021

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I STATE that the present study, entitled “Teacher Training in Educational Robotics: participants’ learning and perceptions” presented by Despoina Schina for the award of the degree of Doctor, has been carried out under my supervision at the Department of Pedagogy of this university.

Tarragona, 7th of July 2021

Doctoral Thesis Supervisors

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To my dearest Tasos & Noula Mela

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Finally, I would like to thank my family and friends all around Europe for supporting me throughout the research and writing. In particular, I would like to thank Aleka and Jane for inspiring me; I hope that I will be able to guide and support my students the way you guide and support your students every day. I would like to thank Petros and Giorgos for motivating me to learn more about technology and programming. You have always been very supportive during this challenging endeavor of mine; I am so grateful to you both. I would like to give special thanks to my good friend Victoria for always being around for the small and big moments and for helping with the front cover of this thesis. I would also like to thank Despoina, Irini, Liza, Ioanna and Myrto for their support throughout.

Table of Contents

Table of Figures

List of Tables

Glossary and List of Abbreviations

Abbreviation	**Explanation**
CS	Computer Science
DC	Digital Competence
DT	Digital Technologies
EC	Exclusion Criteria
ER	Educational Robotics
FLL	First Lego League
SDGs	Sustainable Development Goals
STEM	Science, Technology, Engineering and Mathematics
STEAM	Science, Technology Engineering, Arts and Mathematics
TDC	Teacher Digital Competence
TPL	Textual Programming Language
TUI	Tangible User Interface
URV	Universitat Rovira i Virgili
VPL	Visual Programming Language

Abstract

Purpose: By engaging in educational robotics (ER), students develop 21st century skills, acquire knowledge of different disciplines and improve their attitude to and interest in STEAM disciplines (Science, Technology Engineering, Arts and Mathematics). However, teachers are not always capable of integrating educational robotics (ER) into their teaching as they do not often receive training in this area as part of their university degrees. This study places teacher education in ER and teacher perceptions of ER at the center of educational research as they are influencing the integration of ER into the school curriculum.

Design: The thesis uses an exploratory sequential mixed method design. It first collects qualitative data on teacher perceptions and on current trends in ER teacher training, and then provides a better understanding of teachers' perceptions of ER and learning by collecting qualitative and quantitative data. The thesis starts by examining ER in terms of teacher perceptions, its potential and integration into the curriculum, continues with a review of the literature on international teacher training programs and concludes by launching two training programs for preservice teachers and studying their perceptions of ER and the learning that has taken place. The research was carried out in both formal and informal educational contexts: at the FIRST LEGO League Competition (FLL) of Tarragona-Reus (Spain), in the international literature and, finally, at the Faculty of Educational Sciences and Psychology of the Universitat Rovira i Virgili (URV) as part of the Bachelor's Degree in Pedagogy (pilot training program) and at the Bachelor's in Preschool Education (main training program). The ER teacher training programs introduce participants to the basics of ER and to its interdisciplinary integration in the curriculum and enable them to design ER instructional material in sustainable development (pilot program) and the natural sciences (main training program). The research instruments used for data retrieval and techniques for data analysis are both qualitative and quantitative, and include systematic literature reviews, pre-post opinion questionnaires, student journals, evaluations, and student assignments.

Findings: The findings of the study of teacher perceptions suggest that teachers have a positive view of student learning with ER and are in favor of it being integrated into school curricula even at early educational stages. The duration and requirements of current ER teacher training programs differ substantially, while the best practices are regarded to be collaboration, materials design, instruction in pedagogy, opportunities for practice, and feedback/support. The pilot ER training program, part of the Bachelor's Degree in Pedagogy enabled 21 trainees to integrate ER in educational projects on sustainable development in a variety of disciplines. The results of the main teacher training program, part of the Bachelor's Degree in Preschool Education with 90 trainees, showed that ER had a positive impact on participants' learning and opinions: i) participants integrated ER into a variety of educational projects in the area of natural sciences, ii) their acceptance of and self-efficacy towards ER improved after the program iii) they had positive views of the potential of ER, considered teacher training in ER to be useful for their teaching career and made suggestions for improving the training program such as additional training sessions/resources and time for experimentation.

Value: This thesis provides insight into the impact of ER teacher training and shows the importance of integrating ER into teacher education as it positively affects future teachers' learning and perceptions of ER. It is anticipated that the results of this thesis will contribute to the introduction of ER into the URV's Bachelor's Degrees in Education, Preschool Education, and Pedagogy, thus enriching the education of future teachers and student learning at school. Finally, this thesis provides specific recommendations on ER teacher training programs and research, exemplifies the integration of ER into a variety of disciplines, and expects to inspire practitioners and policy makers.

Resumen

Finalidad: participando en la robótica educativa (RE), los estudiantes desarrollan habilidades del siglo XXI, adquieren conocimientos de diferentes disciplinas y mejoran su actitud e interés por las disciplinas STEAM (ciencias, ingeniería tecnológica, artes y matemáticas). Sin embargo, los profesores no siempre son capaces de integrar la robótica educativa (RE) en su docencia, ya que no suelen recibir formación en esta área como parte de sus titulaciones universitarias. Este estudio sitúa la formación del profesorado en RE y las percepciones de los docentes sobre RE en el centro de la investigación educativa, ya que están influyendo en la integración de la RE en el currículo escolar.

Diseño: la tesis utiliza un diseño de método mixto secuencial exploratorio. Primero recopila datos cualitativos sobre las percepciones del profesorado y sobre las tendencias actuales en la formación del profesorado en RE y, luego, proporciona una mejor comprensión de las percepciones de los docentes sobre la RE y el aprendizaje mediante la recopilación de datos cualitativos y cuantitativos. La tesis comienza examinando la RE en términos de percepción del profesorado, su potencial y su integración en el plan de estudios, continúa con una revisión de la literatura sobre programas internacionales de formación de profesores y concluye con el lanzamiento de dos programas de formación para futuros profesores y con el estudio de sus percepciones sobre RE y el aprendizaje que se ha llevado a cabo. La investigación se desarrolló tanto en contextos educativos formales como informales: en la FIRST LEGO League Competition (FLL) de Tarragona-Reus (España), en la literatura internacional y, finalmente, en la Facultad de Ciencias de la Educación y Psicología de la Universidad Rovira i Virgili (URV) como parte del grado en Pedagogía (programa piloto de formación) y del grado en Educación Infantil (programa principal de formación). Los programas de formación del profesorado en RE introducen a los participantes en los conceptos básicos de la RE y su integración interdisciplinaria al currículo y les permiten diseñar material de instrucción de RE en desarrollo sostenible (programa piloto) y en ciencias naturales (programa principal de formación). Los instrumentos de investigación

utilizados para la recuperación de datos y las técnicas de análisis de datos son cualitativos y cuantitativos e incluyen revisiones sistemáticas de literatura, cuestionarios de opinión pre-post, revistas de alumnos, evaluaciones y tareas de los estudiantes.

Conclusiones: las conclusiones del estudio de las percepciones de los profesores sugieren que los profesores tienen una visión positiva del aprendizaje de los estudiantes con RE y están a favor de que se integre a los currículos escolares incluso en las primeras etapas educativas. La duración y los requisitos de los programas actuales de formación del profesorado en RE difieren sustancialmente, mientras que se considera que las mejores prácticas son la colaboración, el diseño de materiales, la instrucción en pedagogía, las oportunidades de práctica y el feedback / soporte. El programa piloto de formación en RE, que forma parte del grado en Pedagogía, permitió a 21 estudiantes integrar la RE en proyectos educativos sobre desarrollo sostenible en diversas disciplinas. Los resultados del principal programa de formación del profesorado, que forma parte del grado en Educación Infantil con 90 estudiantes, demostró que la RE tuvo un impacto positivo en el aprendizaje y las opiniones de los participantes: *i)* los participantes integraron la RE en una variedad de proyectos educativos en el área de ciencias naturales, *ii)* su aceptación y autoeficacia hacia la RE habían mejorado después del programa, *iii)* tenían opiniones positivas sobre el potencial de la RE, consideraban que la formación del profesorado en RE era útil para su carrera docente e hicieron sugerencias para mejorar el programa de formación como sesiones / recursos de formación adicionales y tiempo para experimentar.

Valor: esta tesis proporciona una visión del impacto de la formación del profesorado de RE y muestra la importancia de integrar la RE en la formación del profesorado, ya que afecta positivamente al aprendizaje y a la percepción de los futuros profesores con respecto a la RE. Se prevé que los resultados de esta tesis contribuirán a la introducción de la RE a los grados en Educación, Educación Infantil y Pedagogía de la URV, enriqueciendo así la educación de los futuros profesores y el aprendizaje de los alumnos en la escuela. Finalmente, esta tesis proporciona recomendaciones específicas sobre programas e investigaciones sobre formación de profesores de RE, ejemplifica la integración de la RE en diversas disciplinas y espera inspirar a los profesionales y a los responsables de políticas educativas.

Resum

Finalitat: en participar en la robòtica educativa (RE), els estudiants desenvolupen habilitats del segle XXI, adquireixen coneixements de diferents disciplines i milloren la seva actitud i interès per les disciplines STEAM (ciències, enginyeria tecnològica, arts i matemàtiques). No obstant això, els professors no sempre són capaços d'integrar la robòtica educativa (RE) en la seva docència, ja que no solen rebre formació en aquesta àrea com a part de les seves titulacions universitàries. Aquest estudi situa la formació del professorat en RE i les percepcions dels docents sobre RE en el centre de la investigació educativa, ja que estan influint en la integració de la RE en el currículum escolar.

Disseny: la tesi utilitza un disseny de mètode mixt seqüencial exploratori. Primer recopila dades qualitatives sobre les percepcions del professorat i sobre les tendències actuals en la formació del professorat en RE i, llavors, proporciona una millor comprensió de les percepcions dels docents sobre la RE i l'aprenentatge mitjançant la recopilació de dades qualitatives i quantitatives. La tesi comença examinant la RE en termes de percepció del professorat, el seu potencial i la seva integració al pla d'estudis, continua amb una revisió de la literatura sobre programes internacionals de formació de professors i conclou amb el llançament de dos programes de formació per a futurs professors i amb l'estudi de les seves percepcions sobre RE i l'aprenentatge que s'ha dut a terme. La investigació es va desenvolupar tant en contextos educatius formals com informals: a la FIRST LEGO League Competition (FLL) de Tarragona-Reus (Espanya), a la literatura internacional i, finalment, a la Facultat de Ciències de l'Educació i Psicologia de la Universitat Rovira i Virgili (URV) com a part del grau en Pedagogia (programa pilot de formació) i del grau en Educació Infantil (programa principal de formació). Els programes de formació del professorat en RE introdueixen els participants en els conceptes bàsics de la RE i la seva integració interdisciplinària al currículum i els permeten dissenyar material d'instrucció de RE en desenvolupament sostenible (programa pilot) i en ciències naturals (programa principal de formació). Els instruments de recerca

utilitzats per a la recuperació de dades i les tècniques d'anàlisi de dades són qualitatius i quantitatius i inclouen revisions sistemàtiques de literatura, qüestionaris d'opinió pre-post, revistes d'alumnes, avaluacions i tasques dels estudiants.

Conclusions: les conclusions de l'estudi de les percepcions dels professors suggereixen que els professors tenen una visió positiva de l'aprenentatge dels estudiants amb RE i estan a favor que s'integri als currículums escolars fins i tot en les primeres etapes educatives. La durada i els requisits dels programes actuals de formació del professorat en RE difereixen substancialment, mentre que es considera que les millors pràctiques són la col·laboració, el disseny de materials, la instrucció en pedagogia, les oportunitats de pràctica i el feedback / suport. El programa pilot de formació en RE, que forma part del grau en Pedagogia, va permetre a 21 estudiants integrar la RE en projectes educatius sobre desenvolupament sostenible en diverses disciplines. Els resultats del principal programa de formació del professorat, que forma part del grau en Educació Infantil amb 90 estudiants, va demostrar que la RE va tenir un impacte positiu en l'aprenentatge i les opinions dels participants: *i)* els participants van integrar la RE en una varietat de projectes educatius a l'àrea de ciències naturals, *ii)* la seva acceptació i autoeficàcia envers la RE havien millorat després del programa, *iii)* tenien opinions positives sobre el potencial de la RE, consideraven que la formació del professorat en RE era útil per a la seva carrera docent i van fer suggeriments per millorar el programa de formació com ara sessions / recursos de formació addicionals i temps per experimentar.

Valor: aquesta tesi proporciona una visió de l'impacte de la formació del professorat de RE i mostra la importància d'integrar la RE en la formació del professorat, ja que afecta positivament l'aprenentatge i la percepció dels futurs professors envers la RE. Es preveu que els resultats d'aquesta tesi contribuiran a la introducció de la RE als graus en Educació, Educació Infantil i Pedagogia de la URV, enriquint així l'educació dels futurs professors i l'aprenentatge dels alumnes a l'escola. Finalment, aquesta tesi proporciona recomanacions específiques sobre programes i investigacions sobre formació de professors de RE, exemplifica la integració de la RE en diverses disciplines i espera inspirar als professionals i als responsables de polítiques educatives.

PhD student's publications

Journal articles

Schina, D., Valls-Bautista, C., Borrull-Riera, A., Usart, M., & Esteve-González, V. (2021a). An associational study: preschool teachers' acceptance and self-efficacy towards Educational Robotics in a pre-service teacher training program. *International Journal of Educational Technology in Higher Education*. https://doi.org/10.1186/s41239-021-00264-z

Schina, D., Esteve-González, V., Usart, M., Lázaro-Cantabrana, J.-L., & Gisbert, M. (2020b). The Integration of Sustainable Development Goals in Educational Robotics: A Teacher Education Experience. *Sustainability*, *12*, 10085. https://doi.org/10.3390/su122310085

Schina, D., Esteve-González, V., & Usart, M. (2020a). An overview of teacher training programs in educational robotics: characteristics, best practices, and recommendations. *Educational Information Technologies*. https://doi.org/10.1007/s10639-020-10377-z

Book chapters in edited volumes

Schina D., Esteve-Gonzalez V., & Usart M. (2021b). Teachers' perceptions of Bee-Bot robotic toy and their ability to integrate it in their teaching. In M. Merdan, W. Lepuschitz, G. Koppensteiner, R. Balogh, & Obdržálek D. (Eds.), *Advances in Intelligent Systems and Computing* (pp. 313-324). Springer. https://doi.org/10.1007/978-3-030-67411-3_12

Borrull, A., Valls, C., Schina, D., & Vallverdú, M. (2020a). INTROBOT: introducción de la robótica educativa en el grado de educación infantil. In R. Roig-Vila (Ed.), *La docencia en la Enseñanza Superior. Nuevas aportaciones desde la investigación e innovación educativas* (pp. 528-538).

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Schina D., Usart M., & Esteve-Gonzalez V. (2020c). Participants' Perceptions About Their Learning with FIRST LEGO® League Competition – a Gender Study. In M. Merdan, W. Lepuschitz, G. Koppensteiner, R. Balogh, & D. Obdržálek (Eds.), *Advances in Intelligent Systems and Computing* (pp. 313-324). Springer. https://doi.org/10.1007/978-3-030-26945-6_28

Schina, D., Usart, M., Esteve-Gonzalez, V., & Gisbert, M. (2020d). Teacher Views on Educational Robotics and Its Introduction to the Compulsory Curricula. In H. C. Lane, S. Zvacek, & J. Uhomoibhi (Eds.), *Proceedings of the 12th International Conference on Computer Supported Education* (pp. 147-154). SCITEPRESS. https://doi.org/10.5220/0009316301470154

Schina, D., Esteve-González, V., & Usart, M. (2019). The role of gender in students' achievement and self-efficacy in STEM. In S. Pérez-Aldeguer, & D. Akombo (Eds.), *Research, technology, and best practices in Education* (pp. 28-38). Adaya Press. ISBN: 978-94-92805-09-6. http://www.adayapress.com/wp-content/uploads/2019/07/RTB3.pdf

Usart, M., Schina, D., Esteve-González, V., & Gisbert, M. (2019). Are 21st Century Skills Evaluated in Robotics Competitions? The Case of First LEGO League Competition. In H. C. Lane, S. Zvacek, & J. Uhomoibhi (Eds.), *Proceedings of the 11th International Conference on Computer Supported Education*, (pp. 445-452). SCITEPRESS. https://doi.org/10.5220/0007757404450452

Schina, D., Esteve-González, V., & Usart, M. (2018). Gender differences in students' feedback and performance in Scratch programming. In REDINE (Ed.), Conference Proceedings EDUNOVATIC 2018, (pp. 36-41). Adaya Press. ISBN 978-94-92805-08-9. http://www.adayapress.com/wp-content/uploads/2019/03/EDUNOVATIC18.pdf

Conference presentations

Valls, C., Borrull, A., Esteve-Gonzalez V., & Schina D. (2021, June 10-16). *Introducción del pensamiento computacional a través de ScratchJr en el grado de educación infantil* [conference presentation]. XIX Jornadas de Redes de Investigación en Docencia Universitaria (REDES 2021) y V Workshop Internacional de Innovación en Enseñanza Superior y TIC (INNOVAESTIC 2021), Alicante, Spain.

Usart, M., Schina, D., Esteve-González, V., Sanromà, M., Grimalt-Álvaro, C., Valls, C., & Gisbert, M. (2021, March 25-26). *Com mesurar la percepció de les habilitats digitals: diferències de gènere entre l'alumnat de primer cicle de primària* [conference presentation]. Congrés Dones, Ciència i Tecnologia (WSCITECH2021), Terrassa, Spain.

Schina, D. (2020, November 18). *La robótica educativa: brecha de género y STEAM* [conference presentation]. III Jornada d´Innnovacio amb Robotica Educativa: Robotica Educativa amb perspectiva de genere, Castellón de la Plana, Spain.

Schina D., Esteve-Gonzalez V., & Usart M. (2020, September 30 - October 1). *Teachers' perceptions of Bee-Bot robotic toy and their ability to integrate it in their teaching* [conference presentation]. 12th International Conference on Robotics in Education (RiE 2020), Bratislava, Slovakia.

Borrull, A., Valls, C., Schina, D., & Vallverdú, M. (2020, June 4-7). *INTROBOT: Diseño e implementación de una propuesta didáctica para introducir la robótica educativa en la formación de maestros de educación infantil* [conference presentation]. XVIII Jornadas de Redes de Investigación en Docencia Universitaria (REDES 2020) & IV Workshop Internacional de Innovación en Enseñanza Superior y TIC (INNOVAESTIC 2020), Alicante, Spain.

Schina, D., Usart, M., Esteve-González, V., & Gisbert, M. (2020, May 2-4). *Teacher Views on Educational Robotics and Its Introduction to the Compulsory Curricula* [conference presentation]. 12th International Conference on Computer Supported Education (CSEDU 2020), Prague, Czech Republic.

Schina, D. (2020, January 29). *An Educational Robotics training program for pre-service primary school teachers* [conference presentation]. VII Seminario Interuniversitario de Investigación en Tecnología Educativa (SiiTE2020), Lleida, Spain.

Usart, M., Schina, D., Esteve-González, V., & Gisbert, M. (2019, May 2-4). *Are 21st Century Skills Evaluated in Robotics Competitions? The Case of First LEGO League Competition* [conference presentation]. 11th International Conference on Computer Supported Education (CSEDU2019), Heraklion, Greece.

Schina, D. (2019, May 2-4). *An Educational Robotics Training Program for Pre-service Primary School Teachers* [Doctoral consortium presentation]. 11th International Conference on Computer Supported Education (CSEDU2019), Heraklion, Greece.

Schina D., Usart M., & Esteve-Gonzalez V. (2019, April 10-12). *Participants' Perceptions About Their Learning with FIRST LEGO® League Competition – a Gender Study* [conference presentation]. 10th International Conference on Robotics in Education (RiE 2019), Vienna, Austria.

Schina, D. (2019, February 4). *Educational Robotics across disciplines in primary school* [Poster presentation]. VII Jornada d'Investigadors Predoctorals Interdisciplinària (JIPI2019), Barcelona, Spain.

Schina, D. (2019, February 1). *Educational robotics across disciplines in primary school* [conference presentation]. VI Seminario Interuniversitario de Investigación en Tecnología Educativa (SiiTE2019), Ibiza, Spain.

Schina, D., Esteve-González, V., & Usart, M. (2018, December 17-19). *Gender differences in students' feedback and performance in Scratch programming* [conference presentation]. 3rd Virtual International Conference on Education, Innovation, and ICT Conference Proceedings (EDUNOVATIC 2018), Madrid, Spain.

