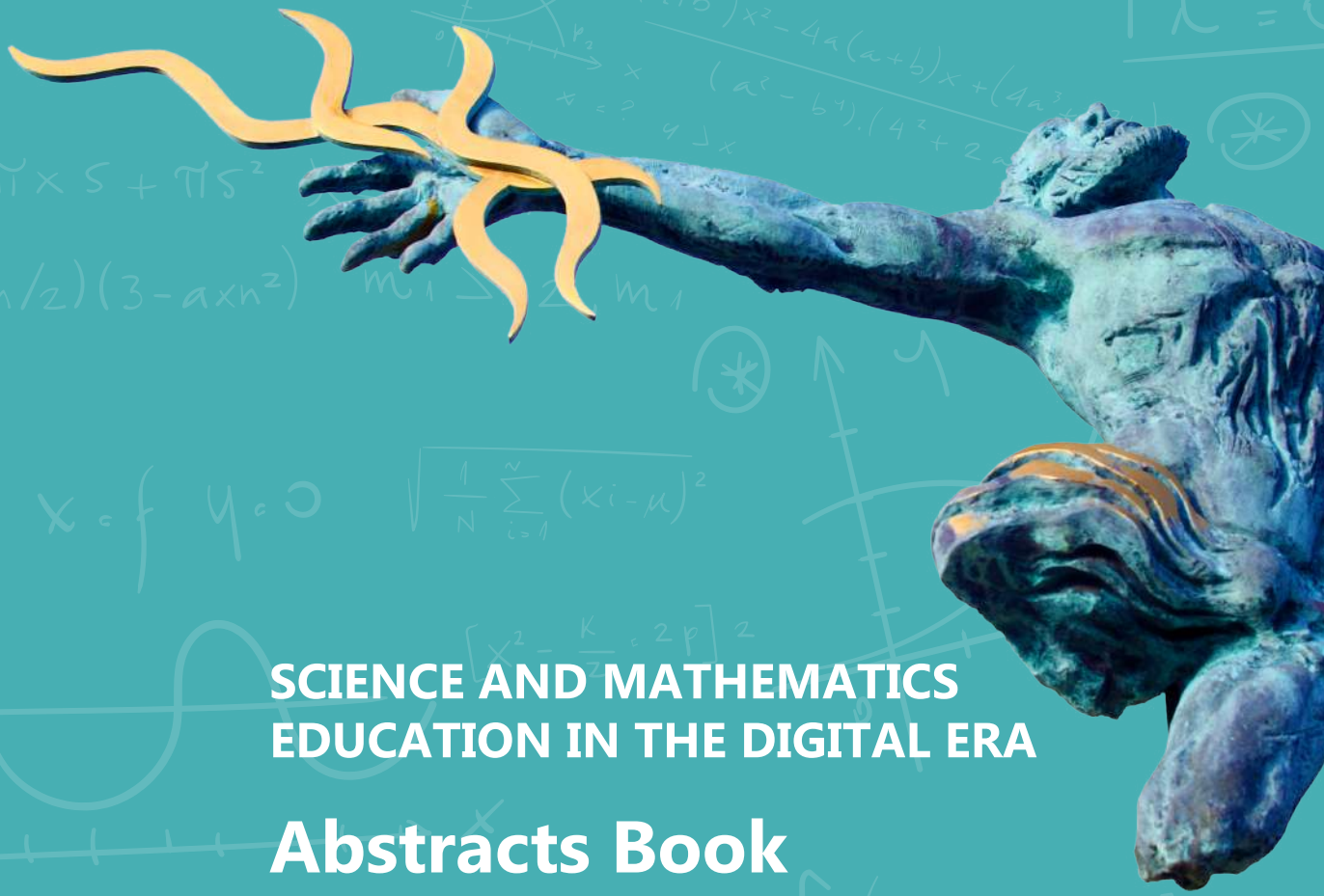
ATEE

Association for Teacher Education in Europe

WINTER CONFERENCE 2026



SCIENCE AND MATHEMATICS EDUCATION IN THE DIGITAL ERA

Abstracts Book

March 30th to April 1st
University of Minho, Braga, Portugal

ATEE WINTER CONFERENCE 2026

SCIENCE AND MATHEMATICS EDUCATION IN THE DIGITAL ERA

ABSTRACTS BOOK

University of Minho

Braga – Portugal

March 30th to April 1st

ATEE Winter Conference 2026: Abstracts Book

Published 2026 (March)

Organizers: Laurinda Leite (Coordinator), Floriano Viseu, Luís Dourado, Maria Helena Martinho, Luísa Carvalho and Sofia Morgado

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Edited by CIEd (Research Centre on Education)
Institute of Education, University of Minho
Braga, Portugal

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Section I

GENERAL INFORMATION

How to Use this Book

The Conference overall programme includes scientific and social events. The former takes place on March 31st and April 1st; the latter takes place on March 30th and 31st. The scientific programme includes slots devoted to Invited Sessions (including Keynote Addresses and a Panel), Parallel Sessions, and a Posters exhibition and discussion. The social programme includes a visit to the Secondary School Carlos Amarante and the Iberian Nanotechnology Laboratory, in Braga, a Welcome Reception and a Social Dinner. Coffee breaks (free) will be served at the Institute of Education, and lunches (free) at the Campus Canteen.

This book is devoted to the scientific programme, and it is structured into three sections: Conference Programme, Invited Sessions Abstracts, and Papers and Posters Abstracts.

The Conference Programme section includes the overall programme, a detailed programme of the Parallel Sessions (listing the papers to be orally presented in each session and room), as well as the list of Posters to be displayed from the beginning of the Conference and discussed as planned in the programme.

As far as abstracts are concerned, they are organized by code and category of presentation, starting with Keynotes, and Panel presentations, followed by oral Papers and Posters abstracts.

In the detailed programme of the Parallel Sessions, the oral paper code (O followed by the paper number), title, and author(s) are given; in the Posters List, the poster code (P followed by the poster number), title, and author(s) are also given.

If you want to find an abstract of a paper or a poster, you should start by looking for the paper or poster code (Oxy or Pxy) in the Parallel Sessions programme or in the List of Posters. Afterwards, you can either activate the hyperlink or move to the Papers and Posters Abstracts section and use the paper or poster code number to look for the abstract you are interested in.

Acknowledgements

Organizing a Conference is only possible with the collaboration of several institutions, organizations, and Individuals. The ATEE Winter Conference 2026 follows this rule.

Fisrt of all, the Organizing Committee members would like to express their gratitude to the Association for Teacher Education in Europe (ATEE), in the person of its President, Professor Agnieszka Szplit, and to the Research and Development Community (RDC) on Science and Mathematics Education, in the person of its chairwoman, Professor Lorraine Harbison, for trusting us as local conference organizers.

Thanks are also due to the University of Minho, in the person of its Rector, Professor Pedro Arezes; the Institute of Education of the University of Minho, in the person of its President, Professor Maria Assunção Flores; the Research Centre in Education (CIEd), in the person of its Director, Prof. José Augusto Palhares; the Department of Literacy, Didactics and Supervision (DLDS), in the person of its Director Prof. Fernando Azevedo, and the School of Psychology, in the person of its president, Professor Pedro Rosário. All of them contributed to this Conference in different and valuable ways.

Thanks are also due to the following individuals: members of the Academic Committee for their valuable contribution to raise the quality of research in the area of Science and Mathematics Education by their careful revision of the paper and poster abstracts; papers' and posters' authors for the kind way they received the evaluation results and reviewed the abstracts; all the participants that decided to attend the conference - without them, the conference would not make sense; Mariagrazia Tagliabue, Lucie Briquet, José Emílio Palmeira, Filipa Pereira, Ana Catarina Silva, Nuno Oliveira and Paulo Oliveira, for their permanent willingness to do what was needed so that this Conference could be a successful one.

Finally, thanks are due to Fundação para a Ciência e a Tecnologia (FCT) for its support, and to the Secondary School Carlos Amarante and the Iberian Nanotechnology Laboratory (INL) for agreeing to receive the Conference participants to share with them how teaching and research in the areas of Science and Mathematics are going on in Portugal.

Thank you all! The success of the Conference is yours!

Academic Committee

Coordinators: Laurinda Leite, University of Minho, Portugal
Lorraine Harbison, Dublin City University, Ireland

Members	Institution	Country
Alexander Aumann	University of Education Weingarten	Germany
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Ana Peixoto	Polytechnic Institute of Viana Castelo	Portugal
Ana S. Afonso	University of Minho	Portuga
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Bento Cavadas	University of Aveiro	Portugal
Clara Vasconcelos	University of Porto	Portugal
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Elizabeth Oldham	Trinity College Dublin	Ireland
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Mónica Baptista	University of Lisbon	Portugal
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Verônica Batinga	Federal Rural University of Pernambuco	Brazil

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Maria Helena Martinho	University of Minho	Portugal
Sofia Morgado	University of Minho	Portugal

Permanent Secretariat

Name	Institution	Country
Mariagrazia Tagliabue	ATEE	Belgium
Lucie Briquet	ATEE	Belgium
Sofia Morgado	University of Minho	Portugal

Welcome to the ATEE Winter Conference 2026

The ATEE Winter conference is one of the three ATEE conferences, which are organized every year, the others being the Spring conference and the annual conference. The Winter conference is usually organized by one (or more) of the several ATEE Research and Development Communities (RDCs). This Conference is organized by the RDC on Science and Mathematics Education, which is one of the longest-standing and most active RDCs.

Science and Mathematics Education is an area of interest to policymakers worldwide. It is a relevant area not only for the ongoing scientific and technological development of modern, globalised and digital societies, but also for citizenship education and the sustainability of the Planet. Moreover, it contributes to the full development of the individual learner. Science and Mathematics teachers, teacher educators, and researchers can therefore help to make a difference beyond the classroom.

However, science and mathematics education are facing multiple challenges associated with the digital transition. Thus, the ATEE Winter Conference 2026 focuses on science and mathematics education in the digital era. The goal of the Conference is to provide a platform for scholars worldwide to reconceptualize, recontextualize, and discuss conventional topics in science and mathematics education research in light of the digital paradigm, as well as to share and realistically discuss the emerging ones, considering their potential, limitations, and possible threats. Additionally, as several countries are faced with the threat of teacher shortage, ways to attract students to science and mathematics, and teachers to the profession will be discussed.

Thus, the Conference encompasses a large set of subthemes that cover the diverse dimensions of the conference theme, as follows:

- Role and features of science- and mathematics-related education in the digital era
- Science- and mathematics-related literacies for a sustainable and digital future
- Science and mathematics materials (e.g., syllabi, textbooks, digital textbooks, etc) in the digital era
- Disciplinary and interdisciplinary approaches to science and mathematics education in the digital era
- Science and mathematics teacher education for a digital future
- Motivating and engaging science and mathematics students in the digital era
- Assessment in science and mathematics education in the digital era
- Opportunities and challenges offered by online science and mathematics education
- Artificial Intelligence in science and mathematics education
- Maker education for promoting STEM learning
- Robotics as an interdisciplinary STEM-promoting tool
- Gamification in science and mathematics education
- Digital labs and other technologies for science and mathematics education
- Digitalization and the leveraging of diversity and inclusion in science and mathematics education

Each Keynote address will focus on a timely and cross-disciplinary topic related to the conference theme. The Panel will offer an opportunity to discuss ways forward concerning the multiple challenges that science and mathematics education face in the digital era.

Over eighty papers and posters will be presented at the Conference. The accepted proposals were blind peer eviewed refereed by at least two members of the Conference Academic Committee, and many of them were reviewed and improved by their author(s) before being accepted. They will surely offer a rich

and multifaceted picture of the Conference theme. However, the ideas conveyed by the papers and posters are those of their authors and may not coincide with those of ATEE or the local organizers.

Finally, it should be emphasized that the Conference will be an excellent opportunity for the members of the Research and Development Community (RDC) on Science and Mathematics Education to hold meetings that will foster ongoing projects and enable the Community to be strengthened and enlarged. First-time attendants are strongly encouraged to join our RDC so that we can develop research together.

Usually, ATEE Conferences offer an opportunity for attendants to get familiar with the host country's culture. The ATEE Winter Conference will not be an exception. Participants will have the opportunity to watch a Gatuna's (Tuna Feminina Universitária do Minho) performance (welcome reception), to enjoy the Portuguese Guitar melody, played by Eduardo Soares (opening ceremony), and to dance to the «energetic» sound of Grupo de Cavaquinhos de Esporões, Braga (Conference Dinner). In addition, they can enjoy the famous Braga Holy Week festivities, which take place in the streets, mainly in the evenings!

On behalf of the Organizing Committee, I would like to welcome all the ATEE Winter Conference participants and to send a special greeting to those who are attending an ATEE Conference for the first time. Wish you a fruitful Conference and a pleasant time at the University of Minho and in Braga.

Laurinda Leite
(Coordinator of the Organizing Committee)

Section II

CONFERENCE PROGRAMME

Conference Overall Programme

Monday, March 30th (Pre-Conference)

14:30-17:30	Visits to Secondary School Carlos Amarante or INL-Iberian Nanotechnology Laboratory
18:00-20:00	Welcome Reception

Tuesday, March 31st

08:30-9:30	Participants' registration
9:30-10:30	Opening ceremony
10:30-11:30	Keynote 1: Teachers as change agents: from technology consumption to creative production in education, Margarida Romero, Université Côte d'Azur, France
11:30-12:00	Coffee break
12:00-13:00	Parallel sessions
13:00-14:30	Lunch
14:30-16:00	Parallel sessions
16:00-16:30	Coffee break
16:30-18:00	Parallel sessions
19:30-22:30	Social dinner

Wednesday, April 1st

09:15-10:15	Keynote 2: The impact of robotics in STEM education, Theodosios Sapounidis, Aristotle University of Thessaloniki, Greece
10:15-10:30	ATEE Annual Conference announcement
10:30-11:00	Posters´ session
11:00-11.30	Coffee break
11.30-13:00	Parallel sessions
13:00-14:30	Lunch
14:30-15:30	Parallel sessions
15:30-16:00	Coffee break
16:00-17:30	Panel*: The challenges of science and mathematics education in the digital era
17:30-18:00	Closing ceremony

*Participants in the Panel:

Paula Korsnakova (International Association for the Evaluation of Educational Achievement, Netherlands)
Lucy Avraamidou (University of Groningen, Netherlands)
Ana Paula Canavarro (University of Évora, Portugal)
Maria Assunção Flores (University of Minho, Portugal)
Lorraine Harbison (Dublin City University, Ireland) - Moderator

Notes: - Meeting point for visits: Institute of Education; Campus de Gualtar, Braga
- Plenary sessions: Multimedia Auditorium, Institute of Education, Campus of Gualtar
- Parallel sessions: rooms 1 - 5, ground floor, Institute of Education, Campus of Gualtar
- Coffee break: main hall - Institute of Education, Campus of Gualtar
- Lunch takes: Canteen, Campus of Gualtar
- Welcome Reception: main hall, Institute of Education, Campus of Gualtar
- Social Diner: Hotel Meliã, Braga

Parallel Sessions Programme

Tuesday, March 31st

12h00-13h00

Chair: Rosalyn Hyde — **Room 1**

Paper	Title	Author(s)
O1	Using real-world and research-based SDG data to support student engagement and quantitative understanding in mathematics	Elena Martelli
O20	The use and impact of digital technologies by teachers of mathematics and science in Europe: findings from TALIS (2024)	Rosalyn Hyde & Yin Wang

Chair: Mónica Baptista — **Room 2**

Paper	Title	Author(s)
O45	Exploring pre-service chemistry teachers' difficulties in introductory Arduino-based activities for chemistry laboratory applications	Cidália André, Carla Morais & Gildo Girotto Junior
O49	PCK of pre-service physics teachers when involved in a lesson study	Mónica Baptista, Teresa Conceição & Maria Francisca Macedo

Chair: Raúl López-Vilar		**Room 3**
Paper	**Title**	**Author(s)**
O8	Activity Theory as a lens for exploring and comparing STEAM and Non-STEAM classroom practices	Raúl López-Vilar, Mireia Usart Rodríguez, José Luis Lázaro Cantrabrana, & Tania Molero-Aranda
O29	The role of design thinking in the development of creativity in an I-STEM learning sequence	Ana Rita Alves, Mónica Baptista & Teresa Conceição

Chair: Malgorzata Zytko		**Room 4**
Paper	**Title**	**Author(s)**
O31	Integrating mathematical games into pre-service and in-service elementary school teacher training	Karolina Prus-Wirzbicka & Malgorzata Zytko
O61	From compass to code: the role of hybrid feedback in the development of Computational thinking in a 2nd cycle mathematical task	Vera Escaleira, Lina Fonseca & Maria M. Nascimento

Chair: Eleanor Byrne		**Room 5**
Paper	**Title**	**Author(s)**
O21	Maker education in the Portuguese low secondary school curricula	Laurinda Leite, Luís Valente, António Osório, Luís Dourado, Ana S. Afonso, Cristiana Araújo, Floriano Viseu, Helena Martinho & Pedro Rangel Henriques
O28	Using GenAI to support curriculum reform in mathematics education: a professional development case study	Eleanor Byrne, Aibhín Bray & Brendan Tangney

Tuesday, March 31st

14h30-16h00

Chair: András Bátkai — **Room 1**

Paper	Title	Author(s)
O12	AI-powered microlearning to support non-specialized mathematics teachers in upper secondary education	Meritxell Valderrama & Mireia Usart
O16	Prospective teachers' views on mathematics education in primary school in the digital era	Ineta Helmane
O37	Homework with sound and image: using student-generated videos in higher mathematics education	András Bátkai & Brigitta Békési

Chair: Bento Cavadas — **Room 2**

Paper	Title	Author(s)
O5	Interdisciplinary digital learning scenarios: a strategy to enhance science and mathematics teacher education	Bento Cavadas & Neusa Branco
O46	STEM definitions over the digital era	Ana Ferreira, Carla Morais, Luciano Moreira & Raquel Ribeiro
O60	Digital game design in biology teacher education: formative experiences in Brazil and Portugal	Alline Bettin de Oliveira, António Osório & Luís Dourado

Chair: Mairéad Holden		Room 3
Paper	**Title**	**Author(s)**
O22	Smart Islands: beyond the bridges	Mairéad Holden, Beverley McCormick, Adrian Boyd & Tríona Nic Fhinn
O54	Integrated STEAM activities in primary teacher education: insights from supervised teaching practice	Marisa Correia & Maria Clara Martins
O56	Lesson study with STEM tasks: the professional development of natural sciences and physics–chemistry teachers	Júlia Prada & Teresa Conceição

Chair: Lorraine Harbison		Room 4
Paper	**Title**	**Author(s)**
O24	Hybrid lesson study for supporting teachers' professional judgement about fractions reasoning across the Island of Ireland	Lorraine Harbison, Miriam Ryan, Elizabeth Oldham, Hamsa Venkat, Geraldine Parks, Mairéad Holden, Shauna McGill & Deirdre Ní Chonghaile
O25	Innovation or regression? Platformization and its impacts on inclusion, knowledge, and the teaching profession	Solange Hassan Ahmad Ali Fernandes & Elaine Pavini Cintra
O52	Bridging teacher knowledge frameworks through a global integrative model	Helena Rocha

Tuesday, March 31st

16h30 – 18h00

Chair: Paulína Koršňáková **Room 1**

Paper	Title	Author(s)
O17	Educating pupils for environmental sustainability in European Union and Western Balkan: comparative overview based on TIMSS 2023 data	Branislav Ranđelović & Valentina M. Ranđelović
O58	The European sustainability competence framework (GreenComp) in light of TIMSS 2023 data	Paulína Koršňáková, Tahira Ali Qadri & Wangqiong Ye
O59	The role of school organizations in promoting sustainability	Inés García-Bohórquez, Dries Verhelst, Fernando Martínez-Abad & Camilo Ruiz

Chair: Natalia Garcia Domenech **Room 2**

Paper	Title	Author(s)
O18	Science through stories: insights from the CAPERS project	Natalia Garcia Domenech & Mairead Holden
O30	Machine learning as a cognitive tool: fostering critical scientific reasoning	Ana Rita Alves, Mónica Baptista & Teresa Conceição
O44	GiroGiraMente: integrating maker education principles for computational thinking development in science education	Nuno Braga, Ileana Souza, Ricardo Silva, Cristiana Araújo & Pedro Rangel Henriques

Chair: Emanuel Santos		**Room 3**
Paper	**Title**	**Author(s)**
O40	Project-based STEM learning in elective high school courses: engineering design, productive failure, and authentic assessment in an international school context	Emanuel Santos
O47	Enhancing preservice primary teachers' STEM self-efficacy: perceptions from adapted SETIS	Marisa Correia & Dulce Martins
O50	Contributions of a STEM education professional development program to the PCK of physics and chemistry teachers	Iva Martins & Mónica Baptista

Chair: Nadia S. Kennedy		**Room 4**
Paper	**Title**	**Author(s)**
O4	Reimagining statistics teacher education with flipped learning	Aslıhan Batur Öztürk, Travis Weiland, Anthony Fernandes & Adnan Baki
O6	Supporting preservice mathematics teachers' entry into data science through structured computational modeling with R	Nadia S. Kennedy & Boyan S. Kostadinov
O23	Statistics education and digital work precarization: teaching experiences in technical courses	Lauro Chagas e Sá & Stella Gomes de Souza

Chair: Mujo Mesanovic		**Room 5**
Paper	**Title**	**Author(s)**
O26	Academic integrity, assessment, and student motivation in mathematics education in the age of artificial intelligence	Mujo Mesanovic
O36	Numbers don't lie? The ethics and responsibility of mathematical modeling in the digital era	András Bátkai
O57	Perceptions of teachers in training on the use of artificial intelligence in formulating and solving problems	Iza Helena Travassos, Maria Helena Martinho & José Augusto Pacheco

Wednesday, April 1st

11h30 – 13h00

Chair: Elizabeth Oldham **Room 1**

Paper	Title	Author(s)
O41	High-stakes assessment of mathematics in the senior cycle of secondary education: challenges and affordances at a time of curriculum change in Ireland	Elizabeth Oldham
O42	STEAM projects and assessment in initial teacher training: evidence from an umbrella review	Cristina Martins & Patrícia Teixeira
O43	InMath - early results of the trial of accessible and inclusive problem-solving activities for intellectual disabilities	Sara Cecchetti & Fabio Sacchi

Chair: Mariana Cortez **Room 2**

Paper	Title	Author(s)
O10	Developing a TPD model for environmental citizenship in science education: bridging critical pedagogy and digital strategies	Larissa Nascimento & Pedro Reis
O15	The missing link in science education: bioethics and geoethics as a double helix of educational tools for science teachers	Marta Paz & Clara Vasconcelos
O27	The importance of a functional teaching laboratory in the training of science teachers in the early years of schooling: scoping review	Mariana Cortez, Marcus Pereira Junior, Patrícia Christine Silva & Ana V. Rodrigues

Chair: Roxana-Madalina Cristea		Room 3
Paper	**Title**	**Author(s)**
O7	STEAM in mathematics versus mathematics in STEAM: what does useful technology implementation mean?	Brigitta Békési, Eva Ulbrich, Tony Houghton, Jana Trgalova, Zsolt Lavicza
O51	Digital learning environments as a support for addressing mathematics anxiety in STEM education	Roxana-Madalina Cristea & Elsa C. Price
O53	Maths in STEM learning for sustainability	Cristina Ribeiro, Maria Luisa Azevedo & Cristina Mesquita

Chair: Isabel Saúde		Room 4
Paper	**Title**	**Author(s)**
O11	PLAYLAB.AI as an AI tutor in pre-service science teacher education	Isabel Saúde, Luciane Penteado Chaquime & José Luís Araújo
O13	Science education for citizenship in basic education: science-technology-society in plate tectonics	Luís Filipe Moreira
O39	Makerspaces in Greek schools: trends, impact and challenges	Christina Volioti, Theodosios Sapounidis, Ioannis Spinos & Genovefa Lachana

Chair: Aparecida de Fátima Silva		Room 5
Paper	**Title**	**Author(s)**
O19	Instructional strategies for teaching Chemical Bonding: reflections on the PCK and ICT-TPCK of postgraduate students	Lara Luciano da Silveira, Mónica Baptista & Brenno Oliveira
O32	The formation of an innovative profile of postgraduate students in chemistry for teaching in higher education	Aparecida de Fátima Silva & Salete Linhares Queiroz
O55	From gravity to the Earth's internal structure: how students construct boundary knowledge between physics-chemistry and natural sciences	Teresa Conceição & Júlia Prada

Wednesday, April 1st

14h30 – 15h30

Chair: Brigitta Békési		Room 1
Paper	**Title**	**Author(s)**
O3	Modern means of communication for teaching mathematics	Brigitta Békési, Eva Ulbrich, Tony Houghton, Jana Trgalova & Zsolt Lavicza
O48	Science and maths education with digital technologies: What does open access research tell us?	Teresa Margarida Loureiro Cardoso

Chair: Marthese Spiteri		Room 2
Paper	**Title**	**Author(s)**
O14	Performing the Anthropocene: non-formal science theatre for promoting youth competencies in global citizenship	Marta Paz & Clara Vasconcelos
O33	Exploring teachers' dispositions to facilitate digital equity in multicultural classrooms	Marthese Spiteri

Chair: Nkosinathi Mpalami		Room 3
Paper	**Title**	**Author(s)**
O2	Analysis of probability tasks promoted in a prescribed grade 6 South African textbook in the digital era	Nkosinathi Mpalami
O34	STEAM implementations and connections within the Portuguese high school mathematics curriculum	Sara Gonçalves & Floriano Viseu

Chair: Helena Rocha		Room 4
Paper	**Title**	**Author(s)**
O35	Perspectives on the STEAM approach from two teachers of different educational cycles	Patrícia Teixeira, Helena Rocha & Cristina Martins
O62	Empowering support teachers in mathematics: a laboratory-based training model at the University of Florence	Laura Menichetti & Duccio Tognini

Chair: Erica Pamela Köchig		Room 5
Paper	**Title**	**Author(s)**
O9	Digital implementation in early childhood education: observations of tablet-based mathematics activities using Innovamat	Erica Pamela Köchig, Beatriz Lores-Gómez & Mireia Usart-Rodríguez
O38	The semiotic potential of robotics for mathematical modelling: towards an analytical framework for mathematics education	Sónia Martins & Maria Andrade

List of Posters

Poster	Title	Author(s)
P1	Integrating digital technologies and research-based approaches in biology teacher education: a TPCK-informed program in a master's degree in biology and geology teaching	Cecília Guerra & Maria João Fonseca
P2	Dialogic and reflective supervision across university and school settings: shaping pre-service biology and geology teachers	Cecília Guerra, Nuno Correia, Alexandra Tabuaço, Anabela Sousa, Liliana Passos & André Pereira
P3	Developing smart ECO-iSTEM educational programmes: a conceptual framework and an education module	Bento Cavadas, Neusa Branco, Elena Revyakina, Florian Danhel & Willfried Swoboda
P4	Developing computational thinking with or without technology in 1st cycle mathematics classes through an exploratory teaching model	Catarina Vasconcelos Gonçalves, Rosa Rocha & Pascoal Costa
P5	Mapping STEM teachers' self-perception of their hard, soft, and digital skills and competencies	Cláudia Faria & Bárbara Coelho
P6	Instrument design for the analysis of students' conceptions about agrifood system in digital era	Jorge Pozuelo Muñoz, Esther Cascarosa Salillas, Eva Terrado, Beatriz Carrasquer, Adrián Ponz & Carlos Rodríguez
P7	Analysis of the use of artificial intelligence for educational science assessment in higher education: a systematic review (2020-2024)	Esther Cascarosa Salillas, Jorge Pozuelo Muñoz, Isabel Iranzo Navarro & Lidia Martín Ronco
P8	A didactic proposal for teaching electromagnetism in a STEAM sequence: evidence from a pretest-posttest study	Alberto Cazaña Garcés, Jorge Pozuelo Muñoz & Ana de Echave Sanz
P9	Science-society relationships in science textbooks: approaches and trends in educational research	Jorge Pozuelo Muñoz & Esther Cascarosa Salillas
P10	Algebraic structure and symmetry in quadratic functions	Leonardo Miranda, Hudson Vieira de Sousa & Fabrício Ferreira de Sousa
P11	Prospective mathematics teachers' initial perspectives on the teaching of mathematical modelling with technology	Sílvia Zuzarte, Hélia Jacinto & Hélia Oliveira
P12	Opinions of biology and geology teachers on the formative needs of students in matters related to environmental ethics	Luísa Carvalho & Luís Dourado
P13	Learning and teaching: insights into the use of artificial intelligence	Ana Pereira Antunes, Márcio Filipe, Sandra Mendonça, Karolina Baras & Nuno Fraga
P14	Water literacy in science education: a Portuguese basic education curriculum analysis	Cláudia Sousa
P15	Use of generative AI tools in practical school activities on rock types: A study with pre-service biology and geology teachers	Marcus Pereira Júnior, Betina Lopes & Rute Coimbra
P16	Interest in contextualized science learning: opinions of experts, teachers, and students	Sofia Morgado & Laurinda Leite

Poster	Title	Author(s)
P17	A Maker project in an initial primary teacher education course	Maria Helena Martinho, Ana Sofia Afonso, Beatriz Carvalho, Maria Almeida & Mariana Costa
P18	Olimpíada Matematicando: gamification and digital information and communication technologies in the Brazilian Amazon	Thalia de Nazaré Trindade da Silva & Iza Helena Travassos
P19	Awareness and action: Pre-service teachers' readiness to respond to digital risks in their future professional practice	Magdalena Bartoszewicz-Sieńko, Agnieszka Laskowska & Adam Naruszewicz
P20	Across systems, algorithms, models, and possibilities: Imagination and combinatorial art in the digital age	Valerio Ferrero

Note: Posters should be displayed from Tuesday morning (in the main hall, Institute of Education) to Wednesday afternoon. Authors should be near their posters to answer questions on Wednesday, 10h30-11h00.