Compendium of publications

Publication 1 Teacher views on Educational Robotics and its introduction to the compulsory curricula

Type of publication: book chapter in conference proceedings

Abstract: This study examines how teachers perceive student learning with educational robotics (ER) and its integration into the school curriculum. The participants are teachers participating as coaches in the regional FIRST LEGO League Competition (FLL) of Tarragona-Reus (Catalonia, Spain). According to the results, teachers have a positive view of student learning with ER and believe that they develop 21st century skills and learn programming. In addition, the findings suggest that teachers support the integration of robotics into school curricula from early educational stages.

Citation:

Schina, D., Usart, M., Esteve-Gonzalez, V., & Gisbert, M. (2020d). Teacher Views on Educational Robotics and Its Introduction to the Compulsory Curricula. In H. C. Lane, S. Zvacek, & J. Uhomoibhi (Eds.), *Proceedings of the 12th International Conference on Computer Supported Education* (pp. 147-154). SCITEPRESS. https://doi.org/10.5220/0009316301470154

Bibliometric Data: Scopus. SJR (Scopus). IF, SJR: 0.19.

Publication 2 An overview of teacher training programs in Educational Robotics: characteristics, best practices, and recommendations

Type of publication: journal article

Abstract: This is a systematic literature review of teacher training research in the field of educational robotics (ER). One of the major findings of this study is the lack of uniformity among the training programs in terms of duration and requirements: duration may vary substantially from study to study, requirements are not standardized, and trainees' and trainers' profiles are not always documented. The most common pedagogical approaches in the selected studies are constructivism and constructionism, inquiry-based learning, and project-based learning, while several studies are not grounded on any particular theory. On the basis of the studies reviewed, the good practices for ER teacher training are associated with collaboration, materials, pedagogy, practice, and feedback/support. The recommendations of this study contribute to improving the content and structure of ER teacher training programs and facilitating their implementation in the future. The recommendations made can also benefit the reliability of the research results and design.

Citation:

Schina, D., Esteve-González, V., & Usart, M. (2020a). An overview of teacher training programs in educational robotics: characteristics, best practices, and recommendations. *Educational Information Technologies*. https://doi.org/10.1007/s10639-020-10377-z

Bibliometric Data: SJR (Scopus) Q1. IF, SJR: 0.92

Publication 3 The integration of sustainable development goals in educational robotics: A teacher education experience

Type of publication: journal article

Abstract: In this study, the students of the Bachelor's Degree in Pedagogy participate in an educational robotics (ER) training program. The objective of the study is to investigate the students' level of teacher digital competence (TDC) and examine their ability to integrate ER into a variety of disciplines by studying the integration of ER in education for sustainable development. This article is a case study which uses the COMDID-A TDC questionnaire, a lesson plan template, and a lesson plan evaluation rubric. The ER teacher training program enabled the students to work on ER in an interdisciplinary manner and carry out ER projects centered on sustainable development goals (SDGs). This research will encourage teacher education institutions to integrate ER into teacher education and address it from an interdisciplinary perspective.

Citation:

Schina, D., Esteve-González, V., Usart, M., Lázaro-Cantabrana, J.-L., & Gisbert, M. (2020b). The Integration of Sustainable Development Goals in Educational Robotics: A Teacher Education Experience. *Sustainability*, *12*, 10085. https://doi.org/10.3390/su122310085

Bibliometric Data: SJR (Scopus) Q1. IF, SJR: 0.61.

Publication 4 INTROBOT: introducción de la robótica educativa en el grado de educación infantil

Type of Publication: book chapter in edited volume

Abstract: In this study, students of the Bachelor's Degree in Preschool education participate in an educational robotics (ER) training program. The aim of the study is to examine how training impacts on participants' learning, on their opinions of the training itself and on the potentialities of ER resources. To achieve these goals, participants' training journals and lesson plan assignments were analyzed and assessed. According to our results, the training course had a positive impact on participants' learning and opinions: they were able to produce effective ER lesson plans and they considered the training to be indispensable for their teaching career. In addition, the participants were very positive about the potentialities of ER and underlined that ER can be applied across disciplines and may increase student motivation and support student collaboration.

Citation:

Borrull, A., Valls, C., Schina, D., & Vallverdú, M. (2020a). INTROBOT: introducción de la robótica educativa en el grado de educación infantil. In R. Roig-Vila (Ed.), *La docencia en la Enseñanza Superior. Nuevas aportaciones desde la investigación e innovación educativas* (pp. 528-538). Octaedro. ISBN 978-84-18348-11-2. https://octaedro.com/libro/la-docencia-en-la-ensenanza-superior/

Bibliometric Data: SPI: Q1.

Publication 5 An associational study: preschool teachers' acceptance and self-efficacy towards educational robotics in a pre-service teacher training program

Type of Publication: journal article

Abstract: This study aims to explore preschool preservice teachers' acceptance of and self-efficacy towards educational robotics (ER) during a university course and examine their perceptions of the course. This is a one-group intervention study with an associational research design that includes both quantitative and qualitative research methods: two pre-questionnaires and two post-questionnaires on pre-service teachers' acceptance of ER and self-efficacy, and participants' training journals. Results show that pre-service teachers' acceptance and self-efficacy towards ER improved after the ER teacher training course. Between the start and the end of the ER training there was a significant difference in pre-service teachers' acceptance in the perceived ease of use of ER, enjoyment, and attitudes, and self-efficacy. In their training journals, the participants positively evaluated the training, and also suggested that it could be improved with additional training sessions, resources, and time for experimentation. Our study provides insight into the impact of an ER training program and shows the importance of integrating ER into pre-service teachers' education.

Citation:

Schina, D., Valls-Bautista, C., Borrull-Riera, A., Usart, M., & Esteve-González, V. (2021a). An associational study: preschool teachers' acceptance and self-efficacy towards Educational Robotics in a pre-service teacher training program. *International Journal of Educational Technology in Higher Education*. https://doi.org/10.1186/s41239-021-00264-z

Bibliometric Data: SJR (Scopus) Q1. IF, SJR: 1.64

Chapter 1. Introduction

1.1. Educational Robotics: emergence, definition, and classification of resources

The field of Educational Robotics (ER) emerged in the 1960s with the work of Seymour Papert at MIT in Cambridge (Massachusetts, USA). Seymour Papert investigated the pedagogical potential of programming an object named "Turtle", controlled by an easy-to-understand programming language called "Logo", the first programming language ever designed with children in mind. Turtle was an "object-to-think-with" (Ackermann, 2001), a tool that children could use to program, reflect on, and make creations. Papert built on Piaget's theory of constructivism which views learning as building knowledge structures (Piaget, 1974), and created the theory of constructionism (Ackermann, 2001). Papert added to Piaget's theory of learning that students' learning is more effective when they are consciously engaged with a context (Papert & Harel, 1991) and argued that students learn by doing, constructing knowledge by interacting with objects.

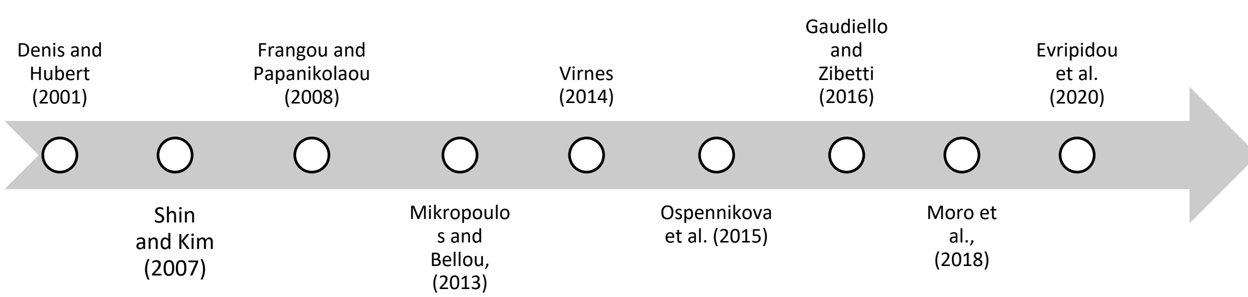
In the 1980s, Kjeld Kirk Kristiansen, the CEO of the LEGO Group, became interested in Papert's work as his ideas about children learning by building matched the company's philosophy. Their collaboration yielded the design of the LEGO/Logo computer-based robotics system under the product name LEGO TC logo, linking the world of LEGO construction with the world of Logo programming (Resckink & Ocko, 1991). In LEGO/Logo, children start by building machines out of LEGO pieces, using not only the traditional LEGO building bricks but also newer pieces like gears, motors, and sensors (Resckink & Ocko, 1991). Papert's research on the pedagogical potential of programming was continued by the work of Mitchel Resnick who worked on programming for children and created the Scratch Programming Language. One of the main values of Resnick's work is that it created technologies that support and suggest a wide range of different explorations for children, known as learning technologies with "wide walls" (Resnick & Silverman, 2005). Papert's theory of constructionism led to the design of a number of computerized educational technology products (Sullivan & Moriarty, 2009) that are used nowadays in different educational contexts around the world. These products are known as educational robotics (ER) resources.

According to Scaradozzi et al. (2019), there is no commonly accepted definition of educational robotics (ER) resources in international papers on education and robotics. Researchers have put forward various definitions (Figure 1) and seem to have different viewpoints regarding the nature, characteristics, and application to the curriculum of Educational Robotics. Twenty years ago, Denis and Hubert (2001) reported that ER "consists in building and programming small robots and conducting them with the help of computer programs that have to be built by the learners themselves" (p. 466). Very close to this definition by Denis and Hubert, Frangou and Papanikolaou (2008) define ER systems as consisting "of building material and software facilities which allow the construction and the programming of various robots" (p.54). Interestingly, more recent research studies define ER by underlining its pedagogical perspective (Mikropoulos & Bellou, 2013; Moro et al., 2018; Virnes, 2014). For example, in Moro et al. (2018), ER is perceived as a didactical approach to learning based on constructionism and constructivism. On the contrary, in Frangou and Papanikolaou (2008) ER technology is viewed as an educational tool. Shin and Kim (2007) also view ER as a learning tool, which provides new and extended possibilities to learn with, from, and about Educational Robotics. In line with this perspective, Gaudiello and Zibetti (2016) categorize ER activities in three main areas: i) learning robotics ii) learning by robotics, and iii) learning with robotics. The first category involves those activities and applications in which learners use a robot as a platform/tool to learn about technology, engineering and robotics. The second category involves robotic technologies that are used to convey knowledge of a certain subject to the learners. This is in line with the interdisciplinarity featured by other authors (Angel-Fernandez & Vincze, 2018; Scaradozzi et al., 2019). Finally, the third category includes learning activities that use humanized robots as assistants in the learning and teaching process. In line with this classification proposal, Ospennikova et al. (2015) suggest that robotics can be presented in the academic process 1) as an object of study, 2) as a tool of cognition, 3)) as a means by which teachers can interact with students and stimulate learning. Most recently, the research by Evripidou et al. (2020) provided an updated definition of the scientific field of Educational Robotics:

“The Educational Robotics field of study was born, evolved, and flourished at the intersection of educational science and computer science, intending to serve and contribute to both scientific areas. Considering the social nature of the student-robot interaction, the research questions posed by Educational Robotics, implemented by activities designed by the theory of constructionism, focus on the development of computational thinking skills, collaborative learning, and project-based learning. ER, primarily, aims at teaching programming skills, sequencing, coding, and algorithmic thinking. Moreover, as an essential branch of educational technology, the ER field of study seeks to increase the efficiency of traditional teaching practices and effectiveness while simultaneously attempting to bring about pedagogical changes to enhance education” (Evripidou et al., 2020, p. 219539).

This definition was formulated after conducting a meta-analysis and observing the connections between the keywords.

Figure 1. Timeline of Definitions of Educational Robotics



Since the emergence of “Turtle”, a wide range of robots have appeared on the educational technology market. There are numerous robotic kits, ranging from low-cost simple kits to more sophisticated ones and to expensive humanoid robots (Mubin et al., 2013). And although the robotics resources “have different technical, structural, and functional features, they share at least one common goal that is education” (Virnes, 2014) (p. 6). Due to the recent emergence of Educational Robotics and the constant appearance of new resources with different characteristics, the research community has not agreed yet on a unified classification of these resources. Nevertheless, individual researchers and research teams have put forward their own classifications of the resources currently available. Sapounidis and Alimisis (2020) classify existing ER technologies on the basis of their main feature. They suggest seven categories: Do It Yourself (DIY) robots, open hardware robots, brick-based robots, pre-assembled robots, only for simple actions or specific purpose robots, humanoid robots and robots-based on tangible programming). On the other hand, Evripidou et al. (2020) propose another classification in terms of the knowledge and programming skills that students need to make effective use of these resources. Their proposal is divided into three categories: “No Code, Basic Code and Advanced Code”. The “No Code” category includes all the educational robotic kits programmed with a Tangible Programming Language. “A tangible user interface (TUI) allows the user to input digital information by manipulating a physical object rather than using a screen, keyboard, or mouse” and target preschool education (p.2) (Strawhacker & Bers, 2014). The “Basic Code” category includes robotics platforms that can be programmed through a Visual Programming Language (VPL). VPL supports one programming construct, event-action pairs, created by dragging and dropping graphical blocks (Magnenat et al., 2014). Finally, the “Advanced Code” category consists of robotics kits that can be programmed with Textual Programming Languages (TPLs). This classification is conflicting as some ER resources can be programmed with various languages. Even though the research community has not agreed upon a single definition and classification of robotics resources, researchers do agree on some requirements for ER resources design. Junior et al. (2013) describe four basic requirements low-cost, appeal, simplicity, and open source. In line with this, other authors point out that cost plays an important role in the design and selection of ER resources (Araújo & Aroca, 2013; Sapounidis & Alimisis, 2020; Weinberg & Yu, 2003). In addition, Araújo and Aroca (2013) point out that the level of difficulty also plays an important role because the higher it is the less likely ER resources will be selected for classroom use. Earlier literature reports that ER technologies should be designed for use and support in a wide range of different investigations and projects (Resnick & Silverman, 2005).

1.2. Educational Robotics in learning

Educational Robotics resources provide multiple opportunities for learning at different educational levels, from preschool education to vocational training. The present thesis proposes three different categories of learning outcomes: i) learning opportunities related to 21st century skills; ii) learning opportunities related to the STEAM disciplines and skills, and iii) attitudinal gains. In several cases, the skills of the first two categories intersect and overlap. In the following subsections, the content of the categories is presented in detail.

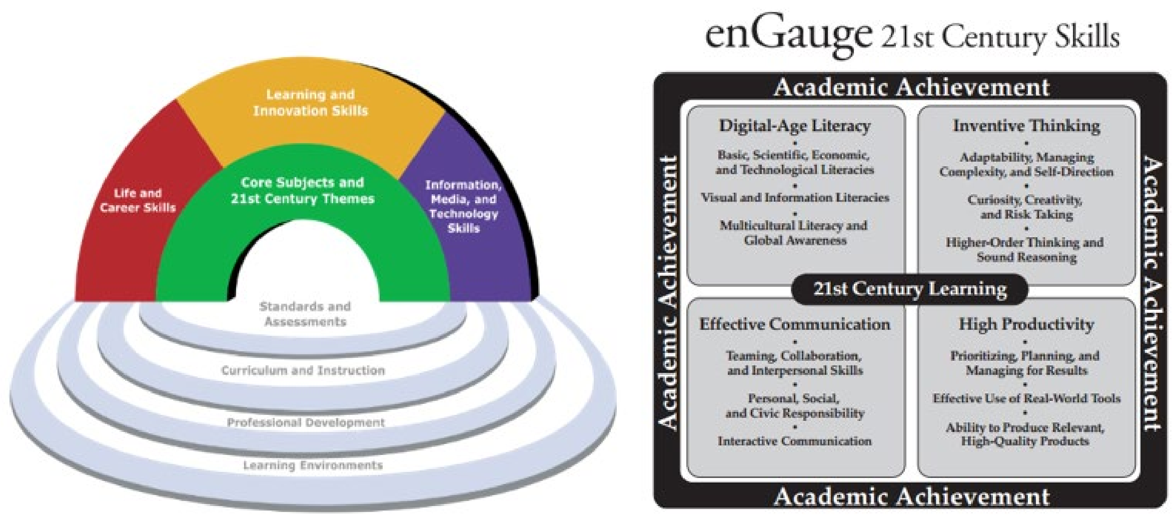
1.2.1. Opportunities for learning 21st century skills

In comparison to the 20th century, the 21st century has brought about important changes in the skills people need for work, citizenship, and self-actualization (Dede, 2010). The new set of skills goes beyond the 20th century literacy requirements – exclusively reading, writing and math – and includes "multiple literacies of the 21st century, aligned to living and working in a globalized new millennium" (Wisniewski, 2010). The new skills include critical thinking, creativity and innovation, cross-cultural understanding, information, media literacy, and career and learning skills. Several educational organizations have developed frameworks on the definition of 21st century skills, although a consensus on a shared definition has not been reached. Two of the most important frameworks are presented in Figure 2 (P21, 2007; Metiri Group & North Central Regional Educational Laboratory, 2003). Given the lack of consensus on the definition of 21st century skills, Romero et al. (2015) conducted a metanalysis of the six most prominent frameworks (Partnership for 21st century skills, 2007; Metiri Group & North Central Regional Educational Laboratory, 2003; Griffin et al., 2012; NETS/ISTE framework; OECD, 2005;

Gordon et al., 2009) and proposed the following eight most mentioned skills: communication, collaboration, ICT literacy, social and/or cultural skills, creativity, critical thinking, problem solving and development of quality products-productivity. All of the most mentioned skills, apart from development of quality products/productivity, are found to be enhanced when students engage in ER activities in formal or informal education contexts. They are summarized in Table 1.

According to current literature, collaboration and problem-solving skills are the most common 21st century skills developed by ER activities (Benitti & Spolaôr, 2017). A school robotics project was found to develop not only students' interpersonal skills but also the exchange of knowledge and collaborative relationships between students and teachers (Nemiro, 2020). Similarly, when robotics was integrated into primary school curricula, it was found that children improved their collaboration and teamwork skills (Scaradozzi et al., 2015). As mentioned above, problem-solving is another key skill being developed by ER activities (Blanchard et al., 2010; Denis & Hubert, 2001; Eguchi, 2017). The research by Blanchard et al. (2010) not only confirms the potential of robotic-based learning for the development of problem-solving skills but also underlines the potential of ER for the development of students' critical thinking. In addition, Denis and Hubert (2001) point out that students may develop other skills such as socialization. Authors also stress the potential of ER for the development of young children's computational thinking (Angeli & Valanides, 2020). Finally, it has been reported that ER fosters students' creativity (Denis & Hubert, 2001; Nemiro et al., 2017; Yang, et al., 2020). In fact, in Yang et al. (2020) an instructional framework was created to support students' development of creativity throughout ER activities.

Figure 2. 21st Century Skills Frameworks - Partnership for 21st Century skills & EnGauge



Note. Adapted from Partnership for 21st century skills (2007) and Metiri Group & North Central Regional Educational Laboratory (2003)

Table 1. ER learning opportunities in 21st century skills

21st century skills	***Research results in literature***
ICT literacy	*Angeli and Valanides (2020)*
Creativity	*Nemiro et al. (2017); Yang, et al., (2020); Denis and Hubert (2001)*
Collaboration	*Blanchard et al. (2010); Eguchi (2016); Nemiro (2020); Scaradozzi et al. (2015)*
Communication	*Eguchi (2016)*
Social/cultural skills	*Denis and Hubert (2001)*
Critical thinking	*Blanchard et al. (2010); Eguchi (2013); Eguchi and Uribe (2017)*
Problem-solving skills	*Blanchard et al. (2010); Varnado (2005)*

1.2.2. Opportunities for learning in STEAM education

The STEM teaching model consists of the disciplines of Science, Technology, Engineering and Mathematics and addresses them as cross-content-area disciplines that create knowledge as a whole (Bazler & Van Sickle, 2017). As reported by Perignat and Katz-Buonincontro (2019) “STEAM education merges the arts with STEM subjects for the purpose of improving student engagement, creativity, innovation, problem- solving skills, and other cognitive benefits and to improve employability skills (e.g. teamwork, communication, adaptability) necessary for career and economic advancement" (p. 31) . Taylor (2016) underlines that STEAM education is not in opposition to STEM education but it enriches and expands its scope. The integration of the arts into STEM provides more opportunities to develop critical thinking, creativity and communication (Bazler & Van Sickle, 2017) and improves student engagement (Engelman, 2017). The "Art" discipline in STEAM education is very broad; as well as fine arts, it includes the language arts, liberal arts, and physical arts (Yakman, 2008).