Section III

INVITED SESSIONS ABSTRACTS

Keynote Addresses

Teachers as change agents: from technology consumption to creative production in education

Margarida Romero

Université Côte d'Azur, France

Concerns about young people's relationship with digital technology have increased in recent years, particularly regarding the pervasive use of social media and video games outside the classroom. These interactions frequently position learners as consumers of digital content rather than as creators. While some policy responses have focused on restricting access to smartphones or social media among young people, a central challenge for education is not only to regulate technology use but to support learners in developing creative agency in their interactions with digital technologies and artificial intelligence. In this context, developing the digital and AI competencies of both teachers and learners has become an important societal and educational challenge. Teachers therefore play a crucial role as change agents capable of transforming learners' relationships with technology from passive consumption to creative production within interdisciplinary STEAM learning activities.

This keynote examines how educators can design and facilitate technology-enhanced learning activities that foster creative problem solving, collaboration, and knowledge co-construction through STEAM approaches. The presentation adopts an epistemological pluralism that integrates sociocultural perspectives, Cultural-Historical Activity Theory (CHAT), and computational approaches in the learning sciences. Within this framework, digital technologies are conceptualized as mediating artefacts embedded in educational activity systems that shape how learners frame problems, generate ideas, prototype solutions, and iteratively refine their work.

The keynote draws on two decades of research in Technology-Enhanced Learning developed across three complementary research programs: Euro-CAT-CSCL (2003–2013), which investigated collaboration awareness tools to support regulation in computer-supported collaborative learning environments; CoCreaTIC (2013–2017), which explored the development and assessment of creativity and computational thinking in STEAM learning activities; and CreaComp (2017–present), which focuses on the study of creative problem solving through educational robotics, maker education, and computational design activities. These research programs have generated a substantial empirical corpus, including more than 1,200 CreaCube experiments, enabling the development of computational approaches for analysing creative problem-solving processes in collaborative learning environments and STEAM-based maker contexts.

Across these studies, particular attention has been given to how teachers' pedagogical design decisions influence learners' opportunities to move beyond using technology as consumers toward becoming creators, designers, and problem solvers. Examples from project-based learning, maker education, educational robotics, creative coding, and emerging AI-supported activities will illustrate how techno-creative STEAM learning environments can support co-creativity between human learners and digital technologies. The keynote will highlight how teachers can orchestrate interdisciplinary STEAM experiences that engage learners in designing artefacts, exploring real-world challenges, and developing both creative confidence and computational agency

The impact of robotics in STEM education

Theodosios Sapounidis

Aristotle University of Thessaloniki, Greece

As robotics continues to shape the future of education, understanding its impact on learning and skills outcomes becomes critically important. This keynote will describe the research efforts of the newly established Educational Technologies and Robotics Laboratory of the School of Philosophy and Education, Department of Education. Specifically, examples of recent research on school-based interventions that use educational robots will be presented. Moreover, the results of our comprehensive meta-analysis on the effectiveness of robotics in educational settings will be presented, synthesizing findings from a range of studies to highlight key trends and challenges. This analysis provides valuable insights into how robotics-based education influences students' outcomes across diverse contexts.

In addition to the meta-analysis, the DuckyCode, a cutting-edge educational system designed to enhance the teaching of programming and robotics, will be presented. DuckyCode incorporates an interactive educational robot, paired with both tangible and graphical programming languages. The tangible interface allows students to engage physically with the system, providing a hands-on learning experience, while the graphical language introduces the fundamentals of coding in an accessible way. This dual-language approach is designed to support a wide range of learning styles and developmental levels.

Drawing on both the meta-analysis and our work with DuckyCode, this talk will explore the potential of integrating physical and digital learning tools to foster skills and learning with robotics from an early age. Finally, we will close with a brief presentation of ideas within the framework of the European Teacher Academy Maker Education (TAME) program.

Panel Presentations

The challenges of science and mathematics education in the digital era

Lorraine Harbison, Dublin City University, Ireland - Moderator

The TIMSS results and challenges for science and mathematics education

Paula Korsnakova

International Association for the Evaluation of Educational Achievement, Netherlands

Trends in International Mathematics and Science Study (TIMSS) assess students' mathematics and science achievement at both the fourth and eighth grades every fourth year since 1995. It is the longest-running large-scale international assessment of mathematics and science, and is recognized by UNESCO as a solid evidence base for researchers, educators, and policymakers interested in monitoring progress towards obtaining a quality education for all (Sustainable Development Goal 4).
The most recent cycle of TIMSS, TIMSS 2023, assessed nearly 360,000 students at 4th grade and almost 300,000 students at 8th grade, across more than 70 education systems. TIMSS 2023 was also followed by TIMSS 2023 Longitudinal, which tested the same students one year later in 2024, to better understand student growth across one school year.
As well as assessing students' achievement in mathematics and science, TIMSS school, teacher, student, and home questionnaires gather extensive information about the contextual factors at school and home which are associated with learning and students' achievement.
TIMSS is designed to provide education-system level data to countries and researchers rather than student- or school-level results, providing policymakers and educators access to invaluable data for monitoring progress, identifying potential areas of improvement, and making informed decisions.
This panel input will provide an overview of trends and achievement gains recorded by recent TIMSS data and some insights into TIMSS transition into computer-based assessment (CBA). Selected individual, home, classroom, and school variables associated with achievement will be given attention, to spotlight some apparent educational challenges indicated by the data.

Longing for more liveable futures: the role of science education

Lucy Avraamidou

University of Groningen, Netherlands

The world is facing a socioscientific polycrisis due to the concurrent and interconnected crises, such as climate change, military conflicts and genocides, food and energy shortages, poverty, global health issues, and AI colonisation, among others. As the global order faces this socioscientific polycrisis, science education cannot remain unaffected. Science education is called upon to engage critically with the societal and educational changes driven by geopolitical instability, the growing influence of BigTech companies on education, and the colonial legacies and neoliberalism within current models of schooling. Such critical engagement requires reconsideration of reform efforts, a redefinition of the purpose of schooling, broadly defined, and the reconstruction of educational systems for the purpose of imagining and creating the liveable futures for all that we are longing for. In this session, I will argue about the urgency of re-imagining science education at its core through a redefinition of its purpose with a focus on bringing about social change/justice. In doing so, I will provide examples of research and curricular or real change that are happening right now at the intersection of science and arts, situated in both school and out-of-school settings.

Challenges for mathematics education in the digital era

Ana Paula Canavarro

University of Évora, Portugal

Mathematics education has always been a field of challenges, but there is no doubt that the current digital era has been enormously amplifying them. The existence of digital devices accessible to all, along with the development of specific applications and software for mathematical work, has provided sufficient reason for the need to rethink the traditional mathematics curriculum. However, current challenges are further heightened by the Artificial Intelligence, which is omnipresent and represents a paradigmatic shift in our way of life, with inevitable consequences for education. Challenges for mathematics education must be viewed within a more global framework, where it is important to perspective education in general and the purposes it needs to serve.

Thus, a challenge that I address in this panel concerns the objectives and contents of the mathematics curriculum. These must encompass much more than mathematical knowledge alone, including mathematical skills and transversal competencies, based on the principle that mathematics is for everyone and that mathematics is unique, yet not the only discipline in the curriculum - the STEM focus deserves discussion.

Another unavoidable challenge that I address in this panel is the education of Mathematics teachers. I am not referring only to the fact that we are living through a period of teacher shortages, but above all to the education they need to deal confidently and competently with the challenges of a mathematics curriculum adapted to the digital age.

We are living through unique challenges, but as always, these carry unique opportunities that are also important to discuss.

Challenges for teacher education in the digital era

Maria Assunção Flores

University of Minho, Portugal

Artificial intelligence is changing, or at least challenging, education, in general, and teacher education in particular. But what does it mean? Are teachers being prepared to teach in a more and more technological world? What are the implications for teachers' role as change agents and intellectual professionals? Are traditional pedagogical approaches and ways of preparing new teachers being changed? If so, in what ways? In this talk, I discuss the challenges and possibilities of integrating AI in teacher education. I argue for the need to invest in AI literacy for both (new) teachers and teacher educators and to consider the pedagogical, ethical and political issues of AI in teacher education, in general, and in science and mathematics teacher education, in particular.

Section IV

PAPER AND POSTER ABSTRACTS

Paper Abstracts

O1 - Using real-world and research-based SDG data to support student engagement and quantitative understanding in mathematics: early empirical evidence from a digital learning platform

Elena Martelli

Mathematics for Change, Italy

Many mathematics teachers recognise the importance of connecting their subject to sustainability-related issues, as highlighted by the United Nations Sustainable Development Goals (SDGs). However, students often perceive mathematics as abstract and disconnected from real-world concerns, which can negatively affect engagement and motivation. *Mathematics for Change* is a digital learning platform designed to address this challenge by providing ready-to-use upper secondary mathematics lessons grounded in authentic, research-based datasets related to the SDGs. Rather than replacing existing curricula, the platform aims to enrich traditional instruction by situating mathematical concepts within meaningful real-world contexts.

This paper reports early empirical evidence from the pilot phase of the platform, focusing on student engagement and quantitative understanding. Drawing on socio-constructivist perspectives and research on data literacy, the guiding research question is: *To what extent can a digital learning platform using real-world and research-based SDG-related data support student engagement and quantitative understanding in mathematics?*

The pilot phase currently involves approximately 30 teachers and around 700 upper secondary students across ten schools worldwide. Data collection is embedded directly within the platform through AI-supported pre- and post-tests and student feedback surveys. To ensure methodological coherence, the quantitative analysis presented here focuses on a single lesson case (*Phone–Life Balance*), selected because it provides a complete and stable set of assessment instruments. The analysed sample consists of 33 upper secondary students from two classes, for whom complete paired pre- and post-test data were available; only these paired cases were included in the learning-gain analysis.

Results show that mean test scores increased from 75.45% in the pre-test to 83.03% in the post-test, corresponding to an average improvement of 7.58 percentage points. Given the relatively high baseline performance, these findings suggest a positive shift in students' quantitative understanding, indicating conceptual refinement rather than remediation. Student engagement was further examined through post-lesson feedback surveys and open-ended reflections, which indicated that students perceived mathematical modelling and quantitative analysis as meaningful tools for interpreting real-world phenomena related to phone use, such as sleep fragmentation, refocusing cost, and daily habits.

Overall, these early findings suggest that embedding mathematical instruction within authentic SDG-related contexts, supported by digital tools and research-based data, can foster student engagement while supporting deeper quantitative reasoning. The pilot phase is ongoing, and additional data from further pilot schools are currently being collected, allowing replication of the analysis on a larger sample by the time of the conference.

O2 - Analysis of probability tasks promoted in a prescribed grade 6 South African textbook in the digital era

Nkosinathi Mpalami

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This paper seeks to contribute to the conversation about how cognitive demands in mathematical tasks (probability) are reflected in curriculum materials such as textbooks. Worldwide, textbooks are commonly used to communicate national curriculum standards, organise instructional time, and present a structured sequence of mathematical concepts and tasks. In this digital era, textbooks are found electronically and easy to use by both teachers and learners. However, in rural areas such as the Eastern part of the Free State both teachers and learners depend solely on hard copies of textbooks due to several challenges that include unreliable internet connectivity and electricity load shading. Research indicates that textbooks often function as key teaching resources globally, particularly in situations where teachers have limited autonomy or inadequate professional development opportunities. The current study seeks to analyse probability tasks for their cognitive demands as found in a Grade 6 South African textbook (Platinum). The book was selected because it is prescribed for use in most public schools. Probability was purposively chosen because it forms an important component of the mathematics curriculum in South African schools. Probability is part of the syllabus because it teaches learners to assess uncertainty and make informed choices at this early stage of schooling. The significance of mathematics textbooks in shaping classroom instruction and affecting learning outcomes is widely recognized especially in the South African context, where curriculum reforms strive to enhance conceptual understanding and promote equitable learning experiences. The analysis focused on the cognitive demands of the tasks, the balance between procedural fluency and conceptual understanding. The analysis was guided by Stein et al., (2000)' framework (memorization; procedure without connections; procedure with connections; and doing mathematics), which categorises tasks as low-level and high-level. The study is framed within cognitive theory. The main finding indicates that out of a total of 35 probability tasks in the chapter, 30 of them were of low cognitive demands. Of the five high level tasks none was a 'doing mathematics' task which is the task with the most cognitive demands. The implication is that with more low-level tasks, the book promotes procedural fluency (mastering algorithms) stead of developing conceptual understanding. It is recommended that despite the lack of electronic resources in rural areas, mathematics teachers might opt to use their personal gargets such as laptops and mobile phones to modify low-level tasks so that they become high level which could adequately challenge and support learners in building strong mathematical proficiency in this digital era.