Several studies have pointed out how important ER is for the acquisition of skills and knowledge across all STEAM disciplines (Table 2). Eguchi (2017) demonstrated that robotics activities can support students as they work to achieve the learning goals which have been set by the US Government standards in the disciplines of mathematics, English language arts, engineering design and computational thinking. In the same vein, Khanlari (2013) reported that robotics is multi-disciplinary, and may support the understanding of scientific and non-scientific subjects. According to Kim et al. (2015), robotics activities improve student learning in science, technology, engineering, and/or mathematics. More precisely, previous literature has demonstrated that students can use ER to improve their knowledge of science. In one case, it was found that students had a greater understanding of physics after a summer camp on robotics (Williams et al., 2007). Also, robotics can help primary and secondary school children to better understand programming and engineering principles (Petre & Price, 2004) and concepts related to computer programming, robotics, mathematics, and engineering (Barker & Ansorge, 2007). The results of an educational robotics program conducted in informal education settings (afterschool clubs and summer camps) were also positive in terms of student understanding of computer programming, mathematics, geospatial concepts, and engineering/robotics (Nugent et al., 2009). In addition, students seem to positively perceive their learning in robotics competitions. After the

First Lego League Competition they felt they had learned about real word problems and developed skills in STEM disciplines (Schina et al., 2020c). As far as STEAM is concerned, there are several applications of robotics in the teaching of arts and social sciences. For instance, in the framework of the Arts & Bots program (Hamner & Cross, 2013), ER was used in history and English with the students building robotic models of historical figures and writing a biography from their perspective. In Ioannou et al. (2018) the Bee-bot was used to teach road safety as part of the school subject "general citizenship and wellbeing" while in Schina et al. (2021b) the use of Bee-bot in English foreign language teaching was discussed and recommended to teachers.

Table 2. ER learning opportunities in STEAM education

STEAM Disciplines	***Results in formal education***
Science	*Barker and Ansorge (2007); Eguchi (2017); Williams et al. (2007);*
Technology	*Barker and Ansorge (2007); Eguchi (2017); Petre and Price (2004)*
Engineering	*Barker and Ansorge (2007); Eguchi (2017); Nugent et al. (2009); Petre and Price (2004)*
Arts	*Eguchi (2017); Hamner and Cross (2013); Ioannou et al. (2018); Schina et al. (2021b)*
Mathematics	*Eguchi (2017); Nugent et al. (2009)*

Taking everything into consideration, ER can be applied in several areas in the school curriculum and bring important benefits to student learning.

1.2.3. Attitudinal gains

As well as creating opportunities for learning 21st century skills (Section 1.2.1.) and STEAM disciplines and skills (Section 1.2.2), Educational Robotics can have a positive impact on student attitudes and perceptions. According to current research, ER enhances students' interest in STEM subjects (Eguchi, 2016) and encourages them to pursue a career in STEM disciplines (Eguchi, 2013;

Kubilinskiene, Zilinskiene, Dagiene, & Sinkevičius, 2017). In addition, ER extracurricular activities such as competitions seem to be a very strong motivation for students and especially for the ones with higher overall marks and programming skills (Theodoropoulos et al., 2017). Along the same lines, Hendricks et al. (2012) report that middle and high school students' participation in VEX robotics competitions have an impact on their interest in pursuing STEM studies and STEM-related careers. Finally, girls' involvement in robotics programs may have a positive effect on their perceptions of their abilities in STEM and career interests (Weinberg et al., 2007). Girls' self-perceptions of skills in STEM disciplines need to be further studied and measured with validated and reliable instruments (Usart et al., 2021).

1.3. Educational robotics in teaching

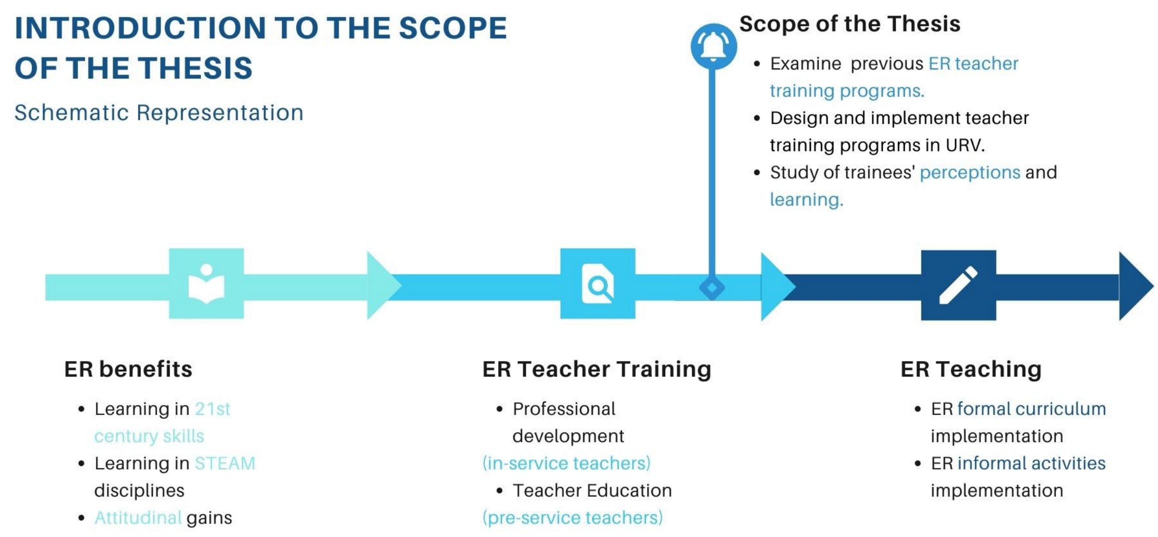
When students participate in ER activities, they may develop 21st century skills (section 1.2.1.), acquire knowledge across different disciplines (section 1.2.2.), improve their attitudes and interests in STEM areas of study and aspire to a career in STEM (section 1.2.3). However, the question that comes up at this point concerns the teachers: their familiarity with ER resources, their ability to use and integrate ER into classroom activities and their perceptions of these digital technologies (DT). Are teachers ready to implement ER activities in their teaching contexts, so that their students can reap all potential benefits?

Current literature underlines the importance of training teachers so that they can implement ER activities at school (Anisimova et al., 2020; Karim et al., 2015). More precisely, Sapounidis and Alimisis (2020) report that teachers should first become aware of the potential benefits of ER in terms of motivating, engaging and involving their students with ER activities. The authors also make three recommendations specific to teacher training. First, they recommend that teachers, especially those who do not have a technical background, should become familiar with the tools and guidelines. Second, they suggest that teachers should learn to use collaboration scripts so that children can work effectively in groups, thus reinforcing their learning outcomes. And third, they propose that teachers should learn proper scaffolding methods so that learners can make faster progress without losing their interest (Sapounidis & Alimisis, 2020). The ER teacher training initiatives that have been reported in the literature are taking place both as part of in-service teachers' professional development (Caballero-González & Muñoz-Repiso, 2017; Hodges et al., 2016; Negrini, 2019; Santos et al., 2016) and pre-service teachers' education at university (Bers et al., 2002; Jaipal-jamani & Angeli, 2017; Kim et al., 2015; Kucuk & Sisman, 2018; Major et al., 2011; Sisman et al., 2019).

As well as suggesting the implementation of ER teacher training programs, several studies in the literature propose that robotics activities be integrated into the formal school curriculum. For instance, Chalmers and Nason (2017) propose curriculum units with robotics to facilitate the learning of STEM "Big Ideas", while Strawhacker and Bers (2017) argue in favor of integrating ER into preschool education from a STEAM perspective. As reported by Benitti and Spolaôr N. (2017) most ER research takes place in extracurricular or hybrid contexts, and the robotics activities documented as being part of school curricula are only 18% of the total amount of ER research. In this thesis, we refer to extracurricular and hybrid research as informal contexts which include afterschool activities, summer camp programs and competitions. Karim et al. (2015) point out that further research is needed to adapt standard curricula and permit the integration of robot-based activities.

The present thesis embraces the implementation of ER activities and its benefits for students' learning, acquisition of skills and attitudes, and acknowledges the need to implement teacher training programs both for in-service and pre-service teachers. The focus of this thesis is on teachers rather than students and aims to contribute to the integration of ER in teacher education at university. We examine previous ER training programs, design and implement our own ER training program for pre-service teachers and study the participants' perceptions of ER and their learning. The scope of the thesis together with its relation to the previous sections of this chapter is presented schematically in Figure 3.

Figure 3. Schematic representation of the scope of the thesis



1.4. General objective, specific objectives, thesis projects, and structure

The general objective of the thesis is to examine current ER teacher training programs, study participants' perceptions of ER and their ability to integrate ER resources in their teaching and provide recommendations for future ER teacher training programs. The specific objectives of the thesis are presented in Figure 4. To achieve the general objective, four different – but interconnected – thesis projects are implemented (Table 3). The first thesis project consists of a preliminary analysis of teachers' perceptions of ER as a pedagogical resource for students' acquisition of STEM and 21st century skills and ER's curriculum integration. The second thesis project examines ER teacher training initiatives documented in current literature in terms of their characteristics (duration, requirements, trainer and trainee profiles, the participant profile, and the scope and duration of the training program and theory) and best practices. The analysis of ER teacher training initiatives (Thesis Project 2) provided this thesis with a deeper understanding of good practices and enabled a new ER teacher training program to be developed and implemented twice at the Faculty of Education Sciences and Psychology of the Universitat Rovira i Virgili. The program was taught for the first time at the Department of Pedagogy as part of our pilot study (Thesis Project 3). It was taught for the second time at the Department of Preschool. Education as part of the main study of this thesis (Thesis Project 4). The order in which the thesis projects took place, and the planning of the whole research, is presented in Figure 5. The present research was carried out in both formal and informal educational contexts: the study of teachers' perceptions was conducted at the FIRST LEGO League Competition (FLL) of Tarragona-Reus (Catalonia, Spain), while the ER teacher training programs were taught at the Faculty of Education Sciences and Psychology of the Universitat Rovira i Virgili (Catalonia, Spain). The research contexts will be presented in detail in Section 4.1.

Figure 4. General objective and specific objectives (SO.1, SO.2 & SO.3)

General objective: To examine current ER teacher training programs, study participants' perceptions of ER and their ability to integrate ER resources in their teaching and provide recommendations for future ER teacher training programs.

SO.1. To explore how teachers perceive the potential of Educational Robotics for students' acquisition of STEM and 21st century skills and how they view a possible integration of ER into the school curriculum.

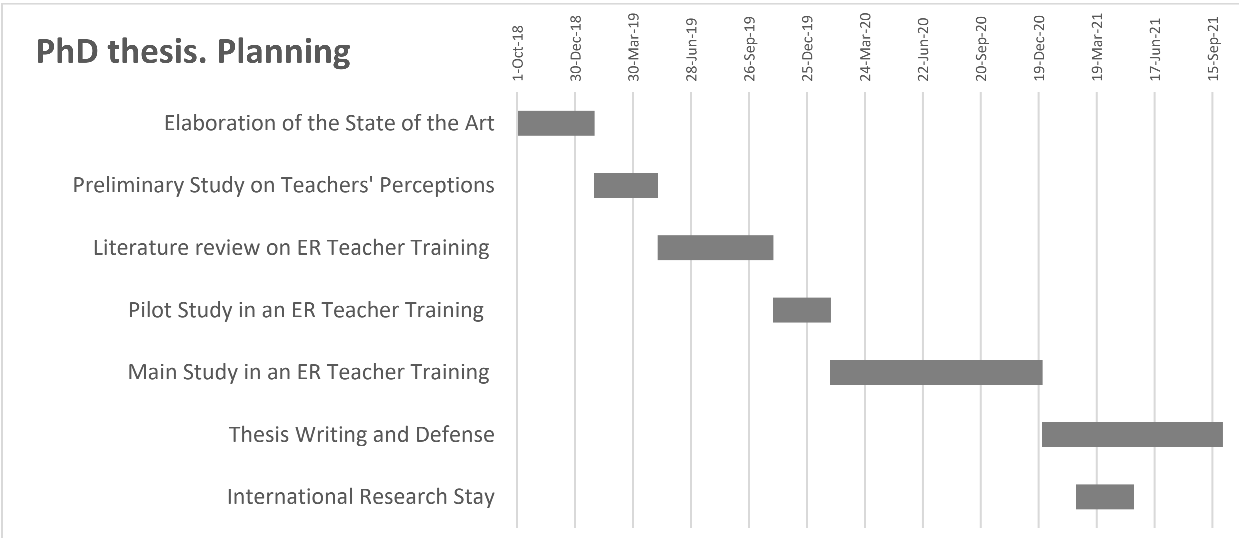
SO.2. To examine the characteristics of ER teacher training programs in international literature and the best practices implemented.

SO.3. To study the impact of ER teacher training on participants' learning and perceptions of ER.

Table 3. Projects of the thesis

Thesis projects	Specific objective	Content
Thesis Project 1	SO.1.	Preliminary study of teachers' perceptions of ER
Thesis Project 2	SO.2.	Systematic literature review of teacher training programs in ER
Thesis Project 3	SO.3.	Pilot study in an ER teacher training program
Thesis Project 4	SO.3.	Main study in an ER teacher training program

Figure 5. PhD thesis. Planning



This PhD thesis yielded several conclusions that will be presented in detail in Chapter 6. Conclusions. The most prominent ones are presented below per research objective:

- In-service teachers with prior experience in ER have a positive predisposition towards student learning and skills development with ER and support its integration into the school curriculum from early educational stages (SO.1.).
- Most current training programs in ER lack a strong pedagogical background and gender perspective and do not set completion requirements. The best practices for ER teacher training involve collaboration among teachers, producing teaching materials, and sharing foundations on pedagogy, practice, and feedback/support (SO.2.).
- The integration of ER in pre-service teachers' education at university has a positive impact on learning. The results of the thesis show that the trainees were able to design interdisciplinary ER activities in sustainable development and the natural sciences (SO.3.).
- The integration of ER in pre-service teachers' education at university improves participants' perceptions, particularly their acceptance and self-efficacy towards ER (SO.3.).

The thesis achieved the following objectives: (1) it has highlighted the importance of teachers' perceptions of ER by placing them at the center of educational robotics research, (2) for the first time it has examined the characteristics of ER teacher training programs, (3) it has developed and implemented an ER teacher training program at the Faculty of Educational Sciences and Psychology (Universitat Rovira i Virgili), (4) it has provided pre-school teachers with training in ER even though preschool teachers are rarely included in ER teacher training.

The thesis is divided into the following chapters. In chapter 2, "Statement of the Problem", the research problem is presented and documented in literature. In chapter 3, "Research Objectives and Questions", the objectives and their respective questions are clearly identified. Then, in chapter 4, "Research Methodology", the research design, research contexts, sample and instruments/techniques are presented in detail for all thesis projects. In Chapter 5, "Results and Discussion", the findings are presented and linked to the literature and theory. In Chapter 6, "Conclusions", the main results of the thesis and its conclusions are presented together with the limitations of the research. Finally, in Chapter 7, "Recommendations", suggestions are provided for innovation in the field of ER teacher training.

Chapter 2. Statement of the problem

Educational Robotics (ER) resources are increasingly present in the field of education worldwide. However, ER has not yet been integrated into the formal school curriculum (Jaipal-Jamani & Angeli, 2017). In 2013, Alimisis (2013) shared the view that the curricula of European school systems gave no systematic introduction to robotics. Likewise, it has been reported that there is no systematic integration of robotics in the school curriculum in Russia (Ospennikova et al., 2015), and the formal US school curriculum does not embrace the integration of robotics "because of the heavy focus on standardized testing and pressure to cover academic standards set by the government and/or their States" Eguchi (2017) (p. 19). Eguchi suggests using activities that align with curriculum standards to bring robotics into formal education. Based on the numerous opportunities that ER offers for learning, developing skills and improving attitudes, integration into the formal curriculum would provide students with important gains. Scaradozzi et al. (2019) are in favor of integrating ER into the formal curriculum at early stages either as a separate curricular subject or as part of a broader subject. Kubilinskiene et al. (2017) recommend integrating ER activities into disciplines other than STEM such as language arts.

This thesis recognizes that applying ER activities at school can positively affect students' 21st century skills, knowledge across the disciplines, attitudes and interests in STEAM. A first step towards putting these activities into practice would be to provide pre- and in-service teachers with training opportunities in ER to equip them with the skills they require. The need for teacher training in ER has been underlined in previous studies (Chalmers, 2018; Hynes & dos Santos, 2007; Karim et al., 2015; Ntemngwa & Oliver, 2018). Anisimova et al. (2020) reveal the teachers' lack of readiness to implement STEAM educational programs with robotics and the literature shows that teachers are not always willing to make use of new digital technologies (DT) in their classrooms (Badia & Iglesias, 2019). Teachers sometimes lack knowledge about robot technology (Chalmers, 2018), or do not know how to integrate robotics into their teaching (Bers et al., 2013; Chalmers, 2018). This thesis suggests that ER training is necessary to ensure that teachers are familiar with the technical and pedagogical aspects of ER resources and to enable them to effectively introduce ER technologies into their formal curricular teaching.

Teachers play an important role in the integration of ER in education. They can influence the way ER is received by pupils (Hussain et al., 2006). Therefore, they must be made to feel comfortable with the introduction of ER into classroom practice (Karim et al., 2015). Together with the study of teachers' ability to successfully integrate these resources in the teaching process, research should also focus on teachers' perceptions in terms of acceptance and self-efficacy towards ER resources. Some studies examine teachers' perceptions of ER (Aksu & Durak, 2019; Karypi, 2018; Khanlari, 2013). This thesis suggests investigating teacher perceptions further and finding out their views and any changes they undergo after their participation in an ER training program. This study of teachers' responses to ER, their perceptions and self-efficacy could enrich current ER training initiatives.

Chapter 3. Research objectives and questions

The general objective of this thesis is to examine current Educational Robotics (ER) teacher training programs and study participants' perceptions and their ability to integrate ER in their teaching. This general objective is divided into three specific objectives that are related to the research questions (Figure 6). These specific objectives (SO), and the derived research questions (RQ) have structured the process of this study.

Figure 6. Research objectives and research questions

SO.1. To explore how teachers perceive the potential of Educational Robotics for students' acquisition of STEM and 21st century skills and how they view a possible integration of ER into the school curriculum.

RQ1: How do teachers perceive student learning with ER?

RQ2: How do teachers view the potential integration of ER into the Spanish compulsory curricula?

SO.2. To examine the characteristics of ER teacher training programs in the international literature and the best practices implemented.

RQ3: What are the characteristics of ER teacher training programs in terms of requirements, duration, trainer and trainee profiles, pedagogical approach, and gender perspective?

RQ4: What best practices for ER teacher training programs are documented in the literature?

SO.3. To study the impact of ER teacher training on participants' learning and perceptions of ER.

RQ5: To what extent are participants able to create ER teaching resources after participating in ER teacher training programs?

RQ6 To what extent does ER teacher training have an effect on participants' acceptance of ER?

RQ7: To what extent does ER teacher training have an effect on participants' self-efficacy in ER?

RQ8: What are the participants' perceptions of ER training programs?

RQ9: How do participants perceive their level of teacher digital competence (TDC)?

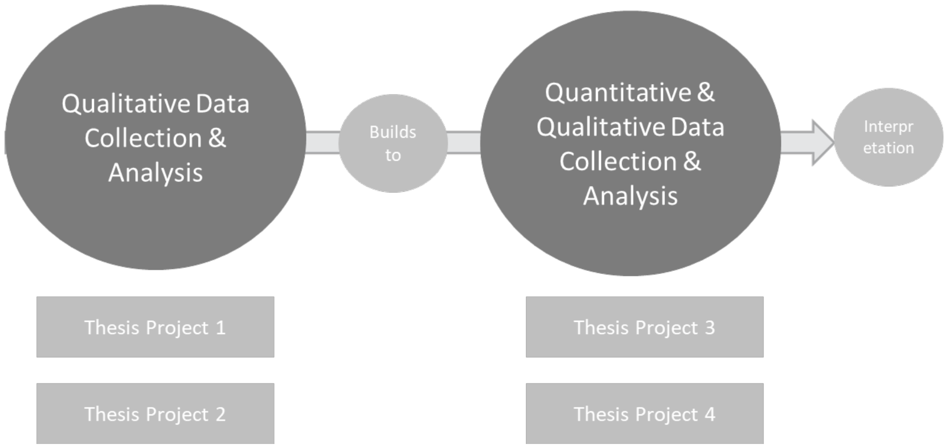
RQ10: To what extent is providing training in teacher digital competence related with participants' acceptance and self-efficacy towards ER?

Chapter 4. Research methodology

This thesis follows a pragmatic research approach, identifying a problem and viewing it within its broadest context and involving both qualitative and quantitative methods (Salkind, 2010). It has an exploratory sequential mixed method design as it first gathers qualitative data to explore a phenomenon and then collects quantitative data to explain the relationships found in the qualitative data (Creswell, 2012). To be more precise, in this thesis we view teachers' learning and perceptions of ER in teacher training as the central phenomena that need to be explored and understood (Creswell, 2002). In Thesis Project 1 & 2 (SO.1. & SO.2), qualitative data are collected to explore the phenomenon of teacher perceptions and teacher training in depth (Figure 7). After teacher perceptions of ER (SO.1.) and the characteristics of ER teacher training programs in current literature have been identified (SO.2.), a new ER teacher training program is designed. Then, in Thesis Project 3 & 4 (SO.3), the ER training program is implemented, and this enables both quantitative and qualitative data to be collected (Figure 7). According to Stebbins (2001) exploration is qualitative or quantitative, although the two are often mixed with qualitative being primary. The quantitative and qualitative results of the Thesis Project 3 & 4 (SO.3) are interpreted to explain the impact of the pilot and main teacher training program on teachers' learning and perceptions.

This chapter presents the context, sample, research instruments / techniques and research design of the individual thesis projects in the following subsections: 4.1 Research contexts and sample and 4.2 Research design, instruments, and techniques. Finally, in subsection 4.3 Content and structure of the teacher training programs, the two ER teacher training programs implemented at the Faculty of Educational Sciences and Psychology are presented in detail.

Figure 7. Exploratory sequential design in the thesis



Note. Adapted from *Educational Research* by Creswell, 2012, p. 541

4.1. Research contexts and sample

As explained in the previous section, every project of this thesis has its own characteristics and takes place in a different formal or informal context (Table 4). The contexts are briefly presented below.

Table 4. Overview of the context and sample of the thesis projects

Specific Objectives	Thesis Projects	Context Type	Research Context	Research Sample
SO.1.	Thesis Project 1	informal	FIRST® LEGO® League Competition, Regional - Tarragona Reus, Spain.	8 teachers & coaches of FIRST® LEGO® League Competition
SO.2.	Thesis Project 2	formal and informal	International literature in Educational Robotics.	38 publications
SO.3.	Thesis Project 3	formal	Course: Design of Educational Resources and Technological Environments for Training – Year 3 (6 ECTS). Bachelor's Degree in Pedagogy, URV.	21 university students
SO.3.	Thesis Project 4	formal	Course: Teaching and learning of the Experimental, Social and Mathematical Sciences III – Year 4 (6 ECTS). Bachelor's Degree in Preschool Education, URV.	90 university students

4.1.1. Thesis Project 1. Context and sample

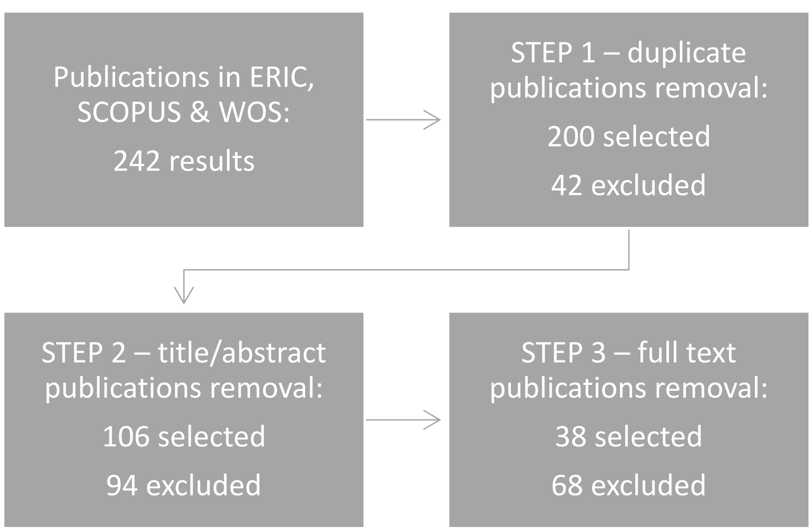
The first thesis project took place in the province of Tarragona (Catalonia, Spain) at the regional FIRST LEGO League Competition (FLL) Tarragona-Reus in 2019. The FIRST LEGO League Competition is an international competition for upper primary and secondary school, while its junior edition is for lower primary school students (FIRST LEGO League, 2020). Every year the FLL Competition has a theme, and in 2019 the competition was about space and called "INTO ORBIT" (FIRST LEGO League, 2020). In the competition, the teams compete in four categories: Robot Design, Core Values, Project, and Robot Game. The competition is international, and the participants are all assessed with the same criteria, while the winners of the local competitions have the chance to participate in bigger international competitions. The FLL competition evaluates teams in terms of participants' development of 21st century skills: communication, collaboration, social/ cultural skills, ICT literacy, creativity, critical thinking, problem solving and developing quality products (Usart et al., 2019). The participants positively perceive their involvement in the competition (Chalmers, 2013; Schina et al., 2020c) as it is an opportunity for learning about real word problems and for gaining skills in the STEM disciplines (Schina et al., 2020c).

The research sample consists of eight coaches whose teams participated in the FIRST LEGO League and FIRST LEGO League Junior Competition of Tarragona-Reus in 2019. The coaches are also schoolteachers (five in primary school and three in secondary school). Most participants have extensive teaching experience and are very familiar with Educational Robotics as they regularly conduct ER activities. The sample was a convenience one. Convenience sampling involves drawing the sample from the population that is close at hand and available/accessible at that time (Cohen et al., 2007). Due to this sampling technique and the limited sample, the results of the project cannot be generalized.

4.1.2. Thesis Project 2. Context and sample

The second project of this thesis was a systematic review of the international literature on teacher training programs in educational robotics. The sample of the study was determined by using the following search string in the search engines ERIC, Scopus and Web of Science: ("robot" OR "robotic" OR "lego") AND ("teacher training" OR "teacher education" OR "teacher development" OR "pre-service teacher" OR "in-service teacher" OR "trainee teacher" OR "practicing teacher" OR "practicing teacher"). The initial results from all three search engines yielded 242 publications, which were reduced to 38 after a process of selection (Figure 8). More specifically, the selection process took place as follows: after the duplicates had been removed (n=42), the publications were filtered on the basis of their title and abstract (n=94), and then some more publications (n=68) were excluded on the basis of their full text content. The criteria for excluding publications are presented in Table 5. The selection process yielded 38 publications for review and are the sample of Thesis Project 2.

Figure 8. Publication selection process for Thesis Project 2



Note. Adapted from Schina et al. (2020a)

Table 5. Exclusion criteria (EC) for Thesis Project 2

Exclusion criteria
EC1: The publication was considered out of context.
EC2: The publication is not a primary study but a synthesis that compares and contrasts studies by other researchers.
EC3: The publication is not in English.
EC4: The publication is not in a correct format.
EC5: The full text is not available.
EC6: The publication refers to teacher training programs on advanced technologies.
EC7: The publication does not provide sufficient information on the training program.

Note. Adapted from Schina et al. (2020a)

4.1.3. Thesis Project 3. Context and sample

The research was conducted in the context of the Bachelor's Degree in Pedagogy of the Universitat Rovira i Virgili. The participants were 21 third-year students enrolled on the course "Design of Educational Resources and Technological Environments for Training" in the first semester of the academic year 2019–2020. The average age of the students was M = 22.14 (SD = 2.65), ranging from 19 to 27 years old, and most of them were female (F=19, M=2). Almost half had had previous teaching experience in extracurricular activities, private classes, support tuition, etc. Six reported that they had had previous experience with Educational Robotics (ER) resources. All participants reported that they would be interested in learning how to integrate ER resources in school contexts.

4.1.4. Thesis Project 4. Context and sample

The research was conducted in the context of the Bachelor's Degree in Preschool Education at the Universitat Rovira i Virgili. The participants were university students in the fourth year of their degree and enrolled on the course "Teaching and Learning of the Experimental, Social and Mathematical Sciences III". The present research took place between February and April 2020 in the framework of the innovation project "INTROBOT" and offered participants a 6-hour training program in ER both on-site and online. There were 90 participants, and their average age was 22.9 (SD=1.985). All participants had had previous teaching experience as part of their university studies. The demographic profile of the participants is presented in Table 6. The convenience sample technique was used as it is a fast and economic way of sampling that allows easy access to available participants, although it fails to yield a representative sample of the target population (Cohen et al., 2007).

Table 6. Sample thesis. Project 4

	Participants	People (n)	Percentage (%)
Gender	Male	5	5.5
	Female	85	94.5
Interests	Participants interested in learning about ER	90	100
	Participants interested in learning how to apply ER in their teaching	90	100
Experience	Participants with prior contact with ER in their personal life	45	50
	Participants who used ER resources in educational contexts	47	52

Note. Adapted from Schina et al. (2021a)

4.2. Research design, instruments and techniques

Table 7. Research design/instruments/techniques per thesis project

Thesis projects	Research design	Research instruments/ techniques
Thesis Project 1	Qualitative research design	1. Teacher Views Questionnaire
Thesis Project 2	Qualitative research design	1. Systematic literature review technique
Thesis Project 3	Quantitative & Qualitative	1. Project Evaluation Rubric (version 1) 2. Lesson Plan Template 3. COMDID-A Questionnaire 4. Acceptance of ER Pre/Post Questionnaire 5. Self-efficacy towards ER Pre/Post Questionnaire
Thesis Project 4	Quantitative & Qualitative	1. Project Evaluation Rubric (version 2) 2. Lesson Plan Template 3. COMDID-A Questionnaire 4. Acceptance of ER Pre/Post Questionnaire 5. Self-efficacy towards ER pre/post Questionnaire 6. Participants’ Training Journals

4.2.1. Thesis Project 1. Research design, instruments and techniques

The objective of Thesis Project 1 was to examine how teachers perceive the development of students’ skills/learning through ER and their views on the integration of ER in the school curriculum. The research design was qualitative, and the variables were teacher views on students’ skills, teacher views on students’ learning of programming and engineering, and teacher views on ER integration into the formal school curriculum. The research instrument implemented was the Teacher Views Questionnaire, based on the questionnaire by Theodoropoulos et al. (2017). It was translated into Spanish and adapted to the research context of the FIRST LEGO League Competition. The Teacher Views Questionnaire can be found in Appendix A. The questionnaire was sent to the coaches of the FIRST LEGO League Competition by the organizers as soon as the competition finished to collect information on coaches’ demographic data, competition preparation and participation data, their views on students’ acquisition of programming and engineering skills/learning with ER and their views on ER integration into the formal school curriculum. The data collection procedure complied with the General Data Protection Regulation—EU (GDPR).

4.2.2. Thesis Project 2. Research design, instruments and techniques

The research design of Thesis Project 2 was qualitative. The literature review followed three steps (Kitchenham, 2004): planning, conducting, and reporting the review. The information extracted from the 38 publications was entered into a database in Excel and grouped in three main themes (Appendix B). Firstly, information was extracted about the publication itself (title, date and authors of the publication). Secondly, information was extracted about the characteristics of the teacher training programs (duration, requirements, trainees' and trainers' profile, pedagogical approach and gender perspective). Thirdly, information was extracted about authors' best practices in ER teacher training studies addressing the second research question. A qualitative synthesis was implemented to synthesize the information collected in the database.

4.2.3. Thesis Project 3. Research design, instruments and techniques

Thesis Project 3 had a qualitative research design. The general aim of this thesis project was to evaluate participants' learning and perceptions of ER after their participation in an ER training program. To evaluate participants' learning, the following instruments were created: i) Project Evaluation Rubric and ii) a Lesson Plan Template. To evaluate participants' perceptions, the following instruments were adapted and implemented: i) the COMDID-A questionnaire for participants' self-perceptions of their digital competence, ii) the Acceptance of ER Pre/Post Questionnaire, and iii) the Self-efficacy towards ER Pre/Post Questionnaire.

First, the instruments used to assess participants' learning will be presented. Regarding the Project Evaluation Rubric (version 1), it comprised of 8 Likert items and was used to assess the ER projects/lesson plans created by the training participants. It evaluated the projects' sustainable development content, learning objectives, interdisciplinarity, project description, and teaching material design. There was one item on the content of sustainable development (C1), two items on learning objectives (OA1 and OA2), one on interdisciplinarity (I3), three on lesson plan description (DPS1, DPS2, and DPS3), and one on teaching material design (MD1). This instrument can be consulted in Appendix C. The rubric evaluation scale ranged from 0 (inadequate) to 3 (very good). As far as the lesson plan template is concerned, the trainees had to provide information on the content and structure of the activity including its duration, age of targeted audience, teaching materials, research objectives, interdisciplinary content, description of the activities and evaluation activities (Appendix D). To assess the projects, the 360 Evaluation method was chosen, and the teacher (teacher evaluation), students (self-evaluation) and fellow students (peer evaluation) were asked to perform the evaluation.

For participants' perceptions, the COMDID-A (Lázaro & Gisbert, 2015) was used to measure theirelf-perception of teacher digital competence (TDC) and was implemented as soon as the ER training had been completed. This instrument (i-DEPOT registration number 116248) measures teachers' perceptions of their own TDC, divided into four factors or dimensions (1. Didactic, curricular and methodological aspects; 2. Planning, organization and management of digital technological resources and spaces; 3. Relational aspects, ethics and security; 4. Personal and professional aspects) (Lázaro & Gisbert, 2015). In addition, the Acceptance of ER Pre/Post Questionnaire was used to collect information on training participants' acceptance of ER before and after the training program. It was adapted from the TAM Diagnostic instrument (Davis, 1989) and, more precisely, from the Spanish version "Instrumento de diagnóstico del TAM" (Cabero & Perez, 2018). It was structured in five sections and the 7-point Likert scale ranged from Totally Disagree to Totally Agree. There were 15 items which were organized as follows; four items on ER usefulness (U1-U4), three items on ER ease of use (F1-F3), three items on ER enjoyment (D1-D3), three items on attitudes towards ER use (A1-A3) and two items on intention to use (I1-I2). The questionnaire items are provided in Appendix E in the original language, Spanish. The pre-questionnaire was given to participants in the first session in which the Blue-bot robotic toy was used, while the post-questionnaire was administered in the last session. Finally, participants' self-efficacy was assessed with the Self-efficacy towards ER Pre/Post Questionnaire, which assessed their ability to make efficient use of ER in the classroom as a teaching resource (Q1-Q6). This questionnaire was adapted from Jaipal-Jamani and Angeli's Self-efficacy for Teaching Robotics Questionnaire (2017) and presents a 5-point Likert scale ranging from Totally Disagree to Totally Agree. The questionnaire can be consulted in Appendix F in the original language, Spanish. The pre-questionnaire was administered to participants in the first session and the post-questionnaire in the last session.

In all cases the data collection procedure complied with the General Data Protection Regulation—EU (GDPR). The students agreed to participate in this research. To ensure respondents' anonymity in all questionnaires and data protection, trainees' names were deleted from the database and changed to "trainee n" identifiers.

4.2.4. Thesis Project 4. Research design, instruments and techniques

Thesis Project 4 had a quantitative research design. The general aim of this thesis project was to evaluate participants' learning and perceptions of ER after their participation in an ER training program. To evaluate participants' learning, the following instruments were created: i) Project Evaluation Rubric (Version 2) and ii) a Lesson Plan Template. To evaluate participants' perceptions, the following instruments were implemented: i) the Acceptance of ER Pre/Post Questionnaire, and ii) the Self-efficacy towards ER Pre/Post Questionnaire, and iii) Participants' Training Journals.

To assess trainees' learning, a Lesson Plan Template and a Project Evaluation Rubric were used. The Lesson Plan Template was the same as the one implemented in Thesis Project 3, while the Project Evaluation Rubric from Project 3 was modified before use. The evaluation rubric (Version 2) in Appendix G consists of 10 Likert items assessing the following aspects of the ER lesson plans: disciplinary content (flora & fauna), learning objectives, activity description, teaching material design and use of resources.

In the evaluation rubric there was one item on content (C1), two items on learning objectives (OA1 and OA2), three on lesson plan description (DPS1, DPS2, and DPS3), three on teaching material design (MD1 and MD2) and two items on the Blue-bot robotic toy (UB1-UB2). The assessment scale ranged from 0 (inadequate) to 3 (very good) and the 360 Evaluation method was selected as in Thesis Project 3. The second version of the Project Evaluation Rubric was created to adapt to the context of Thesis Project 4, to clarify some items by adding details and providing examples, and to improve the overall evaluation process. The categories of the items in the first and second version of the Project Evaluation Rubric are compared in Table 8, while the exact rubric evaluation items are presented in Appendix C (Version 1) and G (Version 2).

Table 8. Project evaluation rubric. Version 1 & 2

	Project evaluation rubric items									
	I1	**I2**	**I3**	**I4**	**I5**	**I6**	**I7**	**I8**	**I9**	**I10**
Version 1	Content	Learning objectives		Interdi-sciplinarity	Activity description			Teaching material design		
Version 2	Content	Learning objectives		Activity description			Teaching material design		Use of resources	

The Acceptance of ER Pre/Post Questionnaire, the Self-efficacy towards ER Pre/Post Questionnaire from Project 3 and the COMDID-A questionnaire were implemented with no changes to assess trainees' perceptions. In addition, to collect information on trainees' perceptions of the training program, they were asked to complete their training journals after they completed every training session. The training journals included prompts that the trainees had to reflect on and complete with their own experience and views. The content of the training journals is summarized below in Table 9, while the training journals prompts are provided in Appendix H. The content of the journals was subject to peer review, with two of the researchers first identifying the key codes and then proceeding to codify the journals. When there were discrepancies between the two researchers' codification, a third researcher was asked to solve the problem.

Table 9. Content of the training journals. Session 1-3

Content of the training journals		
Session 1	Session 2	Session 3
1. Previous knowledge of ER 2. Learning outcomes of the session 3. Opinions on the session 4. Self-efficacy 5. Potential of ER	1. Opinions on the session 2. Self-efficacy 3. Potential of ER	1. Previous knowledge of 360 Evaluation 2. Opinion on 360 Evaluation 3. Opinion on the session 4. Self-efficacy 5. Potential of ER 6. Opinion on the training 7. Aspects to improve in the training

4.3. Description of the ER teacher training programs

In the framework of the present thesis two ER teacher training programs were designed and implemented at the Faculty of Education of the Universitat Rovira i Virgili during which the trainees' learning and perceptions were examined. These two ER teacher training programs constitute Thesis Project 3 and 4, which will be presented in detail in the following two subsections. A summary of the training programs is provided in Table 10.

4.3.1. ER teacher training program. Project 3

The ER training took place as part of the course "Design of Educational Resources and Technological Environments for Training" on the Bachelor's Degree in Pedagogy in the winter semester of the academic year 2019–2020 at the Universitat Rovira i Virgili. The aim of the course is to provide students with tools to design educational resources, collaborative work environments, and virtual teaching-learning environments and use them appropriately in the teaching process. The ER training program consisted of four 4-h sessions which took place from mid-November to mid-December 2019. The purpose of the training was to reinforce trainees' digital skills; familiarize them with different ER resources, visual programming interfaces and basic concepts of programming; and enable them to design interdisciplinary instructional material for the use of ER resources and visual programming interfaces in educational contexts.

In each session, the students were introduced to a programming or robotics resource that was new to them and took part in several hands-on activities. In the first session, the trainees were introduced to basic programming concepts using the Scratch visual programming interface, completed programming tasks of graded difficulty, and were instructed on the potential of programming for developing students' creative thinking, computational thinking, and collaboration skills. In the second session, the trainees built on their previous experience with Scratch and completed additional programming challenges individually and in pairs. Then, the trainees were introduced to the Edison robot, programming interfaces, functionalities and their application in teaching. The trainees completed some tasks with the Edison robot in teams (e.g., car race, tracking lines, disco party, maze, etc.). In the third session, the trainees explored the functionalities of the Blue-bot robotic toy, took part in tasks in groups and were instructed on the potential use of the robotic toy in different areas of the curriculum by experimenting with instructional material developed by the teacher/researcher (interdisciplinary Blue-bot project on gender stereotypes). After that, there was an invited talk on STEM and STEAM education, skills, activities, and methodologies delivered by a technology teacher with extensive teaching experience in educational robotics, programming, and electronics in secondary school. Finally, the trainees were asked to create interdisciplinary instructional material associated with different sustainable development goals (SDGs) in groups using the Blue-bot robotic toy. The groups were assigned to work on the following sustainable development goals in different educational contexts:

1. A group of trainees were assigned to design instructional material to raise awareness among lower primary school students about poverty and hunger in developing countries.
2. A group of trainees were assigned to design instructional material to promote social, financial and political inclusion among teenagers attending a course at a youth center.
3. A group of trainees were assigned to design instructional material to raise awareness among special needs students about marine pollution in a special education institution.
4. A group of trainees were assigned to design instructional material for kindergarten pupils on the importance of protecting the fauna.
5. A group of trainees were assigned to design instructional material to instruct primary school pupils on good practices for saving water.

In the fourth ER teacher training session, the trainees presented the instructional material they had created, their peers experimented with it and evaluated their work by completing the Project Evaluation Rubric (see section 4.2.3). After the presentations, the trainees were introduced to Scratch Jr, explored the interface, created animations, and discussed its characteristics and use. The content and structure of the training activities were based on constructionism and project-based learning and the trainees were immersed in a hands-on and collaborative environment promoting exploration, experimentation and reflection. The objective of the training was to provide trainees with technical skills on educational robotics and programming, and pedagogical knowledge on how to integrate ER across different areas of the curriculum.