O3 - Modern means of communication for teaching mathematics

Brigitta Békési[1], Eva Ulbrich[1], Tony Houghton[1], Jana Trgalova[2] & Zsolt Lavicza[1]

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In this study, we aimed to investigate the communication of mathematical knowledge using modern technology and its impact on two distinct groups: secondary students and pre-service teachers (PST). Specifically, the research evaluates: (1) students' mathematical meaning-making and the development of their 21st-century skills; (2) PSTs' beliefs, motivation and readiness to implement these tools in their future classrooms. While these skills are considered vital for students' future lives, teaching, enhancing and assessing these skills remain challenging. There is a notable lack of research addressing the impact of digital communication tools on student engagement and PST readiness. To address this, we provided Austrian lower-secondary school students of a secondary grammar school and PST at one university with practice opportunities using modern communication tools, such as (1) platforms for shared problem solving, for instance, Padlet, Miro or Whiteboard, and (2) using visual and audio support for knowledge transfer, such as Canva posters or podcasts, as practice may enhance students' and PSTs' interest in implementing these tools. Additionally, this may increase their 21st-century skills and positively impact students' knowledge creation by increasing engagement. This study's design is based on three theoretical pillars: Project-Based Learning (PBL) and Constructionism guided the design of creative activities, while Self-Determination Theory (SDT) was used to study students' and PSTs' motivation and self-efficacy. We designed activities for lower secondary school students (several classes over 4 years, around 90 students) and PSTs majoring in mathematics (various groups over 3 years, around 40 PSTs). The activities included: (1) using Padlet during a project or a whole term to collect and share ideas; (2) creating a summary poster using Canva providing solved problems and visual aids like graphs as preparation for a written exam; (3) explaining homework assignments in screen captures; (4) utilising AI to create podcasts and songs based on a written explanation of mathematical content, for instance, the surface area or the volume of rotational solids. We aimed to study how these activities impacted student and PST motivation to implement these tools and how their perceived self-efficacy changed. We hypothesise that the increased engagement and the positive emotions related to the activities enhance student learning. Additionally, we believe that the practice opportunity positively impacts PSTs' self-efficacy and willingness to implement modern means of communication in teaching. Data were collected at both educational levels via Likert-type questionnaires, semi-structured interviews, classroom observations and analysing the results of the creative processes, such as posters, podcasts and Padlet boards. The quantitative data were analysed using descriptive statistics, while the qualitative data were analysed by structured coding using a bottom-up approach and determining frequencies. The creative process outcomes were studied for correctness and elaborateness. The collected data and the mixed-method analysis suggest that practice opportunities are beneficial for motivation, perceived self-efficacy in tool implementation and knowledge creation. These findings underscore the importance of developing activities that use modern communication tools and integrating such instruction on these tools into PST curricula to ensure comfortable future implementation.

O4 - Reimagining statistics teacher education with flipped learning

Aslıhan Batur Öztürk[1], Travis Weiland[2], Anthony Fernandes[2] & Adnan Baki[3]

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Effective statistics teacher education should promote a deep understanding of statistical concepts and pedagogical content knowledge. Based on theories of the flipped classroom and statistical knowledge for teaching (SKT), this study uses a case study approach to examine the experiences of five pre-service teachers in a teacher preparation program in the United States. We conceptualize SKT as encompassing components of key developmental understandings, curriculum knowledge, knowledge of student, knowledge of teaching, and pedagogically powerful ideas. As typical of case study research, this small sample enables detailed exploration of individual experiences. Specifically, the study examines how well a flipped classroom model supports the development of pre-service teachers' SKT. We addressed two research questions: (RQ1) What patterns of change are evidenced in pre-service teachers' SKT, and (RQ2) How do pre-service teachers explain the role of flipped learning in supporting that development?

The intervention was implemented over a period of seven weeks, with sessions held twice a week. The flipped classroom model incorporated a structured combination of asynchronous pre-class materials and interactive in-class sessions. Pre-service teachers engaged with a range of online resources on Canvas, including e-books and quizzes. These materials were intentionally designed to address foundational topics in statistics, such as the nature and history of statistics, statistical literacy, the formulation of statistical investigative questions, sample and sampling, statistical graphs, and measures of central tendency and variability. Class sessions focused on collaborative problem-solving, peer discussion, and instructor feedback, fostering an environment conducive to active learning and reflective practice. Data for the study were collected through classroom observations, pre-service teachers' artifacts, reflective journals, and an opinion survey. The collected data were then analyzed thematically to identify patterns in the development of pre-service teachers' SKT. Initial codes were guided by the SKT components above, and themes were refined iteratively through constant comparison across data sources.

Findings indicate that engagement with pre-class materials enhanced pre-service teachers' understanding of both statistical content and pedagogical content knowledge. Being prepared for class enabled pre-service teachers to comprehend the purpose of in-class activities more effectively and to participate actively in collaborative exercises. Within these active learning environments, pre-service teachers had opportunities to deepen their understanding, discuss ideas with peers, and address potential misconceptions, thereby supporting the development of their SKT. Furthermore, survey responses suggested that pre-service teachers generally perceived the flipped learning approach positively, reporting that it helped them organize their preparation, engage more effectively in class, and benefit from the overall learning process. Challenges included sustaining interest in pre-class materials, integrating unprepared students, encouraging participation in demanding activities, and supporting pre-service teachers in producing meaningful learning artifacts such as lesson plans.

Incorporating flipped classroom approaches into statistics teacher education can strengthen pre-service teachers' SKT while promoting active, student-centered learning. Furthermore, these findings highlight the potential of flipped classroom strategies to inform future teacher education practices, enhance instructional approaches, and support ongoing professional development in statistics education.

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O5 - Interdisciplinary digital learning scenarios: a strategy to enhance science and mathematics teacher education

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This study was conducted within an initial teacher education (ITE) program focused on science and mathematics (sci&math) education, where preservice teachers (PSTs) were challenged to create Interdisciplinary Digital Learning Scenarios (IDLS) using digital tools for teaching in grades 5 and 6. Learning scenarios are structured lesson plans that incorporate real-life contexts and problem-solving activities, promoting skills. The following research question guided this study: *How does the create-discuss-improve process of developing an Interdisciplinary Digital Learning Scenario enhance PSTs' pedagogical knowledge and digital competencies in integrating sci&math education?*

Teachers encounter significant challenges in forging meaningful connections across STEM domains - such as sci&math. The creation of pedagogical strategies that promote greater interconnection between subjects and the development of an interdisciplinary teacher education model are some of those challenges. Furthermore, fostering digital competencies in teachers is essential to promote the development of skills that students need to succeed in an increasingly digital world, as outlined in the DigComp 3.0 Framework.

This work argues that learning scenarios can support and advance the previous goals, and introduces an innovative strategy: create-discuss-improve IDLS to foster sci&math teacher education.

This study was conducted as part of a collaboration between two courses - Science Education and Mathematics Education - in ITE, taught by two teacher educators. It involved 12 PSTs who worked in small groups to create-discuss-improve an IDLS, using digital tools for sci&math education. Each group' initial IDLS version was collectively discussed, and the insights obtained were used to refine the final version. Data collection included the final IDLS and individual written reflections completed after the create-discuss-improve process. A content analysis was conducted to identify how digital resources were used and to highlight the main aspects of sci&math integration, aiming to uncover pedagogical knowledge dimensions for sci&math teaching expressed by the PSTs. The analysis revealed that PSTs selected, created or adapted digital resources to support teaching and enhance students' learning in sci&math, engage and motivate students, facilitate the presentation of both subjects' content, guide students through digital tasks, and assess. They identified opportunities for connections within the sci&math curriculum and designed learning sequences integrating both areas. Overall, the create-discuss-improve process of IDLS was a significant strategy for enhancing the pedagogical knowledge, fostering interdisciplinarity and PSTs' digital competencies. This approach could be applied in other ITE contexts.

O6 - Supporting preservice mathematics teachers' entry into data science through structured computational modeling with R

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As data-driven reasoning becomes increasingly central, mathematics teachers are expected to integrate data science practices into secondary classrooms. However, preservice mathematics teachers often have limited opportunities to engage with authentic datasets and model-based inquiry during their preparation. This presents a challenge for teacher education programs seeking to cultivate computational literacy and readiness for data science integration. This study addresses this challenge through the design, implementation, and analysis of a professional development workshop that introduced preservice mathematics teachers to computational modeling using R, RStudio, and Quarto notebooks on the Posit Cloud.

The study pursued two primary aims: first, to examine what the design of effective data science activities for preservice mathematics teachers might entail, and second, to investigate how scaffolded computational modeling activities support their understanding and enactment of data science practices. The theoretical framing draws on research in data science education, computational thinking, and learning with scaffolding in complex modeling environments. Data science instruction was conceptualized as an iterative process involving importing, tidying, transforming, visualizing, modeling, and communicating with data. Scaffolding was intentionally designed across procedural, conceptual, analytical, computational, and metacognitive dimensions to reduce cognitive load while supporting participants' movement toward independent modeling and reasoning.

A design-based research approach guided the iterative development, implementation, and retrospective analysis of the workshop. Eight preservice mathematics teachers participated, engaging in scaffolded computational modeling projects using authentic environmental datasets. Data sources included instructional materials, field notes, participants' computational notebooks and written reports, and observational records collected throughout the intervention. Analyses focused on participants' learning trajectories, the role of different scaffolding structures, challenges encountered, and evidence of emerging data science competencies.

Findings indicate that coordinated scaffolding was essential for enabling preservice teachers with minimal prior programming experience to complete sophisticated modeling tasks. Procedural scaffolding supported fluency with R syntax, data structures, and reproducible workflows. Conceptual scaffolding helped participants connect mathematical structures to real-world phenomena and justify model choices. Analytical scaffolding, particularly through comparisons of manual and optimized fits, deepened understanding of least-squares modeling and model evaluation. Computational scaffolding supported the translation of mathematical ideas into code and interpretation, while metacognitive prompts encouraged reflection, debugging, and revision. Across projects involving climate data, sea-ice decline, and carbon dioxide emissions, participants constructed empirical models, optimized parameters, generated predictions, and began envisioning computationally rich tasks for secondary mathematics classrooms.

The study demonstrates that brief professional learning experiences, when deliberately scaffolded, can support preservice teachers' entry into data science and build foundational computational confidence. At the same time, the findings must be interpreted in light of the study's small sample size, which limits generalizability and underscores the need for further research with larger and more diverse cohorts. As calls to integrate data science across K–12 curricula intensify, this work contributes a practical, design-oriented model.

O7 - STEAM in mathematics versus mathematics in STEAM: what does useful technology implementation mean?

Brigitta Békési[1], Eva Ulbrich[1], Tony Houghton[1], Jana Trgalova[2] & Zsolt Lavicza[1]

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This study investigates how STEAM (Science, Technology, Engineering, Art and Mathematics) activities using technology impact student motivation and affect. We explore how teachers define meaningful technology implementation and its effect on student motivation and affect. A central goal was to address the typically minor role of mathematics in STEAM by designing activities that explicitly demonstrate its importance and utility across other disciplines. This study focuses on two sustainability projects: one on renewable energy, and another one on sustainability at the personal level, meaning slow fashion, slow food, slow mobility and waste management. Both projects were conducted in an Austrian secondary grammar school located in an area that is self-sustaining due to numerous water-power stations. The first project involved three classes - two in Grade 8 (46 students) and one in Grade 6 (28 students) - while the second project involved one of these classes a year later in Grade 7 (27 students). Technology implementation involved modelling and 3D printing water-power stations, windmills and cookie cutters, using AI to create a logo, Padlet for project management, students creating interactive quizzes and using Excel for assessing and visualising data. This study is framed by Project-Based Learning (PBL) for the activity design and Self-Determination Theory (SDT) to study student motivation and affect. The activity design follows the five phases of PBL and focuses on the intrinsic motivation of students. Data were collected from students, teachers and parents via 5-point Likert-type items and open-ended questions. We also conducted semi-structured interviews with four teachers, who formed the core team and managed both teachers and students, and with 5 students, the students being selected on the basis of their outstanding motivation. Quantitative questionnaire data were analysed using descriptive statistics, while the qualitative data, the answers to the open-ended questions and the interviews, were analysed using structured coding and defining categories using a bottom-up inductive approach. Analysis suggests that PBL and STEAM activities boost students' meaning-making by networking concepts across disciplines, creating a cohesive learning experience that demonstrates mathematics is useful beyond the classroom. Implementing technology with clear mathematical foundations, such as 3D printing and modelling, significantly enhances motivation by making abstract concepts tangible. From the teacher perspective, meaningful technology implementation serves three main aims: (1) it must fit the curriculum and provide scaffolding for students to understand mathematical content, for instance, creating 3D models enhances students' spatial skills while learning about scaling and direct proportion; (2) it must raise students' interest and motivation to engage in mathematical problem solving while decreasing maths anxiety; (3) it must enhance the 21st century skills through collaboration.

These findings provide practical guidance for pre-service and in-service teachers in designing engaging activities. This study offers a model to improve the effectiveness of mathematics integration across science, technology and engineering disciplines. We derived a definition of meaningful technology implementation, validating that technology should act as scaffolding rather than mere enrichment.

O8 - Activity Theory as a lens for exploring and comparing STEAM and non-STEAM classroom practices

Raúl López-Vilar, Mireia Usart Rodríguez, José Luis Lázaro Cantrabrana & Tania Molero-Aranda

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The digital transformation of education has intensified interest in STEAM (Science, Technology, Engineering, Arts and Mathematics) approaches as a means of strengthening scientific and mathematical literacy, fostering interdisciplinary learning, and promoting the meaningful integration of digital technologies (DT) in classroom practice. Although international policies and curricular frameworks increasingly endorse STEAM as a strategic priority, its classroom implementation remains highly heterogeneous, and its pedagogical value in comparison with non-STEAM approaches is not always clearly articulated or empirically demonstrated. As a result, the distinction between STEAM and non-STEAM practices in everyday teaching is often blurred, particularly in early childhood and primary education contexts. Examining STEAM practices in relation to non-STEAM classroom practices is therefore essential to identify distinctive pedagogical features and to avoid treating STEAM as a self-evident innovation. Since non-STEAM practices remain dominant in many classrooms, they provide a necessary comparative baseline for understanding what STEAM adds or transforms in teaching-learning processes.