4.3.1. ER teacher training program. Project 4

The ER training was part of the course "Teaching and Learning of the Experimental, Social and Mathematical Sciences III" in the Bachelor's Degree in Preschool Education in the spring semester of the academic year 2019–2020 at the Universitat Rovira i Virgili. The training was conducted from the end of February to the beginning of April 2020 and lasted 6 hours in total. Students from two campuses of the Universitat Rovira i Virgili participated in the training: there were two groups of trainees on the Sescelades Campus on the outskirts of the city of Tarragona and one group of trainees on the Baix Penedès Campus in Coma-ruga -El Vendrell. The training started on-site but due to the COVID-19 pandemic the last session had to take place online. The training program was based on constructionism and project-based learning. The content and structure of the training is presented below.

In the first session the trainees were introduced to the most widely used educational robotics resources, especially the ones used in preschool education. In particular, they were introduced to computational thinking, programming and key concepts such as algorithms, sequencing, debugging and the Blue-bot robotic toy and its functions. The trainees experimented with the Blue-bot in groups by conducting scaffolded programming exercises and then they moved on to work with Blue-bot instructional materials and familiarize themselves with the interdisciplinary use of Blue-bot in preschool education. In the second session the trainers provided recommendations on the design of instructional materials with the Blue-bot robotic toy and presented the project assignment for the completion of the training program. The project assignment consisted of creating a Blue-bot project for preschool pupils on the following topic: "Vegetation and/or Wildlife in the region of Catalonia in Spain". After the presentation of the assignment, the trainees brainstormed the content and structure of the Blue-bot project in groups. The trainees had a whole month to work on the Blue-bot project and the accompanying lesson plan and the teaching materials. In the third session, which had to take place online because of the COVID-19 pandemic, the trainees shared a video presentation of their projects and the Lesson Plan Template that included the learning objectives, procedure, description of activities and teaching materials designed. The trainees watched the other groups' presentations asynchronously and went on to give a peer and self-evaluation of the projects.

Table 10. Summary of the ER teacher training programs implemented in URV

	ER TEACHER TRAINING PROGRAM – THESIS PROJECT 3	**ER TEACHER TRAINING PROGRAM – THESIS PROJECT 4**
CONTEXT	"Design of Educational Resources and Technological Environments for Training" course, Bachelor's Degree in Pedagogy, URV	"Teaching and learning of the Experimental, Social and Mathematical Sciences III" course, Bachelor's Degree in Preschool Education, URV
PLANNING	Winter semester, academic year 2019–2020	Spring semester, academic year 2019–2020
SESSION 1	-Introduction to basic programming concepts using the **Scratch** visual programming interface -Completion of graded-difficulty tasks -Discussion on the acquisition of skills through educational robotics and programming	-Introduction to ER, programming and computational thinking, and presentation of ER resources for preschool education -Experimentation with **Blue-bot robotic toy**, classroom projects and teaching materials
SESSION 2	-Completion of programming challenges individually and in pairs with **Scratch** -Introduction to the functionalities, interfaces, and use of **Edison** in teaching and completion of graded-difficulty tasks	-Suggestions on the design of classroom activities with the Blue-bot robot -Presentation of the project assignment -Brainstorming in groups on the project assignment
SESSION 3	-Introduction to the **Blue-bot robotic toy**, its functionalities and potential use in teaching and completion of tasks -Invited talk on STEM and STEAM Education -Presentation of the project assignment	-Presentation of the Blue-bot projects and evaluation
SESSION 4	-Presentation of the Blue-bot projects and evaluation -Presentation of **Scratch Jr**, exploration of the interface, creation of animations, discussion of its characteristics and use	

Chapter 5. Results and discussion

In this chapter the results obtained will be presented from a broader perspective and juxtaposed to the outcomes of previous studies in the field. The results of this PhD thesis can be found in the respective publications (see section Compendium of Publications) and will be presented in the sections below by research objective (SO.1., SO.2. & SO.3.). They are summarized at the end of this chapter in section 5.4.

5.1. Explore how teachers perceive the potential of Educational Robotics for students' acquisition of STEM and 21st century skills and how they view a possible integration of ER into the school curriculum (SO.1)

This thesis started by studying teachers' perceptions of Educational Robotics in the framework of a robotics competition (Thesis Project 1) presented in the publication Schina et al. (2020d). To address SO.1., the teachers whose students participated in a robotics competition were asked about the potential of robotics for developing their students' skills and the integration of robotics into the school curriculum. The teachers reported that through their involvement with Educational Robotics students gain skills in problem-solving, collaboration, creativity, discipline and presenting as well as programming knowledge. In similar studies in previous literature, teachers seem to have a positive perception of their students' involvement with robotics. For example, in the research by Khanlari and Kiaie (2015) and Khanlari (2019), primary school teachers expressed their belief that ER might have a positive effect on their students' learning of science and technology-related topics. In particular, Khanlari pointed out that teachers viewed robotics as a means to facilitate the learning of science as it promotes the student process of scientific inquiry, supports the development of skills for initiating and planning, performing, and recording, and analyzing and interpreting, and improves technology literacy in schools (Khanlari). Primary school teachers also believe that robotics has a positive impact not only on science and technology but also on students' mathematical skills, mathematical reasoning and problem-solving

(Khanlari, 2019). Teachers' positive views on students' problem-solving skills are also reflected in this thesis. Similarly, in Theodoropoulos et al. (2017) teachers report that through ER students develop their problem-solving, creativity and collaboration skills. Positive teacher views regarding students' development of collaboration and creativity through ER are also found in the research by Pina and Rubio (2017). Furthermore, as far as programming is concerned, the results of our study demonstrate that teachers in this sample have a positive perception of their students' learning outcomes in the area of programming. Nevertheless, this does not apply to engineering skills, for which teachers have a less positive perception. Interestingly, the research by Theodoropoulos et al., with whom this research shares a different version of the same questionnaire, provides similar findings. And last but not least, we found that as well as developing skills, teachers think that their students may develop an interest in technology and robotics. This was also pointed out in Khanlari who found out that teachers consider that using robotics will have a positive impact on students' attitudes about STEM disciplines and may encourage them to pursue an education and a professional career in STEM-related fields.

The results of this thesis show that teachers positively perceive the integration of ER into the school curriculum from early educational levels, which is in line with several recent studies proposing that robotics be integrated into the school curriculum, for example, as a part of disciplinary courses (Bernstein et al., 2020), and that CS and robotics be integrated into the curriculum in primary school (El-Hamamsy et al., 2020). However, these changes in the school curricula would raise additional challenges in terms of teacher education and professional development, infrastructure, materials, and time constraints (El-Hamamsy et al). In addition, according to Bacconi et al. (2016), integrating ER into the curriculum would require teachers to share good practices and build a teacher community. This thesis shows that there is a need for professional development, and particularly teacher training, if ER is to be integrated into the curriculum.

The following section presents the results for SO.2.

5.2. Examine the characteristics of ER teacher training programs in international literature and best practices implemented (SO.2)

Implementing important changes in the educational system such as the integration of robotics in the school curriculum would require the educational community to invest time and effort in teacher training. This thesis is in line with previous studies that have pointed out the importance of teacher training if robotics is to be integrated in education (Kradolfer et al., 2014; Chevalier et al., 2016; Balanskat et al., 2017; Jaipal-Jamani & Angeli 2017). This integration into the formal school curriculum calls for largescale professional development programs and for educational robotics to be included in all teacher education programs at university. As a first step in this direction, the present study proposes the study of previously implemented teacher training programs. To address SO.2., a literature review is conducted (Thesis Project 2) to investigate previously implemented ER teacher training programs and to study their characteristics (Section 5.2.1.) and best practices (Section 5.2.2.).

5.2.1. Characteristics of the teacher training programs

The following aspects of previously implemented teacher training programs have been included in the literature review: i) requirements, ii) duration, iii) trainees' profile, iv) trainers' profile, v) pedagogical approaches, and vi) gender perspective. The findings will be summarized below, although details can be found in the respective publication (Schina et al., 2020a) of this compendium. The overview of the characteristics of ER teacher training programs is provided in Table 11.

Table 11. Overview of the characteristics of ER teacher training programs

Main characteristics	Classification			
Requirements	1. Teacher training programs with no requirements	2. Teacher training programs with a final project requirement	3. Teacher training programs with a teaching practice requirement	
Duration	1. Minimum duration training programs (only one day)	2. Short training programs (between 2-5 days and/or 5-19 hours)	3. Medium training programs (over 5 days and/or 20-39 hours)	4. Long programs (over 39 hours)
Trainees' profile	1. Pre-service / in-service teachers	2. Different background (technology, STEM or other)	3. Different experience in programming	4. Majority of trainees are women
Trainers' profile	1. University professors	2. Invited experts	3. Training assistants	
Pedagogical approach	1. Often there is no pedagogical approach	2. Constructivist/ constructionist pedagogy	3. Inquiry-based learning	4. Discovery learning approach
Gender perspective	1. Gender perspective in the content of the training	2. Gender perspective in the analysis of the outcomes		

Note. Adapted from Schina et al. (2020a)

First, the requirements of the teacher training programs' will be presented. These requirements have a direct impact on trainees' involvement with ER, their time commitment and, therefore, their learning. Interestingly, it was observed that only half of the studies in this literature review set requirements for the program's completion: 11 require a final project and 8 teaching practice. The final project requirement could be either to design a robot (Kucuk & Sisman 2018; Sisman & Kucuk 2019) or write some instructional material (Agatolio, 2017; Castro et al., 2018; Gilkes et al., 2014; Kim, 2012; Kim et al., 2015; Nagchaudhuri & Madhumi, 2007), while the teaching practice requirement usually adapts to trainees' daily teaching practice for in-service teachers and to the curricular work experience for pre-service teachers. This lack of requirements raises questions regarding participants' learning, the accomplishment of objectives and effectiveness of the training programs.

The duration of the training programs is observed to vary substantially from study to study. Despite the fact that information on the total amount of the training hours, attendance hours, teaching practice hours, time-commitment is sometimes missing, this literature review attempted to classify the training programs on the basis of time commitment: a) minimum duration training programs (only one day), b) short training programs (between 2-5 days and/or 5-19 hours), c) medium training programs (over 5 days and/or 20-39 hours), d) long programs (over 39 hours), and e) no clear information on the duration of the training programs. The effectiveness of minimum duration training programs (Major et al., 2011; Nagchaudhuri & Madhumi, 2007; Zhou et al., 2015) is questioned; not only do they last a very short time, they also do not set any kind of requirements apart from attendance. For greater impact on trainee learning and perceptions, longer training programs are needed with requirements other than attendance and involvement in workshop activities.

In terms of profile, the trainees are either pre-service teachers attending a university course or in-service teachers who work in preschool, primary or secondary education. Interestingly, teacher training programs for pre-school teachers (Bers et al., 2002; Bers et al., 2013; Caballero-González & Muñoz-Repiso, 2017) and special education personnel (Conchinha, 2015) seem to be less common. The trainees' programming experience and background differs substantially. In some programs, the participants are technology teachers/teacher candidates (von Wangenheim et al., 2017; Major et al. 2011), teachers of STEM subjects (Goodale, 2013; Kay & Moss, 2012; Nagchaudhuri & Madhumi, 2007), or from other disciplines (Gilkes et al. 2014; Leonard et al. 2017; Scaradozzi et al. 2019). In most of the training programs, female trainees outnumber males.

As far as the trainers are concerned, in teacher education programs the trainer-in-charge is usually a university professor with a background in ER, pedagogy and/or technology. In some cases, there is more than one trainer. For example, in Angeli and Jaipal-Jamani (2018) and in Jaipal-Jamani and Angeli (2017), there are two trainers with complementary profiles. In some training programs, experts are invited (Hynes and dos Santos, 2007; Kaya et al., 2017). Also important is the contribution of the training assistants who support the participants throughout the training (Chambers and Carbonaro, 2003; Kay & Moss, 2012).

Not all programs have a well-defined pedagogical approach. Several studies in our sample were clearly not grounded on any pedagogical approach (Caballero-González and Muñoz-Repiso 2017; Kay and Moss 2012; Major et al. 2011; Gilkes et al. 2014; Nagchaudhuri & Madhumi, 2007). The teacher training programs which are based on a pedagogical approach or theory are most commonly grounded on the constructivist/constructionist pedagogy (Agatolio et al. 2017; Alimisis 2014; Alimisis 2019; Bers and Portsmore 2005; Chambers and Carbonaro 2003; Negrini 2019; Scaradozzi et al. 2019; Sisman and Kucuk 2019), inquiry-based learning (Hadjiachilleos et al. 2013; Hodges et al. 2016; Jaipal-Jamani and Angeli 2017; Zhou et al. 2015), or discovery learning (Sullivan & Moriarty, 2009), and learning by design (Alimisis et al. 2009).

Finally, few training programs integrate the gender perspective in the content of the program and the analysis of their outcomes. One of the training programs that did incorporate this perspective in the content of the program was the study by Hynes and dos Santos (2007), who invited two experts, one to deliver a workshop on inclusiveness and bias towards girls in Engineering Design Process and the other to present strategies for recruiting and retaining females in STEM programs. In addition, in some programs, gender plays an important role in the analysis of research data. For instance, in the training program of de Santos et al. (2016), trainees' intention to use robotics simulations in education was studied in conjunction with gender, among other variables. Similarly, in Agatolio et al. (2017) trainees' gender was studied as a variable influencing trainees' attitudes towards educational robotics. Finally, Bredenfeld and Leimbach's training program (2010), based on gender, proposed the use of gender-balanced didactic materials in robotics activities and aimed to raise girls' interests in technical topics and boost their presence in engineering jobs.

In this section, the characteristics of the previously implemented ER teacher training programs have been summarized. The next section will focus on the best practices applied in all training programs.

5.2.2. Best practices in ER teacher training programs

This literature review identified the best practices in ER teacher training and organized them into five categories: collaboration, materials, pedagogy, practice, and feedback/support. The best practices will be summarized in the following paragraph, while more details can be found in the respective publication (Schina et al., 2020a). The best practices emerge from the quality of the evidence from the teacher training programs in the literature review and are defined in Table 12.

Table 12. Definitions of best practices for ER teacher training

Best practice	Definition
Collaboration	Collaboration among trainees takes place during and after the training in a non-competitive atmosphere without panic and stress, including teacher observation, sharing of ideas, and building of a teacher community.
Materials	Upon completion of the training, trainees have at their disposal i) the robots used in the training ii) instructional materials for classroom use that were produced during the training or are part of a database of ER activities.
Pedagogy	Trainees are instructed in both the technical and pedagogical aspects of ER including programming/engineering concepts, pedagogical frameworks, innovative didactic methodologies, and classroom management instruction.
Practice	Trainees put their technical and pedagogical knowledge into practice and implement ER activities in educational institutions.
Feedback & support	Trainees receive feedback and support from the trainers both during the training and after its completion, when they implement ER activities at school.

Note. Adapted from Schina et al. (2020a)

The study of previously implemented teacher training programs was a key step throughout this thesis as it enabled us to proceed to the following steps of the research: the design and implementation of teacher training programs at the Universitat Rovira i Virgili (see section (5.3)).

First, the publications in our sample highlight the significance of participants collaborating. Participants' collaboration can occur during the training (Agatolio et al., 2017; Conchinha, 2015; Scadarozzi et al., 2019), or after the training; the participants can collaborate to implement ER activities at their school (Hynes & dos Santos, 2007). The teacher training programs should be conducted in a non-competitive atmosphere without panic and stress (Kucuk & Sisman, 2018), while teachers should observe each other during ER activities so that they can improve their teaching approaches and share their struggles and successes (Hynes and dos Santos, 2007). Observing how colleagues integrate STEM content in robotics activities might also help them improve their lesson design (Kim et al., 2015). Collaboration among teachers may expand even further into a teacher community for sharing opinions, ideas, and materials (Alimisis et al., 2009; Alimisis 2014; Hamner, Cros & Zito 2016). Another best practice identified was to provide teachers with robotics and instructional materials for classroom use after the training. Alimisis et al. (2009) and Riedo et al. (2012) argue that teachers should be given robotics kits for use with their students in their classroom teaching. This would facilitate future application of ER activities in classrooms (Castro et al. 2018; Hamner et al., 2016; Negrini 2019). In addition, teachers could use the training time to design the ER activities that they will implement later in class (Hamner et al., 2016) and contribute to the creation of a database of educational robotics activities (Negrini, 2019). The third best practice was pedagogy; ER teacher training programs should include instruction in the pedagogical aspects of ER (Kim et al., 2012). In their training program (2018), Castro et al. went much further than using robots in educational settings; the teachers were instructed in pedagogical and learning theories, were shown exemplary ER activities, and were assigned a project. Similarly, in the training presented by Scaradarozzi et al. (2019), the participants were instructed in pedagogical frameworks for ER activities and innovative teaching methodologies. In addition to technical and pedagogical knowledge, teachers should be trained on how to deal with issues that may come up in their classes in the future (for example, classroom management during ER activities) (Morgan & dos Santos, 2007). Another best practice that should be implemented in ER teacher training is that teachers should be encouraged to put the technical and pedagogical knowledge acquired during the training program into practice (Agatolio et al. 2017; Kim et al. 2015). Teachers could make use of the new resources and materials in the teaching process by implementing ER activities in their schools (Hynes & dos Santos, 2007) or by participating in outreach robotic activities (Gilkes et al., 2014). Finally, the last best practice in ER teacher training programs is to support the instructors/ researchers both during the training and after its completion. Trainees should receive feedback and support during the training (Hamner et al., 2016) and also during the ER activities at school (Negrini, 2019).

As explained above, the literature review revealed that the best practices for ER teacher training programs fall into these five categories: collaboration, materials, pedagogy, practice, and feedback/support. The best practices which were identified in this thesis share some aspects of the "basis for a professional teaching–learning community" established by Muñoz-Martínez et al. (2021). The common ground between them is the collaboration and coordination between teachers. Muñoz-Martínez et al. (2021) underline that "collaboration of teachers enriches their practice, increases the diversity of support proposals, increases the sense of responsibility for the learning of all students" (p.13). In addition, Laats (2020) suggests the following good practices for teacher training: incorporating more practical assignments and active learning methods, inviting practitioners to speak, and creating opportunities for discussion and deeper thinking. Laats' (2020) recommendation for integrating more practical assignments is in line with the best practice "putting the technical and pedagogical knowledge acquired into practice" identified in this study. El-Hamamsy et al. (2020) further elaborates on this by pointing out that teachers should be instructed on how to integrate content into the curriculum efficiently and proposing the complementary view that "teachers' representation of CS and Robotics must be addressed in professional development programs" (p. 6). This means that in computer science and robotics teacher training programs, the concepts, ideas, and benefits of technologies should be demystified, thus helping to improve teachers' attitudes towards CS and robotics. Finally, El-Hamamsy et al. (2020) highlight three components that should be considered in pilot teacher training initiatives in the field of CS and robotics: (1) the curriculum, (2) resources and (3) assessment methods. Best practices associated with the curriculum and resources have been mentioned in this thesis (see materials' section), but assessment methods have not. Therefore, the views expressed by El-Hamamsy et al. (2020) on assessment methods would be a good addition to the results of this study.

5.3. Study the impact of ER teacher training on participants' learning and perceptions of ER (SO.3)

The knowledge and experience acquired by studying the characteristics of ER teacher training programs (Table 11) and best practices (Table 12) allowed us to draw up two training programs that were implemented at the Universitat Rovira i Virgili (Table 10). The learning outcomes of the two training programs and participants' perceptions will be presented separately in the two sections below (5.3.1 and 5.3.2).

5.3.1. Participants' learning in pilot and main teacher training program

This section presents the learning outcomes of the two training programs. The detailed results regarding trainees' learning can be found in Schina et al. (2020b) for the pilot training program implemented in the Bachelor's Degree in Pedagogy and in Borrull et al. (2020a) for the main training program implemented in the Bachelor's Degree in Preschool Education. To evaluate trainees' learning, the trainees were asked to develop an ER project to be used at school. As in Kim et al. (2015), a rubric was designed by the researchers to facilitate the evaluation of the trainees' projects. A sample of projects is presented in Figure 9 and Figure 10. In the pilot training (Thesis Project 3), the projects designed were related to the sustainable development goals (Figure 9) while in the main training (Thesis Project 4) the trainees' projects were on the topic of the flora and fauna of Catalonia (Figure 10).

Figure 9. Sample of trainees' projects. Thesis Project 3

Note. Adapted from Schina et al. (2020b)

Figure 10. Sample of Trainees' Project. Thesis Project 4

Trainees' learning outcomes in the pilot and main training programs were considered positive as the ER projects the trainees designed received positive evaluations. Table 13 shows the evaluation results of the pilot training program implemented in the Bachelor's Degree in Pedagogy while Table 14 presents the evaluation results of the main training program implemented in the Bachelor's Degree in

Preschool Education. The projects were evaluated from three perspectives: self-evaluation (SE), peer evaluation(PE) and teacher evaluation (TE). The project evaluation results indicate that in both training programs the trainees' perception of their own work is more positive than the perception of their peers and teacher. Self-evaluation gives the highest results and teacher evaluation the lowest.

Regarding the pilot training program (Thesis Project 3), all five groups of trainees designed the project at a satisfactory level. According to the self-evaluation, the trainees considered that they did very well, particularly in the lesson plan description, teaching material design and content. According to the peer-evaluation, the weakest aspect of the lesson plan was the learning objectives. Finally, according to the teacher evaluation, the areas that needed improvement were the lesson plan description and interdisciplinarity, while the aspect of the lesson plan that the teachers considered to be really good was the material design.

Regarding the main training program (Thesis Project 4), all twenty-seven groups of trainees also carried out the projects satisfactorily. In self-evaluation, the trainees considered that they did very well in all areas but in particular in the content and objectives, while they considered that they needed to improve in the area of activity description. According to peer-evaluation, the strongest aspect of the project was the content while the weakest was the design of teaching materials. In teacher evaluation, the strongest aspect was the content, and the weakest was the description of activities. As can be seen, there is consensus that content is the strongest aspect of the projects across all three evaluation perspectives. However, only self and teacher evaluation converge in viewing the description of activities as the weakest aspect. The results are presented in Figure 11.

Table 13. Evaluation of trainees' projects. Thesis Project 3

	Content	Learning objectives		Interdisciplinarity	Activity description			Material design
	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8
SE	2.80 (SD=0.45)	2.60 (SD=0.55)	2.80 (SD=0.45)	2.60 (SD=0.55)	3.00 (SD=0.00)	2.80 (SD=0.45)	2.60 (SD=0.55)	2.80 (SD=0.45)
PE	2.35 (SD=0.49)	2.35 (SD=0.38)	1.95 (SD=0.93)	2.15 (SD=0.42)	2.35 (SD=0.29)	2.15 (SD=0.60)	2.30 (SD=0.45)	2.25 (SD=0.59)
TE	2.40 (SD=0.35)	2.20 (SD=0.37)	2.12 (SD=0.33)	2.08 (SD=0.30)	1.96 (SD=0.46)	2.08 (SD=0.33)	2.04 (SD=0.68)	2.64 (SD=0.33)

**SE= self-evaluation, PE= peer evaluation, TE= teacher evaluation*

Note. Adapted from Schina et al. (2020b)

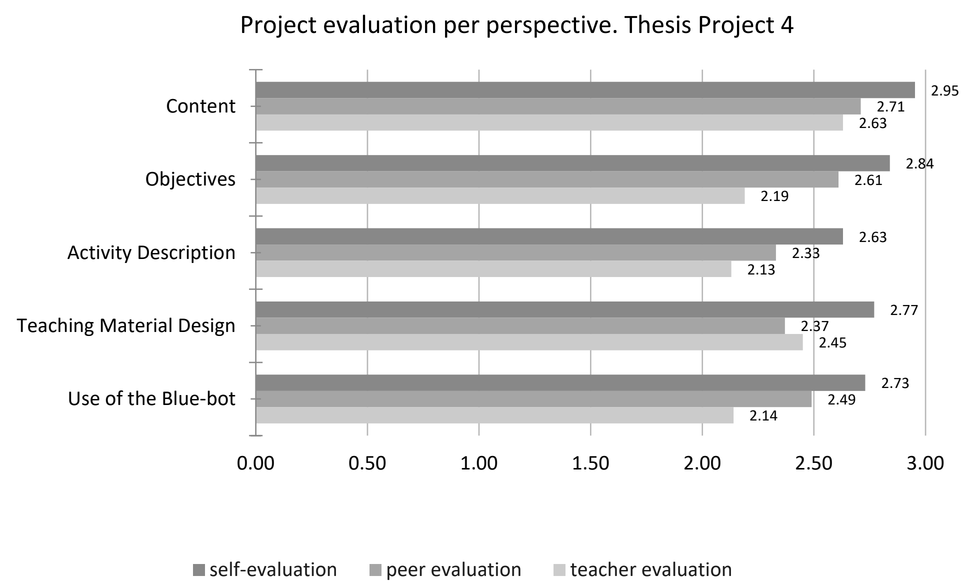
Table 14. Evaluation of trainees' projects. Thesis Project 4

	Content	Learning objectives		Activity description			Teaching material design		Bluebot use	
	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10
SE	2.95 (SD=0.10	2.95 (SD=0.12)	2.72 (SD=0.25)	2.87 (SD=0.14)	2.28 (SD=0.28)	2.73 (SD=0.22)	2.69 (SD=0.44)	2.84 (SD=0.18)	2.79 (SD=0.27)	2.73 (SD=0.26)
PE	2.71 (SD=0.31)	2.75 (SD=0.26)	2.47 (SD=0.28)	2.48 (SD=0.33)	2.21 (SD=0.23)	2.29 (SD=0.38)	2.35 (SD=0.75)	2.38 (SD=0.42)	2.49 (SD=0.31)	2.38 (SD=0.34)
TE	2.63 (SD=0.49)	2.22 (SD=0.42)	2.16 (SD=0.37)	2.32 (SD=0.41)	1.84 (SD=0.45)	2.23 (SD=0.53)	2.60 (SD=0.36)	2.30 (SD=0.41)	1.80 (SD=0.41)	2.14 (SD=0.32)

**SE= self-evaluation, PE= peer evaluation, TE= teacher evaluation*

Note. Adapted from Borrull et al. (2020a)

Figure 11. Project Evaluation per perspective. Thesis Project 4



As the literature points out, self-evaluation by teachers offers unique benefits as it requires close examination of the effectiveness of their own teaching (Taylor, 1994). In fact, when self-evaluation is applied in teacher training, teachers must reflect on their own achievements throughout the training, and this can positively affect their teaching. In educational robotics, self-evaluation has mainly been applied by pupils (Ronsivalle et al., 2019; Skurikhina et al., 2018). Peer evaluation is also quite common in both pupils' assessment during robotics tasks at school (Hovardas et al., 2020; Skurikhina et al., 2018) and teacher training (Kim, 2012). Skurikhina et al. point out that peer evaluation and feedback can improve social regulation and have a positive impact on students' collaboration skills. For all these reasons, trainees' projects were evaluated from all three perspectives.

5.3.2. Teachers' perceptions in ER teacher training programs

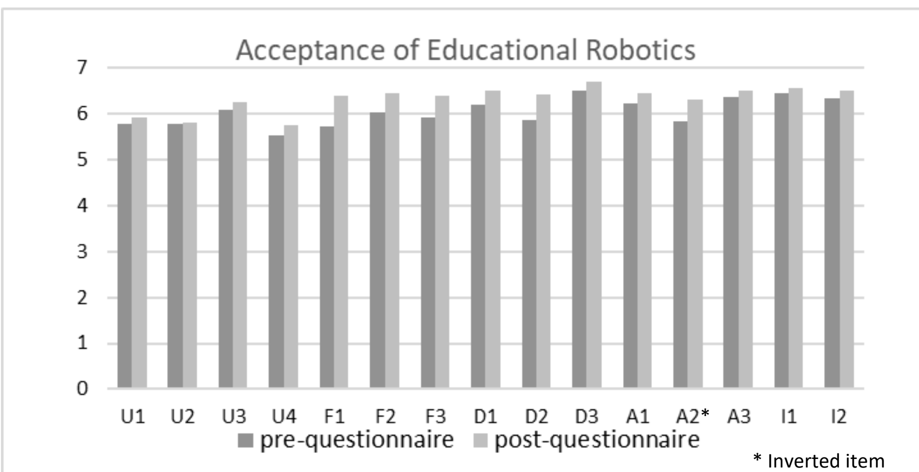
In this section, the impact of the training on trainees' perceptions will be presented in the following subsections (Section 5.3.2.1. - 5.3.2.4.). The perceptions studied are i) their acceptance of ER ii) their self-efficacy towards ER iii) their opinions on the training held and iv) their perceptions of their Teacher Digital Competence (TDC).

Current literature underlines the positive impact of teacher training programs in digital technologies (DT) on trainees' learning and perceptions. To be more precise, according to Khanlari (2019) it is very important to give teachers the chance to participate in hands-on activities with technologies like robotics, as this will decrease their anxiety and encourage them to apply these technologies in teaching. Teacher perceptions and attitudes towards technology have been a topic of interest for a long time now. For instance, teachers' computer anxiety has been thoroughly investigated in research (Hallam, 2008; Gürcan-Namlu & Ceyhan, 2003; Thorpe & Brosnan, 2008). Hallam expressed the concern that computer anxiety among preservice teachers may reduce the effectiveness of computer education and lead to a lack of digital skills and confidence for teachers to use digital technologies int their teaching. There are several studies of teachers' perceptions in educational robotics. For example, some have examined teacher acceptance of robotics (Fridin & Belokopytov, 2014; Kradolfer et al. 2014), teachers' views on the potential of robotics in other disciplines (Khanlari,2019), and acquisition of skills (Kim, 2012). This thesis underlines the importance of studying teachers' perceptions and examines trainees' i) acceptance of ER ii) self-efficacy towards ER iii) opinions on the training and iv) perceptions of their Teacher Digital Competence (TDC) in ER teacher training programs.

5.3.2.1. Acceptance of Educational Robotics

As far as acceptance of educational robotics is concerned, the results of our study implemented in the Bachelor's Degree in Preschool Education demonstrated an improvement in trainees' acceptance of ER after they had taken part in the ER teacher training (Schina et al., 2021a). The results are presented in Figure 12 and are also provided in Appendix I. The improvement was demonstrated with statistically significant differences in the areas of ease of use of Blue-bot resources, enjoyment, and attitudes towards the Blue-bot resource (see Appendix I). On the basis of our results, after engaging in this training the trainees would be eager to use Blue-bot in their future teaching in preschool education institutions. The results of our study go one step further than previous research in the field by offering substantiated quantitative results merged with qualitative data on trainee teachers' perceptions. The quantitative data confirms the qualitative results of Casey et al. (2020) on the improvement in the perceived ease of use of floor robots after the course. As presented in Casey et al. (2020), an improved perception of usefulness is observed after the training, although this is not confirmed by statistically important quantitative data. The detailed results regarding trainees' perceptions in the training program before and after the training program are presented in Figure 12. The items of the questionnaire can be found in Appendix E.

Figure 12. Trainees' acceptance of ER: pre/post questionnaire. Project 4

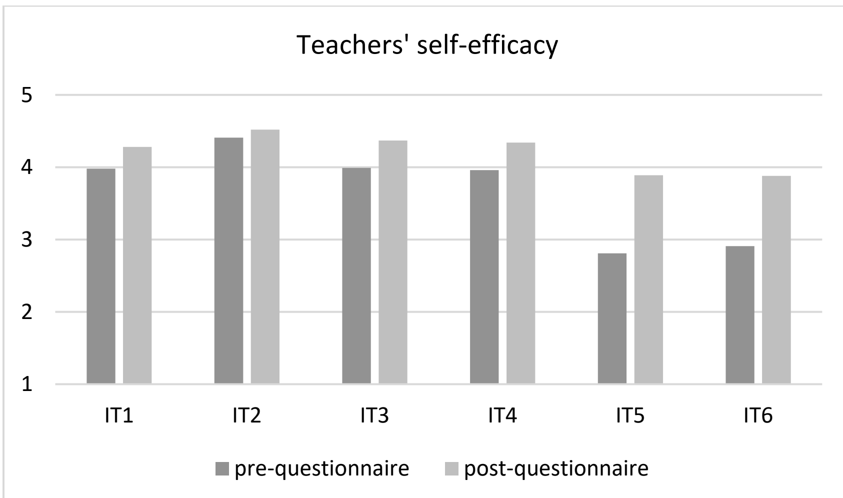


Note. Adapted from Schina et al. (2021a)

5.3.2.2. Self-efficacy towards Educational Robotics

The findings of the study implemented in the Bachelor's Degree in Preschool Education demonstrated a significant improvement in pre-service teachers' self-efficacy after they had taken part in ER teacher training (Schina et al., 2021a). The results are presented in Figure 13 and Appendix J and coincide with those of Jaipal-Jamani and Angeli, (2017) who found that an ER training course at university positively affects preservice teachers' self-efficacy beliefs in robotics as a teaching tool. In the same vein, Hamner et al. (2016) and Liu et al. (2010) found that teachers improved their self-efficacy thanks to a teacher training program. The findings of the present study confirm these research results that an ER teacher training program can have a positive effect on trainees' self-efficacy.

Figure 13. Trainees' self-efficacy towards ER: pre/post questionnaire. Project 4



Note. Adapted from Schina et al. (2021a)

5.3.2.3. Opinions on the training program

The results of the study implemented in the Bachelor's Degree in Preschool Education (Schina et al., 2021a) demonstrated that the trainees held positive opinions on the training program. These positive views were collected from the journals that trainees completed after each session. The content of the journals was analyzed and assigned codes (Appendix K).

Trainees considered that sessions 1 and 2 were interesting, useful, entertaining, practical, and helpful for participants' collaborative work on the project (codes A-E, Appendix K). A closer examination of session 1 shows that the most frequent codes are "The session was interesting" and "The session was useful". In fact, one trainee explained that "during the Bachelor's Degree we did not experiment sufficiently with digital technologies in education." In session 2, the most frequent code is that "The session supported participants' collaborative work on the project." Another trainee explained that "the session was very effective as we discussed our thoughts on the project with the rest of the group members and received instructions and feedback from the trainers." In addition, the code "The session was useful" is also mentioned very frequently in the journals of session 2.

As session 3 was given online due to the COVID-19 pandemic, different codes were selected to analyze the content of the journals (codes F-K, Appendix K). Code I "The online self and peer evaluation helped us recognize the strong and weak aspects of our project and/or our peers' project" was the most frequent. One participant explained that "the online peer evaluation enabled our group to observe the aspects that we did not take into account in the process of the creation of our project". As far as the overall evaluation of the training program is concerned, trainees' opinions are summarized in Appendix K with codes L-O referring to positive aspects of the training, while codes P-S refer to the deficiencies observed. As far as the positive aspects are concerned, the trainees describe the training as useful (code counted 48 times) and interesting (code counted 46 times). In more detail, many of them report that the training was particularly useful for their professional future as teachers and should be part of their teacher education at the university. On the other hand, the trainees highlighted some aspects for improvement: for example, the integration of additional ER resources in the training, additional time for experimentation with the resources, additional training sessions and preference for completing the training on-site. Trainees' perceptions of training programs were also analyzed in previous studies (Jaipal-Jamani & Angeli, 2017; Kay et al., 2014; Kucuk & Sisman, 2018; Majherová & Králík, 2017). The results of Kucuk and Sisman (2018) are in line with the results of our study. Even though the trainees reported that they faced difficulties with programming and collaboration, they underlined the importance of training in robotics for their professional development (Kucuk & Sisman, 2018).

5.3.2.4. Perceptions of Teacher Digital Competence

This section presents the trainees' self-perceptions of their Teacher Digital Competence (TDC) and then goes on to seek potential correlations with their acceptance and self-efficacy towards ER. The results from the pilot training program (Thesis Project 3) and main training (Thesis Project 4) are presented in the following paragraph.

The trainees filled in the COMDID-A questionnaire with their self-perceptions of their teacher digital competence (TDC) when they completed the training program that was part of the Bachelors' Degree in Pedagogy (Thesis Project 3) (see section 4.2.3.). It was observed that their average self-perception of TDC was 79.42% (SD = 10.64), meaning that most of the trainees considered that they were digitally competent. In Dimension 3 and 4 (D3, D4) trainees felt more confident than in Dimension 1 and 2 (D1, D2) (Table 15).

In the training program that was part of the Bachelors' Degree in Preschool Education (Thesis Project 4) the trainees completed the COMDID-A questionnaire just before starting the training program. It was observed that their average self-perception of TDC was 81.51% (SD = 9.11), meaning that the trainees considered that they were digitally competent. Cronbach's alpha was 0.956 which indicated a high level of internal consistency. Like the results of Project 3, the trainees evaluated themselves higher on Dimension 3 and 4 (D3, D4) than on Dimension 1 and 2 (D1, D2) (Table 16) (Borrull et al., 2020b). D1 and D2 are the dimensions that are most closely related to the trainees' professional practice. The analysis of trainees' perceptions of their level of TDC is in line with the study by Gudmundsdottir and Hatlevik (2018), the aim of which was to contribute to the development of their professional digital competence and self-efficacy.

Table 15. Self-evaluation of TDC: Thesis Project 3 & 4

	D1	D2	D3	D4
Thesis Project 3 Mean (SD)	75.615 (SD=13.407)	74.000 (SD=10.739)	84.769 (SD=9.610)	83.30 (SD=8.817)
Thesis Project 4 Mean (SD)	78.094 (SD=10.974)	80.438 (SD=10.326)	84.198 (SD=10.354)	83.604 (SD=9.168)

Note. Adapted from Schina et al. (2020b) and Borrull et al. (2020b)

To measure the relation between trainees' Teacher Digital Competence (TDC) and their acceptance and self-efficacy towards ER, we calculated the Pearson's r. This first correlation analysis showed that TDC correlates with trainees' acceptance of ER in four factors: perceived usefulness, perceived ease of use, enjoyment, and intention to use ER. According to these results, TDC does not correlate with the factor of attitudes towards ER but it does with trainees' self-efficacy. The results are presented in Table 16. This analysis may help to improve our understanding of the role of self-perceived TDC in trainees' acceptance and self-efficacy towards ER.

Table 16. Pearson correlations between trainees' TDC and perceptions

Variables	Perceived usefulness	Perceived ease of use	Enjoyment	Attitudes	Intention to use ER	Self-efficacy
TDC - Pearson's r	0.286**	0.502**	0.394**	0.207	0.324**	0.314**
M	5.781	5.893	6.181	4.922	6.394	3.676
SD	0.967	1.020	0.898	0.646	0.748	0.735
Cronbach alpha	0.885	0.867	0.859	0.798	0.889	0.855

* $p<0.05$; ** $p<0.01$

5.4. Summary of results

The results presented in the previous sections of chapter 5 (5.1. – 5.3) are summarized in Table 17 in the following page. In this table, the results are associated with the thesis' specific objectives, research questions and publication.

Table 17. Summary of results

Specific objective	Research question	Publication	Summary of results
SO.1.	RQ1	Schina et al. (2020d)	Teachers believe that students may develop skills such as problem-solving, collaboration, creativity, discipline, presentation skills and programming knowledge through ER activities.
	RQ2	Schina et al. (2020d)	Teachers positively perceive the integration of ER in the curriculum from early educational levels.
SO.2.	RQ3	Schina et al. (2020a)	Previous ER teacher training programs vary in terms of duration, and trainees' & trainers' profile, and not all of them set requirements for completion or are founded on theory. Few programs have a gender perspective.
	RQ4	Schina et al. (2020a)	Best practices for ER teacher training programs fall into these categories: collaboration, materials, pedagogy, practice, and feedback/support
SO.3.	RQ5	Borrull et al. (2020a); Schina et al. (2020b).	Trainees' learning outcomes in the pilot and main training programs were considered positive as the ER projects they designed received positive evaluations. Self-evaluation of projects is usually higher than peer and teacher evaluation.
	RQ6	Schina et al. (2021a)	Trainees' acceptance of ER improved after their participation in the main ER teacher training program.
	RQ7	Schina et al. (2021a)	Trainees' self-efficacy of ER improved after their participation in the main ER teacher training program.
	RQ8	Schina et al. (2021a)	Trainees had positive opinions of both the pilot and the main ER teacher training programs.
	RQ9	Borrull et al. (2020b); Schina et al. (2020b);	Most trainees considered that they had a good level of Teacher Digital Competence (TDC) in the pilot (TDC= 79.4) and main teacher training programs (TDC= 81.5).
	RQ10	In progress	Trainees' self-perceptions of their TDC correlate with their self-efficacy towards ER and their acceptance of ER in four out of five factors.

Chapter 6. Conclusions

6.1. Thesis conclusions

In this section, the most important conclusions of the thesis will be presented for each specific research objective. The conclusions of every specific objective lead into and construct the next stages of the research.

Regarding the first specific objective (SO.1.) “To explore how teachers perceive the potential of Educational Robotics for students’ acquisition of STEM and 21st century skills and how they view a possible integration of ER into the school curriculum”, the findings of the thesis indicate that ER is positively viewed by teachers with prior experience in this field, in the local context of Tarragona-Reus in Spain. To be more precise, the teachers positively value students’ learning of programming and engineering concepts and acquisition of skills through ER. They also agree that ER should be integrated into the curriculum from early educational stages. The findings related to the first specific objective, provide important insight into the following steps of this thesis. The teachers’ positive views of ER and suggestions for integrating ER into the school curriculum even in preschool and primary school education gave rise to the need to provide teachers with training in ER, thus paving the way for the following steps of the thesis.