This study compares classroom practices with and without a STEAM orientation in early childhood and primary education, focusing on the pedagogical use of DT and differences in teaching–learning dynamics. Rather than positioning STEAM as inherently superior, the study adopts a comparative perspective that highlights contrasts in instructional objectives, tool mediation, participation structures and forms of knowledge construction. The research is grounded in Activity Theory, which conceptualizes teaching and learning as object-oriented, tool-mediated and socially situated activities, enabling a holistic analysis of classroom practice through the relationships between subjects, tools, rules, community, division of labor and instructional objectives.

A comparative design was adopted involving 18 educational practices implemented in Spanish schools: 9 STEAM-oriented and 9 non-STEAM practices in early childhood and primary education. Data were collected through direct classroom observation using a validated observation guideline consisting of 14 indicators. The instrument was developed following a Design-Based Research approach and validated through a three-round Delphi study with experts in education and DT. Inter-rater reliability was ensured through independent observations conducted by two trained researchers. Descriptive and comparative analyses examined differences between STEAM and non-STEAM practices across pedagogical and digital integration dimensions.

Preliminary observations indicate systematic differences between STEAM and non-STEAM practices in student participation, inquiry-based learning, integration of DT and interdisciplinary connections. STEAM practices emphasize collaborative problem-solving and inquiry-oriented uses of technology, whereas non-STEAM practices more frequently reflect subject-bound instructional goals and instrumental uses of DT.

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O9 - Digital implementation in early childhood education: observations of tablet-based mathematics activities using Innovamat

Erica Pamela Köchig[1], Beatriz Lores-Gómez[2] & Mireia Usart-Rodríguez[1]

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Digital applications are increasingly used in early childhood classrooms to support the development of early mathematical thinking and autonomous learning. The use of such tools raises important questions about attention, engagement, and learning processes in young children. This study was conducted at *Escola Montessori de Rubí* (Spain) in October 2024, a multicultural public preschool and primary school where the *Innovamat* mathematics program has been introduced in early childhood classrooms.

The aim of this exploratory study was to document preschool children's engagement with tablet-based mathematics tasks, addressing the following questions: (1) How do preschool children interact with the *Innovamat* interface during mathematics tasks? (2) What engagement behaviours emerge in relation to attention, exploration, emotional response, and persistence during mathematical problem solving? (3) What pedagogical opportunities and risks arise for mathematics learning when using tablet-based applications?

The study is grounded in developmental constructivism, Montessori pedagogy and STEAM education, with a focus on sensorial learning, concentration, and autonomous choice. Research on digital engagement in preschool mathematics suggests that interactive representations can foster conceptual understanding when meaningfully scaffolded.

Participant classroom observations were conducted over three sessions with two groups of five- and six-year-old children. Field notes documented navigation strategies, responses to mathematical feedback, error correction attempts, and peer interactions. Observations were complemented by informal interviews with two teachers to contextualise classroom dynamics and implementation practices. Data were analysed through a qualitative thematic coding and triangulated with informal interview data. The study followed the ethical guidelines and data-management requirements established by the Universitat Rovira i Virgili (URV).

Children demonstrated functional autonomy in activating and navigating the application, following visual step sequences, and initiating self-correction when tasks were not successfully completed. Impulsive selection of screen elements was frequently observed, with children often prioritising rapid digital responses over engagement with mathematical reasoning. Auditory instructions provided by the tablets were inconsistently accessed because individual headphones were not available. In contrast, collaborative behaviours emerged, with children demonstrating solutions to peers, verbalising strategies, and comparing screen outcomes.

Findings highlight the need for careful pedagogical adaptation of digital mathematics tools, including reducing distractive visual elements, ensuring adequate sensory support, strengthening teacher mediation, and integrating digital tasks with concrete and collaborative activities.

This exploratory study contributes initial empirical evidence on how tablet-based applications shape early mathematical engagement in preschool classrooms; however, the short duration of data collection requires that the findings be interpreted cautiously and as indicative rather than generalisable.

O10 - Developing a TPD model for environmental citizenship in science education: bridging critical pedagogy and digital strategies

Larissa Nascimento & Pedro Reis

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Contemporary socio-environmental crises require radical transformations grounded in principles of social and environmental justice. Education for Environmental Citizenship (EC) provides a critical framework for cultivating politically engaged citizens; however, effective in-service Teacher Professional Development (TPD) models explicitly designed for EC remain scarce, particularly in science education. Teachers require support to move beyond value-neutral content transmission towards transformative pedagogies suited to digitally mediated contexts.

Based on these gaps, the central research problem is: *What are the characteristics of an in-service teacher training model that empowers teachers for EC?* To address this problem, the study is guided by four research questions: (Q1) What competences should teachers develop? (Q2) Which methodologies best support these competences? (Q3) What format is most appropriate? (Q4) How may school barriers be overcome?

The research is grounded in a critical framework of meta-citizenships structured around four pillars: Ecological Contextuality, recognising the need for situated citizenship responses; Territory, understood as a socio-political space shaped by power relations, economic dynamics, and symbolic meanings; Biocentric Ethics, acknowledging the intrinsic value of non-human nature; and a Political Dimension focused on empowerment and participation in public spaces.

The study adopts a Design-Based Research (DBR). The prototype emerged through an iterative process informed by four empirical sources: (1) a systematic literature review identifying competences, pedagogical strategies, and constraints in EC-related teacher education; (2) a questionnaire administered to in-service teachers examining perceived training needs; (3) an expert evaluation of the first version of the prototype; and (4) the implementation of a pilot training programme, with data collected through focus groups, semi-structured interviews, and the analysis of pedagogical artefacts produced by participating teachers.

To ensure this critical vision is actionable in the “digital future”, the prototype integrates technology as a strategic component while explicitly acknowledging the contested role of generative AI in education. Rather than positioning AI as a neutral or efficiency-driven tool, the model frames it as an object of pedagogical mediation requiring critical scrutiny. Regarding teacher competences (Q1), generative AI is conceptualised as a tool in design processes, used to surface assumptions, compare alternative framings of socio-environmental issues, and support metacognitive discussion about criteria, evidence, and validity. In this sense, AI supports critical interrogation rather than replacing professional judgement.

Concerning methodologies (Q2), digital citizen science platforms are incorporated to operationalise ecological contextuality by enabling the collection and interpretation of locally situated environmental data. Regarding format (Q3), the model adopts a hybrid TPD structure combining face-to-face sessions with online communities of practice. Finally, in addressing school barriers (Q4), digital tools are mobilised to respond to assessment-related constraints, supporting the co-design of evaluation instruments aligned with EC competences.

This study contributes a structured and empirically informed in-service TPD model that advances a critical and action-oriented approach to EC, offering transferable design principles to support teachers’ agency in complex socio-technical contexts.

O11 - PLAYLAB.AI as an AI tutor in pre-service science teacher education

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The integration of artificial intelligence (AI) in educational processes has been associated with the promotion of active learning, real-time formative assessment, and the development of critical scientific competencies, while also raising ethical concerns related to data privacy, algorithmic bias, and the transformation of scientific knowledge. Recent studies indicate that pre-service teachers often lack confidence, resources, and technical skills to effectively incorporate AI tools into their teaching practices. In this context, chatbots and intelligent tutoring systems such as Playlab.ai are emerging as collaborative and experimental spaces that support digital literacy, foster critical reflection, and facilitate the pedagogical appropriation of AI by future teachers. However, research also shows that pre-service teachers' perceptions fluctuate between recognizing AI's potential to enhance educational quality and expressing ethical and practical concerns that may hinder its adoption.

This exploratory study implemented Playlab.ai as a learning tutor within a pre-service science teacher education program at a higher education institution in Portugal. The aim was to provide a learning experience that enabled participants to critically examine the opportunities and limitations of AI in supporting science learning.

In the first session, the researcher-teacher introduced Playlab.ai, and participants interacted with a pre-trained version designed to support understanding of digital resources in science education and illustrate practical examples. In a second session, participant feedback was collected and the interactions were discussed. Prior to implementation, pilot trials were conducted to refine the tool and ensure that the formative feedback was aligned with the activity's objectives. Additionally, two science education specialists evaluated the relevance and adequacy of the feedback generated by Playlab.ai, thereby ensuring the pedagogical quality of the experience.

Participant feedback and discussions highlighted ease of use, versatility in response generation, and the ability to stimulate interaction and promote critical reflection as key strengths of the tool for science education. Nonetheless, several limitations and challenges emerged, both related to Playlab.ai (occasional responses that were overly brief or repetitive; the need for careful curation to ensure scientific accuracy; risks associated with uncritical or excessive use) and to the Portuguese educational context (unequal access to digital resources; restrictions on electronic devices in classrooms; unstable internet connectivity; lack of adequate equipment).

The findings suggest that the intentional and critically mediated integration of Playlab.ai can serve as a valuable resource for diversifying teaching methodologies and promoting active learning and student autonomy in science education. They also underscore the need to prepare pre-service teachers for the conscious and pedagogically informed use of AI.

This study opens pathways for future research on the integration of digital tutors across different educational levels and on teacher education approaches that bring together technological innovation, scientific rigor, and critical thinking.

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O12 - AI-powered microlearning to support non-specialized mathematics teachers in upper secondary education

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Currently, the shortage of teachers in Spain has become a structural problem, particularly in STEM subjects such as mathematics, which require strong conceptual and pedagogical expertise. This affects the quality of teaching and learning in upper secondary education. However, the incorporation of new teachers does not always guarantee subject expertise, as the Spanish Department of Education frequently hires teachers who are legally qualified to teach a subject but are not specialists in it.

This situation does not guarantee that new teachers are prepared enough to manage a class in a certain subject, given their lack of experience and limited subject-specific pedagogical content knowledge. Consequently, teaching may become a discouraging professional path that reinforces a cycle in which teachers feel underqualified, and resources remain limited.

This study is based on a Design-Based Research (DBR) methodology with the objective of creating and implementing a digital platform with microlearning modules – bite-sized, multimodal instructional units- to support non-specialized teachers during lesson preparation and just-in-time conceptual reinforcement. The platform integrates AI-generated explanatory videos, structured conceptual notes, interactive exercises, and a professional forum where teachers can consult with subject specialists. Unlike traditional microlearning approaches, the AI component enables adaptive learning pathways based on teachers' prior knowledge, immediate instructional needs, and self-identified conceptual gaps. The proposed study extends traditional learning and enables teachers to learn pathways based on prior knowledge.

These AI-supported microlearning interventions are asynchronous, modular, and flexible, allowing teachers to engage in highly targeted professional learning experiences aligned with their immediate instructional demands.

Once these modules are completed, teachers are expected to improve their mathematical conceptual understanding and instructional confidence and be better equipped to teach while continuing their own professional development.

Previous studies on microlearning in mathematics education, mainly focused on students, have shown positive effects on conceptual learning, providing a foundation for exploring its potential in teacher professional development.

In conclusion, this study proposes an innovative AI-powered microlearning approach to support non-specialized mathematics teachers by providing personalized, just-in-time, and adaptive professional learning pathways, while fostering professional dialogue through a collaborative forum. This approach moves beyond traditional microlearning by aligning digital support with teachers' immediate instructional needs and disciplinary challenges.

From an international perspective, this study contributes to the research agenda on mathematics education in the digital age. It aligns with the United Nations 2030 Agenda for Sustainable Development, particularly Goal 4, *Quality education* by promoting professional development and digital support for teachers with the use of AI.

O13 - Science education for citizenship in basic education: Science-Technology-Society in plate tectonics

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Science Education (SE) with a Science-Technology-Society (STS) orientation has the potential to empower pupils to think autonomously, engage meaningfully in diverse contexts, and address socially relevant problems. In contemporary education, integrating STS perspectives connects scientific knowledge with societal challenges, fostering engaged and responsible citizenship. This study was conducted in Portuguese Basic Education, within Year 7 Natural Sciences, and adopted an Action-Research (AR) design to implement and assess a didactic proposal composed of STS teaching resources on the topic "Plate Tectonics and Continental Drift." The intervention was carried out by a teacher-researcher in two classes (n=33) over five weeks, supported by two additional university-based researchers who contributed to data analysis and validation. The central aim was to assess the contribution of these resources to pupils' learning, focusing specifically on the mobilisation and construction of scientific knowledge.

The theoretical framework was grounded in STS perspectives and sociocritical approaches to scientific literacy (SL), emphasising the articulation between scientific knowledge and societal issues. This framework positions SE not merely as the transmission of disciplinary content but as a dynamic process in which pupils apply scientific concepts to real-world contexts. By situating geoscience topics such as plate tectonics within broader environmental concerns, the study sought to highlight the relevance of SE for citizenship and to demonstrate how pupils can construct knowledge that is both scientifically accurate and socially meaningful.

Methodologically, the study employed multiple instruments to capture evidence of pupils' learning. Data collection involved an adapted Views On Science-Technology-Society (VOSTS) questionnaire, analysis of pupils' written communication, and systematic observation using a knowledge-focused checklist. These tools provided complementary perspectives on how pupils mobilised and constructed scientific knowledge during the intervention. Data analysis combined descriptive statistics with content analysis based on scientific knowledge categories, ensuring both quantitative and qualitative insights.

Findings revealed that pupils demonstrated a positive evolution in their STS conceptions, with realistic responses increasing and naïve ones decreasing. Written production showed medium to high quality in clarity, justification, logic, and depth. Evidence of scientific knowledge mobilisation and construction was observed in pupils' responses, frequently expressed through correct answers and logical explanations. These results suggest that the didactic proposal was effective in supporting pupils' engagement with complex geoscience concepts and in promoting the articulation of scientific knowledge with broader societal issues.

The implications of this research are significant for both teachers and researchers. For teachers, the study provides practical STS-oriented resources that can be integrated into Geoscience Education, offering evidence of how carefully designed materials enhance pupils' capacity to mobilise and construct scientific knowledge. For researchers, it contributes to understanding how action-research methodologies can innovate in SE, reinforcing the importance of sociocritical perspectives in curriculum design, supported by complementary resources such as video-based platforms, QR codes, and online educational environments, highlighting key implications for SE in the digital era.