Regarding the second specific objective (SO.2.) “To examine the characteristics of ER teacher training programs in international literature and the best practices implemented”, the following conclusions were drawn. Current training programs in ER as documented in international literature are highly diverse in terms of duration, requirements, trainers’, and trainees’ profiles. Despite this, there are common patterns: for example, the lack of requirements, the lack of a strong pedagogical background and the lack of a gender perspective. These deficiencies, if addressed, would lead to training programs having a higher impact on trainees’ learning. Despite the inadequacies observed, the literature review presents several useful strategies and ideas for ER teacher training programs, which have defined a series of best practices: collaboration among teachers, production and sharing of teaching materials, foundation on pedagogy, practice, and feedback/support. The ER teacher training programs conducted at the Universitat Rovira i Virgili were built upon the best practices identified in this literature review.

As far as the third specific objective (SO.3.) is concerned "To study the impact of ER teacher training on participants' learning and perceptions of ER", several interesting conclusions were drawn. First, holding ER teacher training programs as part of teacher education at the university has a positive impact on trainees' learning. Learning here does not refer to trainees' understanding of programming and engineering principles but to their ability to design interdisciplinary classroom activities with ER resources. The ER training programs are addressed to students at the Faculty of Education who will become teachers and who will need both technical and pedagogical skills to apply ER in their educational contexts. The outcomes of this thesis demonstrate that the training enabled the trainees to design interdisciplinary ER activities in sustainable development and natural sciences. However, the impact of ER teacher training is not limited to trainees' learning; it also influences their perceptions. Teaching personnel's perceptions of technological tools should not be neglected as they determine classroom implementation. In this thesis it was concluded that the implementation of ER teacher training programs positively affects trainees' acceptance of ER technologies in the classroom and boosts their self-efficacy towards conducting ER activities at school. The findings also demonstrated that the trainees positively view this training as they recognize the necessity to learn about ER for their professional career, as it has not been addressed by their Bachelor's Degree. Finally, the trainees positively perceive their own teacher digital competence. These positive perceptions could allow further implementation of teacher training programs in technology.

6.2. Main contribution and strengths of this thesis

Among the conclusions of this thesis, the following four aspects are distinguished for their scientific impact at a national and international level:

1. The thesis emphasized teachers' perceptions; it examined in-service teachers' views on students' acquisition of skills and their views on the integration of ER into the curriculum and studied pre-service teachers' evolution of perceptions throughout the ER teacher training program. Teachers' perceptions play a vital role in using technology in the school classroom and for this reason they have a key role throughout this thesis.
2. The thesis explored for the first time the literature on teacher training programs in educational robotics. The results of this systematic literature review are expected to benefit the content, structure, and implementation of future ER teacher training programs, while they are also expected to improve the design of future research studies in this area.
3. In the framework of this thesis, two ER teacher training programs were developed and implemented for the first time at the Faculty of Educational Sciences and Psychology at the Universitat Rovira i Virgili (URV). Even though the use of robotics technologies in the classroom is expanding in many schools all over the world, teaching personnel often does not have the skills as they did not receive instruction in these technologies during their teacher education at university. In the Bachelor's Degrees of the Faculty of Educational Sciences and Psychology in URV there are no courses on educational robotics.
4. Finally, the particular contribution of this thesis is the profile of the participants, who are pre-service pre-school teachers. Preschool teachers are rarely included in teacher training programs in ER or in research on the subject. This thesis shows that a teacher training program in ER specifically designed for preschool teachers can have a positive impact on their learning and perceptions.

6.3. Limitations of the study

Despite the positive outcomes of this thesis, there are some limitations that mainly affect the generalizability of the results. The limitations are the following:

1. The first limitation is the fact that the data were collected in a specific context, and they do not provide any evidence on other national or international contexts.
2. The second limitation has to do with the sample size. In Thesis Project 1 only 8 teachers participated in the research, while in Thesis Project 3 and 4 there were 21 and 90 trainees, respectively. The limited sample size prevents this thesis from generalizing its results.
3. The following limitations have been found in the teacher training programs at the Faculty of Education Science and Psychology at the Universitat Rovira i Virgili:
    a. Even though the quantitative data demonstrate that the participants' acceptance and self-efficacy towards ER improved throughout the course, these conclusions cannot be confirmed as there is no classroom evidence on trainees' ER classroom integration.
    b. Another limitation was the duration of the teacher training programs. In particular, the duration of the training program conducted in the framework of Thesis Project 4 was relatively short, just three sessions (6 hours in total), conducted over 2.5 months.
    c. The teacher training programs did not include a classroom implementation stage. The trainees designed instructional materials, but they did not have the chance to apply them in educational contexts.

These limitations (a-c) are closely related to the COVID-19 pandemic. The training program implemented in the Bachelor's Degree in Preschool Education (Thesis Project 4) was planned to be longer, with additional training sessions that would allow the trainees to put into practice the instructional material designed. This would have provided the research with classroom evidence on trainees' acceptance and self-efficacy and would have enriched the research results. The participants did not have the opportunity to apply the knowledge acquired through the training, in the preschool educational context, as schools in the region remained closed the rest of the school year after the outbreak of the pandemic in March 2020.

4. Another limitation of the study is the missing data. To be more precise, some trainees in the pilot training (Thesis Project 3) did not complete the pre/post questionnaires on acceptance and self-efficacy. This made it even more difficult to draw conclusions from the pilot training on trainees' acceptance and self-efficacy. Regarding the main training program (Thesis Project 4), the trainees completed all questionnaires, but sometimes information was missing from their training journals. Given all the above, designating classroom time for completing the questionnaires and training journals would have facilitated the data collection process.

Chapter 7. Recommendations

The experience gained from all stages of this thesis including the production of training materials, data collection and analysis, and conclusions, allows us to make several recommendations for future ER teacher training programs and research (Table 18). The recommendations propose improvements in certain aspects of ER teacher training and research and aim to provide high quality training content and attain reliable and generalizable research results. In this section recommendations will be provided on the following aspects of the ER teacher training programs: recommendations on a) the implementation of ER teacher training programs, b) the content of ER teacher training programs, c) the structure/modality of the training programs, and d) research in ER teacher training. The summary of the recommendations is provided in Table 16. Finally, there is a final recommendation for university policy makers.

Table 18. Summary of the recommendations of the thesis

Recommendations for the implementation of future ER teacher training programs	**Recommendations for the ER teacher training content**	**Recommendations for ER structure and modality**	**Recommendations for future ER research design**
Promote teacher exchange of ideas and/or materials during and/or after the training.	Integrate instruction on inclusiveness and equity in ER teacher training programs.	Conduct long training programs.	Implement pilot studies and/or control groups, use rigorous research methods (quantitative & qualitative) and reliable and validated data collection instruments.
Technical and pedagogical aspects should be integrated in ER training. Trainees to put technical and/or pedagogical knowledge into practice during the training program.	Instruct trainees on how to boost the interest of females and other under-represented groups in ER (use of appropriate ER tools and curriculum, and instructors as role models).	Provide instruction in different ER resources, suitable for the trainees' background and educational level.	Set requirements for the ER teacher training completion to evaluate trainees' skills.
Provide trainees with the robotics kits used in the	Instruction in teaching methodologies for ER.	Allow time for experimentation with ER resources.	Extend the sample by inviting educators who do not usually participate in

training for classroom application, if available.			ER training programs (e.g., special, and preschool education teachers).
Create a positive learning atmosphere by promoting collaboration during the training program. The trainees should receive support from the trainers during and after the training.		Online learning could replace on-site learning when necessary.	Hold longitudinal research studies.
Adjust the pace and/or the content of the training program to the trainees' needs and preferences.			

7.1. Recommendations on the implementation of ER teacher training programs

The recommendations on the implementation of ER teacher training programs' are based on the best practices encountered in the studies reviewed in Schina et al. (2020a). Firstly, trainees should be encouraged to exchange views and/or materials during and/or after the training. They can benefit from the sharing of ideas and instructional materials during the training itself and their follow-up teaching practice, and also from observing their fellow trainees in their classroom practice. Once the training has been completed, a teacher network should be constructed for public school teachers who have previously attended teacher training programs in ER and/or are currently using ER resources in their schools. This network could be organized at a local level, coordinated by the countries' ministries, and support its members by holding events and seminars, which would facilitate the exchange of teaching materials among teachers and enable the members of the community to discuss and cope with common difficulties encountered in their educational context. Furthermore, the trainees' educational institutions should be provided with an adequate number of ER resources for classroom use, particularly those used in the training, so that the teachers are already familiar with them. If this is not possible, the schools are encouraged to share resources with their neighboring institutions, under the supervision of local ministries or services. It is also recommended to make sure that the trainees have access to instructional materials for classroom use after the training. The instructional materials could be provided by the trainers after the training or be designed by the trainees during the sessions. As well as providing instruction in using robotics resources and/or programming, the ER training should have a pedagogical aim. Trainees should be familiarized with such aspects of classroom implementation as pedagogical frameworks for implementing ER activities, innovative teaching methodologies for integrating ER into different fields, and classroom management during ER activities. It is also recommended to give the trainees the opportunity to put their technical and/or pedagogical knowledge into practice by organizing hands-on activities for assembling and programming robotics, practicing with robots and software in specific exercises and encouraging teachers to carry out ER activities in their schools or as part of outreach educational programs. Additionally, the pace and/or the content of the training should be adjusted to trainees' needs and preferences; the trainees are teachers themselves and can identify the areas they need more help with and which will be more useful for their educational context and level. Finally, as trainees' first contact with ER can be quite demanding, they should be given continuous support by the trainers during the training itself and afterwards during the implementation of ER activities at their schools. The ongoing support could vary between a semester or a school year depending on the teacher's profile and performance in the training sessions. The support could be technical (programming, assembling etc.), or pedagogical (related to instructional materials or classroom management issues).

7.2. Recommendations on the content of ER teacher training programs

As far as the content of the ER teacher training programs is concerned, instruction should be given on inclusiveness and equity, and teaching methodologies. Trainees should be instructed on how to raise awareness of gender and equality in their ER classes and on how to strengthen the interest, participation and learning outcomes of females and other under-represented groups. For example, trainees should be shown how to design inspiring instructional materials in programming, engineering, and ER to engage these under-represented groups. As has been demonstrated by previous research, female students have significantly less desire and less confidence to learn robotics than male students (Kucuk & Sisman, 2020). To boost students' confidence, ER activities should be offered in schools in line with appropriate curricula and approaches, and to reduce the gender gap in robotics, they should be applied to improve girls' personal interest from educational stages as early as preschool (Kucuk & Sisman, 2020). Sullivan and Bers (2019) provide evidence that developmentally appropriate robotics and coding tools, and the curriculum has the potential to positively impact girls' interest in engineering. They suggest that the curriculum be taught by an all-female teaching team and with a collaborative approach. The all-female teaching team could work as role models for female students because role models encourage female interest in STEM-related areas (Weber, 2011) and, therefore, in ER activities. In addition, to increase girls' interest and performance in computer science, the curriculum should focus on helping behaviors (Sullivan & Bers, 2019), as research has shown that girls are significantly more interested than boys in jobs that help society (Cunningham & Lachapelle, 2010). Therefore, the content of the training programs should include training in all these aspects and enable the trainees to design interesting ER classes that engage all students. Finally, as far as teaching methodologies are concerned, the ER teacher training programs should have a strong pedagogical background and provide instruction to the trainees on the teaching methodologies used in the field of ER. As Altin and Pedaste (2013) reported, the most popular methodologies in ER are problem-based, constructivist and competition-based learning. The trainees should receive instruction and support on how to implement ER classes based on these methodologies.

7.3. Recommendations on the structure of the ER teacher training programs

Teacher training programs should i) be long, ii) use a variety of resources and iii) allow time for experimentation. Online learning is an option if on-site learning is not possible. A sufficient number of training sessions can boost trainees' understanding of ER, and their acceptance and self-efficacy towards ER while the resources should be varied and appropriate to the trainees' background and educational context. For example, preschool teachers could be instructed in resources such as Scratch Jr (Papadakis et al, 2016), KIBO (Bers et al., 2019), RoboTito (Gerosa, et al., 2019) and Bee-bot (Di Lieto et al, 2017). Time also plays a crucial role in the training program. Trainees should have enough time to experiment with the resources so that they feel more comfortable and confident, and enjoy the learning process. Future ER training programs could be conducted entirely or partly online in health emergencies such as the COVID-19 pandemic. Moorhouse's suggestions (2020) can be used to adapt on-site training programs to online and blended programs: for example, use small group discussions (breakout rooms), reinforce the structure of the sessions, add a preparation task with the session materials prior to the class, provide time for group discussion and feedback, record the sessions, combine synchronous and asynchronous instruction. Immediate feedback to trainees and online robotics simulations can also be integrated in online and blended ER teacher training programs. As Sun et al. (2020) suggested, educational institutions should view the COVID-19 pandemic as an opportunity to reform the online education they offer by improving the course content, digital technologies (DT) and management.

The following recommendations are made for research in ER teacher training programs. The study design of ER research should be enhanced by implementing pilot studies and/or control groups, making use of rigorous research methods (both quantitative and qualitative) and using reliable and validated data collection instruments. In addition, setting requirements for completing teacher training courses (e.g. robot design, program creation, instructional material design or teaching practice) could facilitate trainees' evaluation and allow data to be collected. It is also advisable to carry out further ER teacher training research for educators who do not usually participate in ER teacher training programs (for example, special needs and preschool teachers). It is also recommended to use gender-balanced random sampling with an appropriate sample size to increase the representativeness and generalizability of the research results. To achieve this, researchers should be given access to samples in educational institutions (see also Pedersen et al. (2020)). The reliability of the findings could be improved by engaging in longitudinal research studies. This can be achieved by making training programs longer.

Last but not least, it is of crucial importance to integrate educational robotics in teacher education at university. Even though programming and educational robotics is key content in primary education in Catalonia (COMPETÈNCIA 1, Seleccionar, utilitzar i programar dispositius digitals i les seves funcionalitats d'acord amb les tasques a realitzar [Competence 1, Select, use and program digital devices and functionalities according to the tasks to be carried out]) (Departament d'Ensenyament, 2013), university students studying at the Faculty of Educational Sciences and Psychology at the Universitat Rovira i Virgili in Catalonia do not receive instruction in programming, coding or educational robotics during their degrees. It is important that teachers are educated, guided, and supported to meet the standards of the new school curriculum (Tuomi et al., 2018). Therefore, policy makers at the Universitat Rovira i Virgili should adapt the curriculum of the Bachelors' and Master's Degrees at the Faculty of Education and enable future teachers to equip their students with 21st century skills in programming and educational robotics. Adding basic coding/programming/engineering skills to teacher education and professional development has been suggested by several previous studies (García-Peñalvo, 2016; Kong & Wong, 2017; Wu et al., 2020).

7.4. Future research

To ensure ER activities are successfully implemented in educational institutions, teachers' acceptance of ER, self-efficacy towards ER and Teacher Digital Competence (TDC) need to be further studied. Future research should examine the role of self-efficacy and both actual and self-perceived Teacher Digital Competence (TDC) in teachers' acceptance and future use of ER resources at school. As Kucuk & Sisman (2020) suggested "relationships between variables affecting student attitudes towards robotics and STEM can be examined by using structural equation modeling" (p. 9). Structural equation modelling (SEM) can be used to assess the accuracy of a model and examine the role of TDC and self-efficacy in teachers' acceptance of ER. The findings of a SEM study could contribute to the understanding of the factors that determine teachers' acceptance of ER resources and the use of ER resources at school. Therefore, the research community will be better able to identify the changes that need to be made to teacher training programs in ER resources to improve their results and impact.

Chapter 8. Other research and dissemination activities

8.1. International research stay

I completed a 3-month research stay at the Laboratoire d'Innovation et Numérique pour l'Éducation (LINE) at Université Côte d'Azur from the 15th of February 2021 until the 16th of May 2021, supervised by Dr Margarida Romero. The research stay certificate can be found in Appendix L. The research stay included the following tasks:

- **Collaboration in content creation for the Let's STEAM project.**

The Let's STEAM project aims to provide secondary school teachers in the field of STEAM topics (Science, Technology, Engineering, Art and Mathematics) with teacher training in programming and the use of programming boards in educational contexts. The teacher training program that is being drawn up will include transversal training sessions in creativity, interdisciplinarity, computational thinking and innovative pedagogical strategies. I collaborated in creating content for Module 2, "Interdisciplinarity, Creativity and Integration", which builds on the knowledge acquired from Module 1 (instruction in the basics of programming and use of programming boards) and develops multidisciplinary learning projects and activities for classroom use.

- **Collaboration in data collection and analysis of the CreaCube activity**

I collected data from the CreaCube problem-solving activity with modular robotics in a primary school in Nice, France. The data were analyzed to study collaborative problem-solving processes. The activity with the Cubelets modular robots was used to examine the collaboration roles that primary school pupils play when they are involved in the CreaCube activity. For the purpose of this study, twelve primary school pupils of 7-8 years old completed the CreaCube activity in both mixed and same-gender pairs.

- **Participation in dissemination activities**

I participated in techno-créativité – Séminaire du 17/03/2021. The seminar was organized and held at LINE (Laboratoire d'Innovation et Numérique pour l'Education) in Nice on March 17, 2021. Its main objective was to present and discuss learning activities supporting techno-creativity as well as to assess creativity through different approaches. I presented my PhD thesis results.

8.2. Participation in the competition "Vols saber què investigo?

The Unit for Scientific Culture and Innovation, ComCiència, and the Postgraduate and Doctoral School of the Universitat Rovira i Virgili organized the competition "Vols saber què investigo". PhD students from the URV presented their PhD thesis as a scientific monologue. "Vols saber què investigo" is an opportunity for early-stage researchers to explain to a non-specialized public (secondary school students) their research in an engaging way, adapting their language to the audience’s background and ages, and relying only on communicative and personal skills without the support of presentation tools. I participated in the competition in 2021 and received the second jury award (Appendix M).

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Appendix

Appendix A – Items of Teacher Views Questionnaire

1. Género
2. Profesión
3. Años de experiencia docente.
4. Has participado como enterenador de: First Lego League/ First Lego League Junior /First lego League y First Lego League Junior
5. Has participado como enterenador en el torneo de …(por ejemplo FLL Tarragona-Reus , FLL Sevilla etc.)
5. ¿Con qué frecuencia has tenido reuniones con los alumnos para prepararlos para la competición FLL?
6. ¿Dónde se desarrollaron las reuniones de los equipos? ¿A que horas?
7. ¿Ha habido estudiantes que han dejado el grupo?
8. ¿Cómo se han financiado los gastos de participación en la competición FLL?
9. ¿Qué problemas o dificultades han surgido durante la preparación para la competición FLL?
10. ¿Los premios de la competición y la posible participación en competiciones internacionales FLL, han sido una motivación para tu participación?
11. ¿Vas a participar en otras competiciones FLL en el futuro?
12. ¿Qué crees que les gustó más a los alumnos sobre su interacción con la robótica?

13. Crees que los alumnos a traves de robótica desarrollan: [i) habilidades de comprensión y resolución de problemas], [ii) una cultura de cooperación y organización de un proyecto.] , [iii) habilidades de creatividad], [iv) habilidades de disciplina], [v) habilidades de presentación (sociabilidad)] , [vi) divertirse]
14. ¿Qué beneficios (a corto y largo plazo) consideras que surgen de la interacción de los alumnos con la robótica?
15. Describe tu grado de acuerdo con las siguientes afirmaciones: [i) El uso de robots en la educación motiva a los estudiantes a aprender sobre el proceso de aprendizaje.] [ii) Los estudiantes interesados-as en robótica suelen estar interesados-as en la programación.], [iii) Los niños están más interesados-as en la robótica que las niñas], [iv) Los estudiantes que tienen una actitud positiva hacia la tecnología tienen más motivación para lidiar con la robótica], [v) Existe un vínculo entre la motivación de los estudiantes para participar en actividades de robótica y su autoestima.]
16. ¿Crees que los alumnos aprendieron los principios básicos de programación? 16a. Si elegíste 1 o 2, desarrolla su respuesta:
17. ¿Crees que los alumnos aprendieron los principios básicos de ingeniería? 17a. Si elegíste 1 o 2, desarrolla tu respuesta:
18. ¿Crees que debería incluirse la robótica educativa en la educación obligatoria? 18a. Si elegíste 1 o 2, cómo crees que se puede realizar y en que niveles educativos y edades.
19. ¿Consideras que los padres de los alumnos ven la interacción de sus hijos con la robótica de manera positiva?