O14 - Performing the Anthropocene: non-formal science theatre for promoting youth literacies in global citizenship

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This paper examines how a non-formal science theatre project supports adolescents' engagement with and reflection on dimensions of global citizenship through bioethical and geoethical dilemmas. The intervention was conducted in a social-care institution with students aged 12 to 16 who participated in a multi-activity programme combining theatre-based work with digitally mediated learning experiences. These included QR-code guided tasks, game-based quizzes, a hybrid digital–physical escape room and mobile sensing applications used in simulations of socio-environmental phenomena, alongside collaborative script writing, rehearsal and public performance. The project culminated in the presentation of a science theatre play to younger peers, addressing two central issues: bioethical questions related to the use of animals in scientific research and human responsibility for the current state of the planet. The study adopts a qualitative case-study design, drawing on two focus-group interviews with 12 adolescent participants, individual interviews with three institutional collaborators and the theatre script analysis. The analysis explored participants' engagement, ethical awareness, understanding of bioethical and geoethical concepts, capacity for argumentation and collaboration, and their ability to articulate and discuss socio-environmental dilemmas. In this study, literacies associated with global citizenship are approached through processes of ethical reflection, dialogue, collaborative meaning-making and interaction with scientific issues using both digital and non-digital resources. Findings, based on participants' narratives and perceptions, indicate high levels of motivation and sustained engagement. Although bioethics and geoethics were initially perceived as challenging, students reported that the project activities facilitated understanding and discussion. Institutional collaborators corroborated these observations, highlighting gains in critical thinking, argumentation, curiosity, and ethical awareness, as well as the project's inclusive and motivating nature. They further noted that older students' involvement in performing for younger peers fostered positive group dynamics and strengthened relationships. Overall, the study suggests that non-formal science theatre, supported by interactive and digitally mediated activities, offers a meaningful way to integrate scientific understanding with ethical reflection. By foregrounding ethical, scientific and digital literacies, this approach contributes to forms of global citizenship required for the Anthropocene and responds to current challenges in science and mathematics education for a sustainable and digital future.

O15 - The missing link in science education: bioethics and geoethics as a double helix of educational tools for science teachers

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Science teachers increasingly face the challenge of addressing socio-environmental issues that are scientifically complex, ethically sensitive and central to modern societies. Traditional approaches to scientific literacy no longer suffice to prepare young people for the interconnected crises of climate change, biodiversity loss, technological acceleration and global instability. Yet teachers frequently feel unprepared to work with ethically charged topics: they report limited ethics training, uncertainty about managing open discussion, concerns about controversy, and hesitation to link ethical-philosophical questions to scientific content. Bioethics and geoethics offer complementary lenses for addressing these challenges, helping teachers foster responsible decision-making, systems thinking, and ethical awareness in science classrooms. This paper examines how these frameworks can enrich science education in grades 7-12. Although grounded in a Portuguese non-formal education context, the findings have broader relevance for European science education, particularly in informing innovative approaches to initial and in-service teacher education focused on ethics, citizenship and sustainability. This paper explores how ethically grounded tools, such as role-play, games, structured ethical deliberation and guided discussion, can help teachers connect scientific ideas with the moral, ecological and societal dilemmas that students increasingly encounter. The guiding question is how bioethics and geoethics, understood as intertwined ethical frameworks, can support teachers in addressing the complexity of the Anthropocene while sustaining meaningful student engagement and competence development. The argument draws on three strands of contemporary scholarship. The OECD's *Education for Human Flourishing* highlights ethical competence, understanding the world and responsible action as key learning outcomes for the 21st century. The notion of Anthropocene literacy underscores the need for interdisciplinary and reflexive teaching that acknowledges uncertainty, interdependence and value-laden scientific decisions. Ethics-infused perspectives on science education emphasise bioethics for issues related to life, health, biotechnology, equity and care, and geoethics for concepts such as Earth stewardship, planetary boundaries, resource use and intergenerational responsibility. Bringing these strands together, the paper argues that integrating bioethics and geoethics gives teachers practical ways to embed ethical reasoning within scientific inquiry. This approach broadens the scope of science education beyond factual content, enabling students to examine dilemmas at the intersection of life, the Earth system and society. It also supports teachers in fostering dialogue, critical reflection and informed action aligned with the competencies required for the Anthropocene. The paper concludes that viewing bioethics and geoethics as an intertwined pair of pedagogical resources offers a coherent and innovative framework for teacher education. It strengthens the link between scientific understanding and ethical action, helping teachers cultivate students' responsibility and resilience in the face of global challenges.

O16 - Prospective teachers' views on mathematics education in primary school in the digital era

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The present study explores the views of prospective primary school teachers on the evolution of mathematics education in the digital era. The study focuses particularly on their perceptions of the role, value and limitations of digital technologies in primary mathematics teaching and learning. In the contemporary educational landscape, where digital tools are progressively influencing instructional practices, it is imperative to comprehend how future teachers conceptualise mathematics education within this paradigm. Their conceptualisations exert a significant influence on pedagogical decision-making and the subsequent implementation in the classroom. The study conceptualises mathematics education enhanced through digital technologies as a form of instruction in which digital tools are intentionally used to support mathematical understanding, visualisation, exploration, and student engagement, rather than merely replacing traditional resources. The theoretical framework is grounded in technology-enhanced learning and constructivist perspectives on mathematics education, emphasising the relationship between teachers' beliefs, pedagogical approaches, and the use of digital tools.

A mixed-methods design was employed in this study. A total of 145 full-time and part-time students enrolled in the Primary School Teacher study programme at the University of Latvia were the subjects of the data collection process during the 2024/2025 academic year. A structured questionnaire was utilised to examine the views of prospective teachers on changes in mathematics education related to digital technologies. The focus of the questionnaire was on mathematics content, teaching and learning processes, and learner characteristics. Quantitative data were analysed using both descriptive and inferential statistical methods in order to identify prevailing trends and relationships. In order to achieve a more profound interpretation of the results obtained from the questionnaire, semi-structured interviews were conducted with a purposively selected sample of participants. This approach enabled the acquisition of a more nuanced understanding of their perspectives. The findings indicate that prospective teachers predominantly perceive digital technologies as enhancing mathematics education by supporting visualisation, inquiry-based learning, and student motivation. Concurrently, their perspectives evince an ambivalence regarding the equilibrium between digital and traditional methodologies, particularly with regard to the potential substitution of textbooks and concrete manipulatives. These perspectives suggest that future teachers view the digital transformation of mathematics education as both an opportunity and a pedagogical challenge.

The study emphasises the significance of incorporating prospective teachers' views regarding the modification of mathematics education within the framework of teacher education programmes. It is imperative that critical reflection on the pedagogical role of digital technologies is supported in order to prepare future teachers to navigate the evolving landscape of mathematics education in the digital era.

O17 - Educating pupils for environmental sustainability in European Uunion and Western Balkan: comparative overview based on TIMSS 2023 data

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In this paper we discuss TIMSS 2023 findings, in the light of similarities and differences of EU and Western Balkan education systems, regarding sustainability competence framework. This research is focused on the theoretical issues and implications for the education systems. It is based on the published results and data from TIMSS 2023 study, environmental awareness in TIMSS 2023, GreenComp competences and especially on newest research. Our aim is to compare the education systems and to develop some conclusions and recommendations.

offers a comprehensive exploration of sustainability discourse, from the GreenComp European sustainability competence framework to global education research perspectives, insight how science education can foster environmental awareness, as well as the context for investigating learning for environmental sustainability, GreenComp in the light of TIMSS data, teaching environmental sustainability in the science classroom, the role of school organizations in promoting sustainability and TIMSS data relation with sustainability indicators. We discuss wide geographical area of Europe, emphasizing the findings and connections between the TIMSS Study and environmental sustainability learning and how to addresses different dimensions of environmental awareness and sustainability. We present EU-WB similarities in findings, and some aspects with expected differences. All presented results arise from Hastedt D. et al. 2026. Having in mind large sample of TIMSS study and the quality of the argument, the conclusions are very relevant.

We focus on environmental sustainability and explore how key concepts intertwine with science education, influencing views and expectations of the domain, particularly in the context of transformative change - both in EU and Western Balkan education systems. We emphasize results in aspects related to a sustainable and digital future and propose recommendations for the improvement of science education, which are important because of their implications in the digital era.

O18 - Science through stories: insights from the CAPERS project

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Lack of engagement in science, technology, engineering and mathematics (STEM) has been a long-standing issue worldwide. In Ireland, underrepresented groups in STEM include those experiencing socioeconomic disadvantage; people for whom English is not their first language and learners with additional needs.

Children and Parents Enjoying Reading and Science (CAPERS) is an engagement initiative led by university-based materials scientists in collaboration with the creative writing charity Fighting Words and Dublin City Libraries. CAPERS explores how science storytelling, mediated through interaction with scientists, supports engagement and a sense of belonging for communities traditionally underrepresented in STEM.

How do students experience science storytelling as a vehicle to support their dispositions to STEM, literacy and creativity?

Drawing on boundary crossing, CAPERS emphasises co-construction of knowledge through social interaction using stories as boundary objects. The project leverages critical literacy frameworks, recognising storytelling as a tool for agency and identity formation. By pairing students with scientists, scientific ideas are mediated through narrative, conversation, and shared meaning-making. Through these practices, CAPERS subscribes to a Science Capital agenda that integrates community knowledge and relational engagement to broaden STEM access.

CAPERS involved upper primary students (n=19) in a Dublin school. Over 12 weeks, four structured in-person workshops were facilitated by scientist volunteers, along with Fighting Words facilitators. Initial workshops focused on reading, dialogue and relationship-building. Later, students co-created their own science stories with peers using paper-based and digital tools, including GenAI for storyboarding and to generate illustrations. Between sessions, students engaged in informal science discussions as they developed their stories. Qualitative data were thematically analyse including written reflective accounts and student work samples

Findings suggest that a shift from consumers to producers of knowledge allowed students to connect scientific ideas with personal experiences, local issues, and creative expression. Findings indicated an increase in students' confidence with reading and writing; willingness to ask scientific questions; and enthusiasm for collaborative learning. In this digital era, CAPERS highlights the value of community-embedded approaches to reduce barriers to STEM participation, offering a model for integrating reciprocal networks that support both literacy and scientific thinking.

O19 - Instructional strategies for teaching Chemical Bonding: reflections on the PCK and ICT-TPCK of postgraduate students

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The topic of Chemical Bonding (CB) is central to Chemistry, as it provides the basis for understanding the structure and properties of substances. In this context, it is important to investigate the knowledge of teachers and/or pre-service teachers about instructional strategies for teaching this topic. Thus, the aim of the present study was to access the PCK of postgraduate students in Physics and Chemistry Education concerning the topic of CB, using an adapted format of the CoRe (Content Representation). The instrument included demographic questions, followed by 10 open-ended questions, all focused specifically on the topic of CB, addressing the key concepts (or ideas) participants consider central to teaching this topic in 11th-grade upper secondary education, as well as aspects of the teaching process, learning difficulties, and assessment strategies. The instrument was administered in person, lasting approximately one hour, and a total of 16 postgraduate students participated: 1 with a degree in Chemical Engineering, 7 with a teaching degree, 5 with a master's degree, and 3 with a doctorate, all in Chemistry, Physics, or related areas. In this study, data were analyzed using Content Analysis, with a focus on participants' responses concerning instructional strategies. Thirteen participants reported having teaching experience at one or more educational levels, including lower secondary education, upper secondary education, vocational education, and higher education. The analysis revealed that participants frequently mentioned the use of Information and Communication Technologies (ICT), such as videos (12) and simulators (8) for teaching the concepts (or ideas) they consider central in CB, including Lewis structure (9), covalent bonding (5), ionic bonding, metallic bonding, the octet rule (4 each), molecular geometry (3), among others. Although these ICT were associated with the topic under discussion, participants did not clearly articulate when or how such strategies would be implemented in their pedagogical practice. This finding raises questions about the extent to which teacher education programs have supported the development of TPCK. The strategies reported also included practical activities (5), representations or drawings, demonstrations (3 each), games (2), as well as slides, and animations (1 each). For ICT to effectively contribute to student learning, teachers must mobilize their knowledge of digital tools and their affordances, together with their pedagogical and content knowledge, while considering the teaching context and learners' difficulties, in accordance with the ICT-TPCK model. However, inequalities in access to ICT, along with insufficient teacher training for their pedagogical use and some teachers' reluctance to adopt these technologies, may influence the effectiveness of these practices. Given the growing use of digital technologies in education, the findings highlight the importance of strengthening teacher education programs to foster ICT-TPCK competences, enabling teachers to identify topics for which ICT offers added value, particularly abstract scientific concepts such as CB. This can be achieved through the integration and exploration of digital tools, expanding teachers' pedagogical possibilities, promoting a shift beyond traditional teaching by enabling the use of representations that are difficult to achieve through conventional approaches, and enhancing student motivation, engagement, and understanding in science learning.

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O20 - The use and impact of digital technologies by teachers of mathematics and science in Europe: findings from TALIS (2024)

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Digital technologies have been used by mathematics and science teachers for many years and teachers in these two subjects have often been early adopters of new technologies. The 2024 OECD Teaching and Learning International Survey (TALIS) provides an opportunity to explore teachers' beliefs in their capabilities to use digital resources and tools and their attitudes toward their use for student learning.
This project sought to answer the following questions about lower secondary school teachers of mathematics and science in Europe: 1) What beliefs in their own capability to use digital resources and technologies do they have? 2) What opinions do they have regarding the impact of such technologies on students' learning and 3) Are there differences between teachers of mathematics and science, and are there differences between teachers in different European regions? A subsample of the TALIS data was identified, choosing teachers from European countries who reported teaching lower secondary school (ISCED 2) mathematics or science. The sample selected contains over 17400 teachers from 29 European countries, split roughly evenly between the two subjects. The analysis drew on Hannula's (2012) dimensions of mathematics related affect to consider teachers' beliefs, motivations and emotions and focused on two multipart questions from the survey. Firstly, a question asking the extent to which teachers considered that they could do a range of tasks with digital resources and tools and secondly, a question asking about their opinions on the impact on student learning with teachers.
Secondary data analysis used descriptive statistics to analyse the distribution of responses across survey items, and applied Pearson's chi-square tests to assess whether observed differences between groups were statistically significant. Principal component analysis was used for dimensionality reduction to summarise multiple correlated questions with underlying latent structures. Countries were split into five regional European groups for further comparison.
The research found teachers held high levels of belief in their own capability to use digital resources and tools in their teaching. Science teachers had higher levels of belief in their own capability than mathematics teachers with the difference was statistically significant. At regional level there was variation, particularly regarding those teachers reporting that they had little belief in their own capabilities. Teachers reported a range of views regarding the impact on student learning. In some cases, there were significant differences between teachers of mathematics and science.
These findings have implications for teacher educators. Whilst we found encouraging levels of teachers' belief in their own capability, there was a small core of teachers with low levels of belief in their own capability who need considerable further support to develop their use of technologies in their teaching. The variation between European regions also suggests that, in some areas, there is more to be done. The range in views regarding the impact of technologies on student learning indicates that this is a key area that needs to be addressed through both initial and continuing teacher education.