Appendix B – Qualitative Analysis of Publications

Main areas	Categories
Information on the Publication	Title
	Date
	Authors
Characteristics of the training programs	Duration
	Requirements
	Trainees' profiles
	Trainers' profiles
	Pedagogical approach
Best practices	Best practices implemented in ER teacher training studies

Appendix C - Project Evaluation Rubric (Version 1)

Evaluador: _____________

Grupo que se evalúa: _____________

Puntuación			Insuficiente (0 puntos)	Aceptable (1 punto)	Bien (2 puntos)	Muy bien (3 puntos)
Contenido	C1	/3	La PS no aborda el tema de desarrollo sostenible del caso presentado.	La PS aborda el tema de desarrollo sostenible pero le falta adaptarlo al caso presentado.	La PS está relacionada con el caso de desarrollo sostenible pero le falta claridad.	La PS aborda claramente el aspecto del desarrollo sostenible del caso presentado.
Objetivos de aprendizaje	OA1	/3	Los objetivos de aprendizaje no constan en la PS.	Los objetivos de aprendizaje de la PS están presentados de forma confusa.	Los objetivos de aprendizaje de la PS están presentados pero uno o más son mejorables.	Los objetivos de aprendizaje de la PS están claramente presentados y elaborados en detalle.
	OA2	/3	Ningún objetivo de aprendizaje está relacionado con las competencias del siglo XXI.	Alguno de los objetivos de aprendizaje está relacionado con las competencias del siglo XXI.	Alguno de los objetivos de aprendizaje está relacionado con las competencias del siglo XXI y tiene en cuenta el caso.	Los objetivos de aprendizaje están mayoritariamente relacionados con las competencias del siglo XXI y están bien justificados teniendo en cuenta el caso.
Interdisciplinaridad	I1	/3	El robot se usa en la PS para enseñar contenido de tecnología o robótica, sin tener en cuenta las disciplinas del currículum.	La PS está relacionada con alguna disciplina del currículum, pero sin establecer conexiones entre diferentes materias.	La PS establece conexiones entre diferentes materias del currículum.	La PS establece conexiones entre diferentes materias del currículum y están bien justificadas, con un objetivo común.
Descripción de la PS	DPS1	/3	La descripción de las actividades carece de estructura y contenido.	La descripción de las actividades es mejorable por lo que se refiere a estructura y contenido.	La descripción de las actividades es correcta en cuanto a estructura y contenido pero debería ser más detallada y clara.	La descripción de las actividades es clara, organizada y suficientemente detallada.

	DPS2	/3	Las actividades presentadas no son originales.	Las actividades presentadas son poco originales.	Las actividades presentadas son bastante originales.	Las actividades presentadas son originales.
	DPS3	/3	En la PS no se incluyen actividades de evaluación.	En la PS se incluyen actividades de evaluación pero no están relacionadas con los objetivos de aprendizaje.	En la PS se incluyen actividades de evaluación que están relacionadas con los objetivos de aprendizaje aunque no de forma clara.	En la PS se incluyen actividades de evaluación que están relacionadas de forma clara con los objetivos de aprendizaje.
Diseño del material didáctico	MD1	/3	El material didáctico no se ha desarrollado.	El material didáctico elaborado no facilita un buen desarrollo de la sesión con la bluebot.	El material didáctico es variado y facilita el desarrollo de la sesión con la bluebot.	El material didáctico es variado, coherente con los objetivos de aprendizaje y facilita el desarrollo de la sesión con la bluebot.

PS - Planificación de la Sesión

Appendix D – Lesson Plan Template

<table>
<tr><td>Nombre del grupo:

(nombre del grupo d' emprenedoria)</td><td>Duración de la actividad:

(tiempo necesario para el desarrollo de la actividad)</td></tr>
<tr><td>Título de la actividad:

(el título tiene que estar relacionado con el contenido de la actividad)</td><td>Edad de los alumnos:

(la edad de los alumnos va a influir el contenido de la actividad y su desarrollo)</td></tr>
<tr><td colspan="2">Materiales didácticos:

1. (Enumera los materiales que necesitarás para desarrollar la actividad por ejemplo 5 bluebots, alfombra, ficha de ejercicios y cuántos de cada uno necesitas)
2. ...</td></tr>
<tr><td colspan="2">Objetivos de aprendizaje:

1. (hay que incluir un mínimo de tres objetivos los cuales están relacionados con el contenido de la sesión y las competencias del siglo XXI)
2. …
3. ...</td></tr>
<tr><td colspan="2">Contenido de materias asociadas:

1. (Enumera todas las materias o ámbitos de conocimiento asociados a las que está destinado esta unidad didáctica, si es interdisciplinaria, enumera varias materias ej. ciencias naturales, ciencias sociales, educación física etc.)</td></tr>
<tr><td colspan="2">Descripción de las actividades:

(Las actividades tienen que estar presentadas de manera clara y detallada)</td></tr>
<tr><td colspan="2">Actividades de evaluación:

(¿Cómo evalúas si tus alumnos han alcanzado los objetivos de aprendizaje y desarrollado las competencias requeridas?)</td></tr>
</table>

Appendix E – Acceptance of ER Pre/Post Questionnaire

Item ID	Acceptance of ER - questionnaire items
U1	El uso de la BlueBot mejorará mi aprendizaje y rendimiento en esta asignatura.
U2	El uso de BlueBot durante las clases me facilitaría la comprensión de ciertos conceptos.
U3	Creo que la BlueBot es útil cuando se está aprendiendo.
U4	Con el uso de la la BlueBot aumentaría mi rendimiento.
F1	Creo que la BlueBot es fácil de usar.
F2	Aprender a usar la BlueBot no es un problema para mí.
F3	Aprender a usar la BlueBot es claro y comprensible.
D1	Utilizar la BlueBot es divertido.
D2	Disfruté con el uso de la BlueBot.
D3	Creo que la BlueBot permite aprender jugando.
A1	El uso de la BlueBot hace que el aprendizaje sea más interesante.
A2	Me he aburrido utilizando la BlueBot.
A3	Creo que el uso de la BlueBot en el aula es una buena idea.
I1	Me gustaría utilizar en el futuro la BlueBot si tuviera oportunidad.
I2	Me gustaría utilizar la BlueBot en la eseñanza de varias disciplinas.

Appendix F – Self-efficacy towards ER Pre/Post Questionnaire

Item ID	Self-efficacy - questionnaire items
IT1	Considero que tengo las habilidades necesarias para usar la robótica en el aula.
IT2	Estoy seguro de que puedo involucrar a mis alumnos para que participen en proyectos basados en robótica.
IT3	Estoy seguro de que puedo ayudar a mis alumnos cuando tienen dificultades con la robótica.
IT4	Me siento capaz de enseñar al alumnado temas relacionados de ciencias utilizando robots educativos.
IT5	Tengo suficiente conocimiento de robótica para integrarla en los procesos de enseñanza-aprendizaje.
IT6	Tengo suficiente conocimiento de pensamiento computacional respecto al desarrollo de actividades de robótica en contextos educativos.

Appendix G - Project Evaluation Rubric (Version 2)

Evaluador: ____________ Grupo que se evalúa: _____________

Puntuación			Insuficiente (0 puntos)	Aceptable (1 punto)	Bien (2 puntos)	Muy bien (3 puntos)
Contenido El objetivo de la actividad es aumentar el conocimiento sobre la vegetación autóctona de Cataluña	C1	/3	En la actividad no aparece la vegetación como temática.	En la actividad aparece la vegetación pero esta no es autóctona de Cataluña.	En la actividad aparecen elementos de la vegetación autóctona de Cataluña y otros que no lo son.	La actividad se basa en la vegetación autóctona de Cataluña.
Objetivos de aprendizaje	OA1	/3	Los objetivos de aprendizaje de la actividad no están redactados correctamente. No empiezan con infinitivo ni están encaminados a alcanzar un objetivo.	Los objetivos de aprendizaje de la actividad son un poco confusos. Y presentan fallos como puede ser no empezar con un infinitivo o bien no ir encaminados a alcanzar un objetivo.	Los objetivos de aprendizaje de la actividad son claros, pero presentan fallos en su redacción. No empiezan con infinitivo ni están encaminados a alcanzar un objetivo.	Los objetivos de aprendizaje de la actividad son claros y están redactados correctamente. Empiezan con infinitivo y están encaminados a alcanzar un objetivo.
	OA2	/3	Los objetivos de aprendizaje no se alcanzan con el desarrollo de esta actividad.	Alguno de los objetivo de aprendizaje se alcanza gracias al desarrollo de esta actividad.	La mayoría de objetivos de aprendizaje se alcanzan con el desarrollo de la actividad.	Todos los objetivos de aprendizaje planteados se alcanzan gracias al desarrollo de esta actividad.
Descripción de la actividad	DPS1	/3	La estructura de la actividad no es coherente, no está relacionada con los objetivos de aprendizaje ni está bien explicada para poder ser realizada.	La actividad se puede realizar, pero tiene más de una de estas carencias: no está bien explicada, le falta coherencia o bien no está relacionada con los objetivos de aprendizaje.	La estructura de la actividad es coherente. Está bien organizada, relacionada con los objetivos de aprendizaje, pero no está relacionada con los objetivos de aprendizaje.	La estructura de la actividad es coherente. Está bien organizada, relacionada con los objetivos de aprendizaje, y está bien detallada para su realización.
	DPS2	/3	Las actividades presentadas no son originales ni innovadoras. Ha sido copiada de una actividad ya presentada.	Las actividades presentadas son poco originales. Han modificado un poco una actividad ya presentada en clase.	Las actividades presentadas son bastante originales. La actividad presentada tiene algunos elementos originales no vistos anteriormente.	La actividad presentada es original e innovadora, diferente de las vistas hasta ahora.

	DPS3	/3	En la actividad no se incluyen actividades de evaluación (preguntas para plantear a los niños que realizan la actividad, fichas,…)	En la actividad se incluyen actividades de evaluación, pero no están relacionadas con los objetivos de aprendizaje.	En la actividad se incluyen actividades de evaluación que están relacionadas con algunos de los objetivos de aprendizaje.	En la actividad se incluyen actividades de evaluación relacionadas con todos los objetivos de aprendizaje.
Diseño del material didáctico	MD1	/3	El material didáctico no se ha desarrollado. (ej. no se ha creado la alfombra)	El material didáctico no está muy bien elaborado ya que no facilita un buen desarrollo de la sesión con la bluebot (ej. la bluebot no se puede desplazar correctamente).	El material didáctico está bien elaborado, pero tiene algunos problemas para el desarrollo de la actividad.	El material didáctico se ha elaborado y permite que la actividad se desarrolle perfectamente.
	MD2	/3	El diseño del material didáctico no es adecuado a la edad que va destinada.	El diseño del material didáctico es adecuado a la edad que va destinada en el contexto, o en el desarrollo de la actividad, o bien, en la recogida de evidencias.	El diseño del material didáctico es adecuado en dos de las fases: contexto, desarrollo de la actividad, recogida de evidencias.	El diseño del material didáctico es adecuado en contexto, en el desarrollo de la actividad, en la recogida de evidencias.
Uso de la Bluebot	UB1	/3	La actividad desarrollada no justifica el uso de la bluebot y podría utilizarse otro tipo de material para conseguir los mismos objetivos de aprendizaje.	La actividad es más ágil gracias a la ayuda de la bluebot, aunque no es imprescindible su uso.	La actividad desarrollada justifica el uso de la bluebot, pero no utiliza todo su potencial educativo. (ej. hay comandos de la bluebot que no se utilizan)	La actividad planteada justifica perfectamente el uso de la bluebot para mejorar el aprendizaje.
	UB2	/3	El uso de la bluebot no permite mejorar el interés en la materia, el trabajo en equipo, la creatividad, ni el pensamiento computacional.	El uso de la bluebot permite mejorar alguna de las siguientes potencialidades educativas: interés en la materia, el trabajo en equipo, la creatividad, ni el pensamiento computacional.	El uso de la bluebot permite mejorar la mayoría de las siguientes potencialidades educativas: interés en la materia, el trabajo en equipo, la creatividad, ni el pensamiento computacional.	El uso de la bluebot permite mejorar el interés en la materia, el trabajo en equipo, la creatividad y el pensamiento computacional.
Puntuación Total:	______					

Appendix H – Participants' Training Journals

Reflexión sesión 1

1. Antes de realizar la sesión de hoy sobre robótica educativa sabia

____
____

2. Al finalizar la sesión de hoy he aprendido sobre robótica educativa

____
____

3. La sesión de hoy me ha parecido

____
____

4. Al acabar la sesión de hoy, considero que se hacer _____________________que antes no me sentía capaz de hacerlo y lo he conseguido y considero que sigo sin poder hacer ____ y necesitaría ____ para sentirme capaz de ello.

5. Los potenciales educativos que veo de la robótica son

____
____

Reflexión sesión 2

1. La sesión de hoy me ha parecido

____
____

2. Al acabar la sesión de hoy, considero que se hacer _____________________que antes no me sentía capaz de hacerlo y lo he conseguido y considero que sigo sin poder hacer ____ y necesitaría ____ para sentirme capaz de ello.

3. Los potenciales educativos que veo de la robótica son

____
____

Reflexión sesión 3

1. ¿Conocías antes de esta sesión la evaluación 360º?

____
____

2. ¿Qué opinión tienes sobre este tipo de evaluación?

____
____

3. La sesión de hoy me ha parecido

____
____

4. Al acabar la sesión de hoy, considero que se hacer _____________________que antes no me sentía capaz de hacerlo y lo he conseguido y considero que sigo sin poder hacer ____ y necesitaría ____ para sentirme capaz de ello.

5. Los potenciales educativos que veo de la robótica son

____
____

6. Esta formación en robótica educativa me ha parecido

____
____

7. ¿Qué aspectos modificarías sobre el desarrollo de la formación recibida en robótica educativa?

____
____

Appendix I - Results of Questionnaire 1

Item	Mean (SD)/ Item - ER Perceptions prequestionnaire	Mean (SD) /Item - ER Perceptions postquestionnaire
U1	5.78 (1.130)	5.91 (1.205)
U2	5.77 (1.112)	5.79 (1.353)
U3	6.07 (1.003)	6.26 (0.978)
U4	5.51 (1.229)	5.74 (1.354)
F1	5.73 (1.159)	6.40 (0.818)
F2	6.03 (1.194)	6.43 (1.039)
F3	5.91 (1.088)	6.38 (0.907)
D1	6.18 (1.087)	6.49 (0.811)
D2	5.82 (1.680)	6.29 (1.392)
D3	6.50 (0.783)	6.68 (0.684)
A1	6.23 (0.937)	6.44 (0.836)
A2	4.82 (1.680)	5.29 (1.392)
A3	6.36 (0.839)	6.50 (0.707)
I1	6.44 (0.795)	6.56 (0.751)
I2	6.34 (0.781)	6.49 (0.782)

Mean (SD)		t	p	Cohen's d
Usability - pre 5.781 (0.967)	Usability – post 5.925 (1.118)	1.279	0.204	0.135
Ease of Use – pre 5.893 (1.020)	Ease of Use – post 6.404 (0.781)	4.369	<0.05	0.461
Enjoyment – pre 6.181 (0.898)	Enjoyment – post 6.526 (0.785)	3.244	<0.05	0.412
Attitudes – pre 6.137 (0.897)	Attitudes – post 6.411 (0.776)	2.957	<0.05	0.342
Intention of Use – pre 6.394 (0.748)	Intention of Use – post 6.522 (0.753)	1.314	0.192	0.138

Appendix J - Results of Questionnaire 2

Item	Mean (SD) /Item - ER Self-efficacy prequestionnaire	Mean (SD) /Item - ER Self-efficacy postquestionnaire
IT1	3.98 (1.016)	4.28 (0.600)
IT2	4.41 (0.652)	4.52 (0.565)
IT3	3.99 (0.977)	4.37 (0.626)
IT4	3.96 (0.982)	4.34 (0.673)
IT5	2.81 (1.027)	3.89 (0.678)
IT6	2.91 (1.077)	3.88 (0.700)
Self-efficacy	22.06 (4.41)	25.28 (3.01)

Appendix K - Examples of coded journals of session 3 (week 6)

Code ID	Codes	Example comments Student 1	Example comments Student 2
F.	The presentation and evaluation of the projects was interesting.	-	-
G.	The presentation and evaluation of the projects was useful.	-	-
H	The projects' online evaluation was practical.	-	-
I.	The online self and peer evaluation helped us recognize the strong and weak aspects of our project and/or our peers' project.	Pienso que es muy adecuada para saber reconocer los errores y mejorar como futura docente.	Hemos podido añadir nuestro punto de vista sobre la creación de las alfombras de diferentes grupos y de la propia, y nos ha servido para darnos cuenta de qué aspectos podríamos mejorar para la próxima vez.
J.	The self, peer and teacher evaluation were fair.	Me ha parecido muy correcta, para identificar los propios errores y ser capaz de evaluar objetivamente a los compañeros de clase.	De esta manera, le daremos un enfoque más objetivo a la evaluación y nos facilita aportar nuestra opinión sobre las debilidades y fortalezas de cada grupo y su trabajo realizado.
K	I'd prefer to try out the projects in class.	-	-
L.	The training was innovative.	-	-
M.	Participating in the training was useful.	me ha parecido muy útil para la formación docente y lo encuentro necesario para poder innovar en la educación y mejorar.	El hecho de crear una alfombra por grupos me ha parecido una idea genial, porque nos será útil en un futuro si lo queremos poner en uso con nuestros alumnos, y es una manera de probar si la realización de

			nuestro proyecto sería factible.
N.	Participating in the training was entertaining.	-	
O.	Participating in the training was interesting.	-	El proyecto de robótica me ha parecido muy interesante para nosotros, los futuros maestros.
P.	Need for additional ER resources.	Tener más tiempo para experimentar con las tabletas y diferentes robots, no solo el Blue-Bot, pero por el corto periodo que la hemos impartido me ha parecido muy completa para iniciarte en este mundo.	-
Q.	Need for additional time for experimentation with the resources.	Tener más tiempo para experimentar con las tabletas y diferentes robots, no solo el Blue-Bot, pero por el corto periodo que la hemos impartido me ha parecido muy completa para iniciarte en este mundo.	-
R.	Preference for completing the training on-site	-	-
S.	Need for additional training sessions.	-	-

Appendix L – Research Stay Certificate

Laboratoire d'Innovation et Numérique pour l'Education

INTERNATIONAL RESEARCH STAY CERTIFICATE

This is to certify that Despoina Schina has completed a research stay of 3 months from the 15th February to the 16th May 2021 at the Laboratoire d'Innovation et Numérique pour l'Éducation (LINE) at Université Côte d'Azur.

During her stay she collaborated within the Let's Steam project, participated in the data collection and analysis of the CreaCube task and shared with the members of LINE lab the progress and conlcusions of her PhD thesis.

Margarida ROMERO, Full professor
Learning, INnovation and Education (LINE) research lab, Université Côte d'Azur
43, avenue Stephen Liégeard, 06100, Nice, France
Tél : (+33) (0) 6 81 21 | 65 25 margarida.romero@univ-cotedazur.fr
https://www.researchgate.net/profile/Margarida_ROMERO

Appendix M – Concurs 'Vols saber què investigo?' 2021

Link to the recording of the competition: https://www.youtube.com/watch?v=bVBoQX0hVNM

UNIVERSITAT ROVIRA i VIRGILI

Josep Ribalta Vives, amb N.I.F. 35086161-Y, com a Vicerector de formació doctoral i director de l'Escola de Postgrau i Doctorat de la Universitat Rovira i Virgili, amb N.I.F. Q-9350003-A, de Tarragona,

CERTIFICA:

Que Despoina Schina del programa de doctorat en Tecnologia Educativa, amb el NIE Y3188820E ha participat en la final del concurs de monòlegs científics "Vols saber què investigo una activitat de divulgació de la recerca i ha quedat **classificada en segona posició**:

- Dia i hora: **21 de maig de 2021** de **10.00 a 13.30 h.**, a l'Aula Magna del campus Catalunya de Tarragona . Final del concurs de monòlegs

Ha participat també en:

- Una sessió informativa i tres sessions d'assaig durant els mesos d'abril i maig.

Organitza: Unitat de Comunicació de la (UCC+i) de la Universitat Rovira i Virgili i l'Escola de Postgrau i Doctorat de la URV.

I per a què així consti, signa aquest certificat.

Josep Ribalta Vives - DNI 35086161Y (SIG)

Firmado digitalmente por Josep Ribalta Vives - DNI 35086161Y (SIG)
Fecha: 2021.05.27 09:34:50 +02'00'

Josep Ribalta Vives
Vicerector de formació doctoral i director de l'Escola de Postgrau i Doctorat de la URV

Tarragona, 26 de maig de 2021

UNIVERSITAT ROVIRA i VIRGILI