O21 - Maker education in the Portuguese low secondary school curricula

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The maker movement started about 20 years ago, and, since then, there has been an ever-increasing interest in maker education. Overall, this movement values creation, achievement, and invention through the practice of "do it yourself". However, there are different definitions of the maker education concept, some more focused on hands-on and others broader and more able to integrate digital dimensions. The TAME project team conceptualizes making as a process of project-based learning, characterized by agency, interdisciplinarity, creativity, social interaction, and reflection. They consider that in such a process, learners apply both analogue and digital tools in iterative design cycles to create and share meaningful physical or digital artifacts that address real-world problems, enabling personal or societal value. A maker education mindset both requires and develops personal, methodological, content, and social competences, valuing diversity and promoting inclusion. These competences are relevant to facilitating students' learning of school subjects and to use in their present and future lives outside school, which are increasingly shaped by digital technologies. They are also consistent with the European Digital Competence Framework (DigComp), which provides a common understanding of what digital competence is, and with the Digital Competence Framework for Educators (DigCompEdu), which describes what it means for educators to be digitally competent. Even though the maker concept is not new in education, the recent popularization of the digital world and the decrease in prices of production equipment and hardware have been important in creating favourable conditions for the introduction of the maker movement in schools. School subjects may provide contexts for maker education if their syllabi allow pedagogical innovation through maker education. This paper aims to find whether the Portuguese syllabi, in the STEAM area, are consistent with maker education and or provide opportunities to develop students' making-relevant competences. Two types of documents were content analyzed taking as reference the TEAM's framework: The Students' Profile Upon Leaving Compulsory Education, which sets the competences that should be expected from students when they complete the 12th grade; and the Essential Learning guidelines of the low secondary school subjects of the STEAM area, which provide information on what and how should be done in school, considering the targets set in the students' profile. Results indicate that there are differences between school subjects, but overall, the curriculum documents acknowledge and may convey a maker culture, as they promote the development of the maker features referred to above. Encouragement of critical and creative thinking, problem-solving, collaboration, experimentation, and the use of technology for active construction of knowledge are examples of maker related-strategies that are acknowledged by students. These results enable the promotion of maker education in Portuguese schools without jeopardizing the development of the prescribed curriculum. However, research on how teachers both feel towards maker education and develop the maker dimension of the curriculum is required.

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O22 - Smart Islands: beyond the bridges

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By weaving together STEM disciplinary knowledge, community priorities, and multilingual dialogue, we can extend beyond traditional notions of STEM education to support agency and active citizenship in a rapidly changing world. Here, we critically reflect on our learning journey as an interdisciplinary cross-border leadership group of educators, university-based scientists and engineers leading 'Smart Islands', a science/STEM engagement initiative using Lego® Serious Play® (LSP) to connect remote primary schools on Rathlin Island in Northern Ireland (NI) and Inis Mór in the Republic of Ireland (ROI).

Smart Islands aims are threefold: 1. Build capacity in island schools and their local communities by using STEM-based inquiries to connect with real-world challenges relevant to their lives; 2. Bring scientists and bioengineers into sustained dialogue with marginalised communities to strengthen engagement in STEM, while enabling researchers to better appreciate social, environmental, and cultural dimensions of island life; 3. Generate interdisciplinary and cross community links to facilitate shared learning across the island of Ireland.

We reflect on our evolving interdisciplinary collaboration through the theoretical lens of boundary crossing. Specifically, we explore the affordances of LSP models as boundary objects to support reflection, cultivate shared learning and facilitate relationship building among our leadership group.

We employ Schön's (1983) notion of reflection-on-action to engage in systematic critical reflection on our experiences with LSP to engage island communities. Data were generated through reflective diary entries. These were documented systematically and analysed using a grounded theory approach. Diary entries responded to our shared portfolio of visual images of co-constructed models as well as post-meeting reflections. To support collective sense-making, Brookfield's (2017) lenses of self, theory, peers, and learners offered us a range of perspectives to glean insights for future practice.

Our findings indicated our co-created Lego® models supported us to uncover tacit assumptions to move towards shared meaning-making across our disciplinary and cultural backgrounds. In this way, we suggest that the models operated as boundary objects which supported us to transcend sociocultural boundaries and disciplinary knowledge silos.

We propose that participatory arts-based approaches like LSP offer a bridge to overcome STEM engagement barriers by cultivating democratic interdisciplinary spaces where diverse ideas can be shared to address real-world problems. This work offers practical and methodological insights for researchers and educators interested in developing inclusive interdisciplinary approaches to STEM engagement.

O23 - Statistics education and digital work precarization: teaching experiences in technical courses

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The expansion of digital technologies has reshaped labor relations, intensifying platform-mediated work, data-driven management, and unstable employment conditions. In this context, new segments of workers, referred to as "infoproletarians", depend on digital infrastructures while experiencing precarious labor conditions. This study, developed within a Brazilian Professional Master's program, investigates how Statistics Education can contribute to critically examining these transformations in Integrated Technical High School courses related to computer science. Grounded in the Marxist perspective of work as an educational principle and in Critical Mathematics Education, the research adopts a critical approach to Statistics Education. The guiding research question was: How can a didactic proposal using Statistics to analyze digital-era work contribute to the education of students enrolled in computer science technical courses? To address this question, a qualitative pedagogical intervention was conducted with forty-one students from two Integrated Technical High School classes. The intervention comprised nine sessions, totaling approximately twenty hours, including theme selection, data collection on digital work conditions, organization and representation of data, statistical analysis, and the production of infographics as a communicative outcome. Data were analyzed through an interpretative approach, considering classroom interactions, students' productions, and reflective discussions. The findings indicate three main contributions. First, students demonstrated the appropriation of statistical concepts such as variability, percentages, measures of central tendency, and graphical representation within meaningful investigative contexts. Second, they were able to interpret statistical information critically, questioning narratives about flexibility and entrepreneurship commonly associated with digital work. Third, the articulation between statistical analysis and discussions about labor conditions fostered deeper reflections on their own professional trajectories and social positioning. These results suggest that integrating Statistics Education with the analysis of contemporary labor conditions expands the pedagogical role of mathematics in technical education. Rather than restricting Statistics to procedural exercises, the intervention positioned it as a means of reading and problematizing social reality. For Mathematics Education in the digital era, the study highlights the potential of investigative scenarios connected to socio-economic issues, especially in vocational contexts where students are affected by technological change. By linking statistical reasoning to the critical examination of digital work precarization, this research contributes to discussions on how Statistics Education can support socially grounded professional formation in Integrated Technical High School programs.

O24 - Hybrid lesson study for supporting teachers' professional judgement about fractions reasoning across the island of Ireland

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Amidst strong overall performance in international assessments such as TIMSS, students across the island of Ireland continue to show relative weaknesses in mathematical problem-solving and reasoning at higher cognitive demand levels. These areas feature strongly in recent curriculum reforms North and South. Supporting primary teachers to build deeper mathematical knowledge for teaching fractions and to design classroom practices that foreground reasoning is therefore a critical priority, particularly across two jurisdictions (Ireland/Northern Ireland) and across Irish- and English-medium contexts. Lesson study offers a structured, practice-centred model for collaborative inquiry into teaching and learning and aligns with Teaching Through Problem Solving (TTP) approaches that position problem solving as integral to instruction rather than an 'add-on'.

This empirical study uses a cross-border, dual-language hybrid (online/in-person) lesson study design to support collaborative professional learning and to investigate teachers' professional judgement in mathematics. The focus is a fractions reasoning task for middle primary students, *Fractions - Sharing Brownies* (Lamon, 2012), available in Irish and English on the Mathscify website. Eight teachers are participating: four from schools in Northern Ireland and four from schools in the Republic of Ireland; five teach through English and three through Irish. Within this, we have English-medium and Irish-medium schools in both jurisdictions, together with one teacher in an English-medium southern school who intends to consider the potential of the task from a CLIL perspective. Teachers work with a cross-border teacher educator group in a joint initial workshop (lift-off event), followed by language-based groups that collaboratively design a lesson around the shared task.

The broad aim of this study is to understand the potential of a hybrid short-run lesson study model to deepen and extend teachers' mathematical and pedagogical repertoires. The research question of interest is therefore to understand: How do teachers initially interpret and position a reasoning-focused fractions task within their curricular, linguistic, and classroom contexts during the lesson study lift-off event?

Our analytic focus is shaped by TTP and by comparative pedagogy perspectives that attend to how pedagogy is framed by curriculum, language and wider cultural expectations. We are particularly interested in how teachers use a "teaching through solving" stance to work on fractions reasoning within their own curricular and language settings, and how the hybrid professional learning structure supports (or constrains) this work.

In this presentation, teacher educators from the Science and Mathematics Education Research and Development Community of the Association for Teacher Education in Europe report on data from the audio transcripts and supplementary field notes of the initial collaborative learning day. Although data collection is ongoing, we anticipate that the analysis of the lift-off event will capture teachers' initial pedagogical framing of the task, their anticipation of student thinking, and how curriculum, language, and context enter planning talk. Focusing analytically on this phase further enables examination of teachers' initial professional judgements and assumptions before classroom enactment, providing a baseline for understanding subsequent developments across the lesson study cycle

O25 - Innovation or regression? Platformization and its impacts on inclusion, knowledge, and the teaching profession

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The digital era has been widely promoted as an opportunity for curricular modernisation, strengthened student autonomy and expanded pedagogical innovation. Educational technologies are expected to enhance learning, democratise access and enable personalised instruction. Yet the rapid spread of digital platforms in school systems - now acting as central mediators of pedagogy and curriculum implementation - raises critical questions about their real educational value and the unintended consequences they produce. In Brazil, the accelerated platformisation of public education - characterised by standardised digital curricula, algorithmically guided tasks and externally regulated instructional sequences - has generated tensions with the formative purposes of science and mathematics education and with the principles established in the National Common Curricular Base (BNCC), which defines learning rights for basic education students and aims to promote equity and integral human development. This paper analyses a case in the state of São Paulo in which the adoption of digital platforms and scripted lessons, combined with external accountability mechanisms and large-scale assessments, produced loss of teacher autonomy, homogenisation of pedagogical practices, curricular impoverishment and weakening of the formative dimension of science and mathematics teaching. The guiding question is to what extent platformisation constitutes innovation and what its pedagogical, inclusive and professional implications are for science and mathematics education. The argument is structured around three perspectives: the relationship between technology, curricular standardisation and educational governance as discussed in the literature on the platform society; an anthropophagic critique addressing the importation of decontextualised educational models and so-called reheated innovations, contrasting technical consumption with pedagogical creation; and inclusion and equity as substantive criteria for evaluating digital education policies, particularly regarding students in conditions of vulnerability and teacher professional development.

Empirical material derives from teachers' narratives collected in a discussion circle within the project *Good Practices for an Equitable, Inclusive and Quality Education: Partnership between University and Schools*. The accounts describe intellectual precarisation, professional exhaustion, methodological constraint and the obstruction of investigative and experimental practices central to scientific and mathematical learning. Findings indicate that platformisation simplifies educational experience and reduces pedagogical agency. In science and mathematics — disciplines requiring modelling, reasoning, experimentation, problem solving and situated use of representations — complex cognitive processes are replaced by fragmented and repetitive tasks. New forms of exclusion also emerge, particularly affecting students with disabilities and those in socioeconomically vulnerable conditions, for whom digitalisation does not ensure participation or development.

The study demonstrates that platformisation is not neutral: it reconfigures disciplinary meaning, alters the status of teaching work and reorganises the temporal structure of schooling. For research, it highlights the need for critical investigation of digital education policies and their pedagogical materialisations; for practice, it reopens debates on teacher autonomy, experimentation and the situated nature of scientific and mathematical activity. The paper concludes that innovation without a formative educational project deepens inequalities and impoverishes school disciplines, and that technology must be repositioned as a pedagogical, curricular and democratic mediation rather than an organising principle of schooling

O26 - Academic integrity, assessment, and student motivation in mathematics education in the age of artificial intelligence

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Rapid advances in artificial intelligence, wearable technology, and consumer electronics have transformed higher education and reshaped long-standing discussions of academic integrity. In mathematics education, these developments intersect with persistent concerns related to assessment practices, student motivation, and the perceived relevance of mathematical knowledge. While digital technologies are often associated with integrity challenges, they are not inherently good or bad; rather, the educational implications depend on how and for what purposes they are used. Current debates therefore call for a more nuanced examination of integrity issues that situates technology use within broader curricular, pedagogical, and epistemological contexts.

This paper aims to examine how contemporary digital and AI-enabled technologies interact with assessment practices and students' perceptions of learning in mathematics education. The central guiding question is: *How do students' experiences with AI-supported technologies, together with their perceptions of relevance and assessment practices, reshape understandings of academic integrity in mathematics education?*

The discussion is grounded in academic integrity theory, mathematics education research on student motivation and relevance, and cognitive perspectives on mathematics anxiety. These frameworks are used to argue that technology-assisted misconduct should not be viewed solely as an ethical or disciplinary failure, but as a symptom of deeper tensions between assessment designs that emphasize routine procedural performance and students' evolving epistemological beliefs about mathematical knowledge in an era of automation.

The paper argues that when digital tools and AI systems are perceived as substitutes for procedural knowledge, students may rationalize inappropriate technology use as a pragmatic response rather than an ethical violation. This perspective challenges traditional assumptions about effort, expertise, and learning, and highlights the need to reconsider how mathematical understanding is defined and assessed in technologically saturated learning environments.

The discussion underscores the importance of assessment practices that integrate conceptual understanding, procedural fluency, reasoning, and interpretation. It also highlights the need for teacher education programs to explicitly address responsible technology use, academic integrity, and students' epistemological beliefs, providing future educators with guidance for supporting ethical and meaningful engagement with digital tools.

By framing academic integrity as an educational issue situated at the intersection of assessment, motivation, and technological change, this paper contributes to contemporary debates in mathematics education research. It offers a conceptual lens for understanding integrity challenges and supports future research and policy development focused on assessment reform and responsible technology use in mathematics education.

O27 - The importance of functional teaching laboratories in the training of science teachers in the early years of schooling: a scoping review

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Science education from the early years (3-11 years old) tends to employ passive and decontextualized teaching methods, which hinder the promotion of scientific literacy in children. In Portugal, this is compounded by the lack of adequate material resources and infrastructure in schools to conduct experimental activities more systematically and frequently. Considering that teachers' perceptions and pedagogical-didactic knowledge influence their practices, investing in initial (and ongoing) teacher training emerges as a predictor of improved science education. In initial teacher training, it is essential that students, future education professionals, experience teaching methods and strategies consistent with those they are expected to adopt with children, as well as develop skills to organize and adapt spaces to the conditions of educational contexts. In this sense, science teaching laboratories are configured as formative spaces that can support the promotion of these skills. Therefore, the study's research question was defined as "What contributions and gaps emerge from research on science teaching laboratories in the initial training of educators and teachers from the early years of schooling, especially regarding their conception, implementation, and evaluation as formative spaces?" and the research objective was defined as follows: To map the available scientific evidence regarding the focuses and purposes of didactic science laboratories in teacher training and the pedagogical, organizational, and didactic principles underpinning their creation and operation. A documentary approach of an exploratory and qualitative nature was adopted, using the scoping review method. The documentary corpus was constructed from searches in four internationally relevant databases (Scopus, Web of Science, ERIC, and SciELO), using the following terms linked by the Boolean operator "AND": "teaching laboratory OR didactic laboratory OR laboratory work", "teacher training OR teacher education OR initial teacher education", and "science education OR science teaching". The research was conducted in English, Portuguese, and Spanish. Initially, 557 articles were identified in the English search: 85 in Scopus; 358 in Web of Science; 13 in ERIC; and 101 in SciELO. After eliminating 49 duplicate articles, inclusion criteria were applied, focusing on articles that simultaneously addressed: i) the initial training of educators and teachers; ii) teaching laboratories; and iii) the sciences. Following the application of these criteria, the final corpus of analysis consisted of 12 articles: 2 from Scopus; 8 from Web of Science; 1 from ERIC; and 1 from SciELO. The preliminary analysis of the studies reveals a predominant focus on comparisons between virtual and physical/traditional laboratories and on the analysis of the effects of laboratory activities on the learning of students, future teachers. As a contribution, it is expected that this study will highlight implications for future research and practice, particularly in relation to interventional, design, or action-research studies aimed at the (re)creation of science teaching laboratories in the initial training of educators and teachers from the early years of schooling. Furthermore, the proposed mapping is expected to provide insights into potential developments in teacher education within higher education, particularly by systematizing emerging trends such as the use of virtual laboratories and other digitally mediated approaches in science education.

O28 - Using GenAI to support curriculum reform in mathematics education: a professional development case study

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Mathematics, as a foundation stone for STEM, is an important subject for our technology-dependent society. Issues in mathematics education - such as an over-reliance on procedural fluency and the perception of students that the subject is difficult - persist, despite the best efforts of reforms to reimagine the way mathematics is taught. Teachers struggle to plan and implement lessons that support their students to see mathematics as useful and connected and to develop problem-solving skills; the aims of recent curricular reforms.

Technology has been identified as a facilitator of reform and Generative Artificial Intelligence (GenAI) is the latest technology that could be used to support reform aims. However, Professional Development (PD) is essential. For PD to be effective, it needs to be embedded in the teachers' own practice, and provide opportunities for collaboration and reflection.

Maths AIde is a GenAI-supported, collaborative PD offering focused on developing Units of Learning (UoL) that support the teaching of mathematics as a connected series of ideas with activities that foster problem-solving opportunities. The teachers are invited to create a UoL with their colleagues by engaging with GenAI and using it as an "object to think with". This research seeks to answer the following RQ: To what extent does a GenAI-supported collaborative PD model - Maths AIde - support teachers in implementing curriculum reform in mathematics?

A mixed-methods, case-study approach was followed involving n=30 teachers, who participated in four workshops. Findings indicate that teachers' use of, and confidence in using, both curriculum documents and GenAI increased throughout the intervention. Results show that as the intervention progressed, outputs were created that were increasingly in line with curriculum intentions. However, while progress was made with consideration of the intended curriculum, issues were identified with how the teachers engaged with the GenAI outputs. There was no evidence that outputs were being critiqued and reworked, with results showing that the GenAI was being used in a manner similar to a search engine. Therefore, future iterations of the intervention necessitate a specific focus on how to support teachers to critically engage with GenAI outputs. This research identifies the potential benefits of GenAI usage for supporting the implementation of curricular reform while highlighting the ongoing need for further PD involving GenAI.

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O29 - The role of design thinking in the development of creativity in an I-STEM learning sequence

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In an era of rapid scientific and technological change, educational systems often struggle to adapt teaching and learning practices to these developments. This challenge has highlighted the need for educational approaches that move beyond disciplinary fragmentation and simultaneously foster scientific literacy and transversal competencies such as problem-solving, critical thinking, and creativity. Within this context, Integrated STEM (I-STEM) education has emerged as a relevant framework, emphasising the articulation of knowledge across disciplines through engagement with authentic, real-world problems. Engineering design activities, particularly those grounded in Design Thinking (DT), play a central role within I-STEM, as they support interdisciplinary integration while fostering creativity and the development of essential competencies for contemporary society. Nevertheless, existing research on DT in education frequently adopts a broad perspective, offering limited insight into students' engagement with its distinct phases and the ways creativity evolves throughout the iterative design process. To address this gap, this qualitative study examines how the cognitive and functional dimensions of creativity emerge within a DT–based I-STEM sequence. Specifically, it seeks to answer the following research question (RQ): *How do cognitive and functional dimensions of creativity manifest across the different phases of DT?*

The theoretical framework draws on I-STEM education, which emphasizes the integration of disciplinary knowledge to address authentic problems, and on DT, understood as an iterative process that combines analytical and creative modes of thinking. Creativity is understood as a multifaceted construct comprising two complementary dimensions: a cognitive dimension, integrating divergent and convergent thinking processes associated with idea generation, evaluation, and refinement, and a functional dimension, concerning the transformation of ideas into solutions characterised by novelty, relevance, and functionality. The study involved 30 students (aged 16–18) from a 12th-grade Science and Visual Arts class. Over ten lessons (450 minutes), students collaboratively developed functional prototypes for monitoring indoor air quality (CO_2) using Micro:bit and sensors. Methodologically, this study employed a qualitative content analysis of multiple data sources, including classroom observations, written records, photographs, videos, and prototypes. The DT process was mapped across five phases: Problem Scoping, Brainstorming and Planning, Construct, Evaluation, and Redesign. Creativity was analysed through a four-level rubric encompassing idea development, originality, thematic coherence, prototype functionality, and iterative resilience. Findings highlight iteration as central to fostering creativity: groups engaging in frequent iterative cycles demonstrated greater originality and resilience. Cognitive creativity was most evident during ideation and evaluation phases, supporting divergent and convergent thinking, while functional creativity emerged as students translated abstract ideas into tangible and robust artefacts. In contrast, more linear processes limited opportunities for innovation and refinement. Overall, this study highlights the central role of DT in I-STEM contexts, as its iterative phases enable the integration of scientific and technological knowledge while supporting the development of both cognitive and functional dimensions of creativity. These findings suggest that Science curricula would benefit from prioritising methodologies grounded in iterative design and sustained engagement with problem-solving processes, enabling students to position themselves not merely as passive users of technology but as critical and creative developers of solutions to complex scientific challenges.

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O30 - Machine learning as a cognitive tool: fostering critical scientific reasoning

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The integration of Artificial Intelligence (AI) into science education raises a pedagogical challenge: how to avoid the use of technology as a "black box" and ensure that it effectively supports the development of analytical skills fundamental to scientific reasoning. While Machine Learning (ML) offers opportunities for students to engage with authentic scientific practices, such as data analysis and modelling, it also carries the risk of encouraging uncritical acceptance of algorithmic outputs. In educational contexts, this may lead students to mistake statistical correlations produced by algorithms with causal scientific explanations, weakening the development of critical scientific thinking.

In response to this challenge, this study investigates how students engaged in the construction of ML models and which analytical skills they mobilise throughout this process. The research involved 124 students from the 8th, 10th, and 11th grades who participated in a learning sequence integrating physics and chemistry content with computational modelling, structured according to the Design Thinking (DT) process, which framed learning as an iterative and reflective activity.

Students used the Machine Learning for Kids platform to develop explainable supervised learning models, specifically decision trees, to analyse indoor environmental comfort data, including variables such as CO_2 concentration and temperature. The use of decision trees enabled students to visualise how variables influenced predictions, supporting reflection on the relationship between data, model structure, and outcomes.

Data collection included students' written artefacts, modelling outputs, and reflective texts. A qualitative content analysis was conducted to identify distinct modelling practices. Students' critical engagement with models was examined through three complementary dimensions of scientific critical thinking: the interpretation of data and identification of patterns, the justification of modelling choices based on evidence, and the recognition of limitations and uncertainties inherent in both data and models.

The results indicate that the pedagogical approach effectively promoted students' involvement in data interpretation through ML. All student groups demonstrated basic cognitive engagement, particularly in recognising patterns and selecting relevant variables. A substantial proportion progressed towards more advanced forms of reasoning: 71% of the groups justified their modelling decisions using evidence, and 79% explicitly identified limitations, such as restricted data ranges or potential bias related to sample size. Notably, 46.4% of the groups reached the most advanced modelling profile, characterised by an integrated articulation of data interpretation, evidence-based justification, and critical reflection on model constraints.

These findings suggest that combining DT with explainable ML tools supports the development of scientific critical thinking. By positioning ML models as objects for interrogation rather than definitive sources of knowledge, this approach enables students to distinguish between algorithmic predictions and scientific explanations. Therefore, this study provides empirical evidence that ML can function as a cognitive tool for model-based reasoning, highlighting its potential to promote scientific critical thinking and, consequently, a more informed use of Artificial Intelligence.

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O31 - Integrating mathematical games into pre-service and in-service elementary school teacher training

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This article addresses the challenge of identifying teaching tools that support a shift in mathematics education from a transmission-oriented model towards approaches grounded in dialogue, exploration, and the construction of mathematical meaning through social interaction. Particular attention is paid to mathematics games (board, card, and dice-based games) used in the education of prospective and in-service lower primary school teachers. The focus is on teachers' experiences with these games and their reflections developed during mathematics education courses.

The study adopts a qualitative research design embedded in the theoretical framework of Realistic Mathematics Education (RME). Data were collected through four focus group interviews with in-service teachers working in elementary education schools and four individual interviews. The empirical material consists of reflective comments and discussions provided by pre-service and in-service teachers participating in mathematics education courses. Games are interpreted as meaningful contexts for cognitive activity and as starting points for initiating mathematical discourse, understood as collaborative work aimed at negotiating meanings, justifying solutions, and critically analysing problem-solving strategies. The analysis follows an interpretative qualitative approach focusing on recurring themes related to teacher role, student interaction, communication, and attitudes toward mathematics.

The main research question is: How do in-service and pre-service lower primary school mathematics teachers interpret the role of educational game-based experiences in the development of their professional competencies? How do these experiences influence their attitudes toward mathematics teaching methods, and how do they affect teachers' self-perception regarding their own relationship with mathematics?

The analysis of the interviewed teachers' statements includes the following categories: initial attitudes toward the use of games in education; description of experiences with applying a specific model of game use; deepening the understanding of the functions of games in one's own practice; and the conditions influencing changes in attitude.

Preliminary findings suggest that game-based activities contribute to lowering mathematics anxiety, support the diversification of mathematical strategies, and create learning environments conducive to mathematical reasoning and argumentation through verbalising thinking processes and comparing alternative solution methods. These findings are grounded in the preliminary analysis of the focus group data. Furthermore, the analysis indicates that the use of games in teacher education may act as a catalyst for redefining the teacher's role - from a transmitter of knowledge to a designer of learning environments in which mathematical communication, reflective teaching practice, and sensitivity to learners' experiences are central. The data also provide insight into teachers' self-perceptions, including their confidence and attitudes toward mathematics, showing how participation in game-based activities may influence their sense of competence and relationship with the subject.

At the next stage of the research, classroom observations are planned in order to verify and deepen the understanding of teachers' declarations concerning the implementation of game-based approaches in their practice, allowing for the triangulation of self-reported and observational data.

O32 - The formation of an innovative profile of postgraduate students in chemistry for teaching in higher education

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In today's globalized and digital society, science education in higher education needs to be rethought in order to promote the development of scientific and digital literacy, as well as citizenship and social justice. The appropriate use of digital technologies in science and mathematics education can foster the construction of diverse knowledge and the development of cognitive and socio-emotional skills. Teacher training needs to include the deepening of pedagogical knowledge necessary to promote meaningful learning. According to Almeida and Pimenta (2014), unpreparedness and a certain lack of scientific knowledge of the teaching and learning process in higher education institutions still predominate. This qualitative study addresses the development of a course in one of the Teaching Improvement Programs at a state university in São Paulo, Brazil, with 32 postgraduate students. Teaching strategies were studied, such as the use of ICTs, problem-based learning, case studies, history of Chemistry, experimental teaching, cooperative and collaborative learning, assessment, teaching plans. The research question was: What are the conceptions of teaching and learning and Didactic Models held by postgraduate students for teaching in Higher Education? In order to understand the students' conceptions, two questionnaires and an interview were applied. Bardin's (2011) Content Analysis was used to analyze the ideas that emerged. All students answered the first questionnaire, investigating their conceptions about the teaching and learning process and their didactic models. Most students expressed conceptions of a hybrid model, involving Traditional, Spontaneous, and Alternative Models. In the second Likert-type questionnaire, students showed total agreement with most of the characteristics of an innovative teacher presented, such as: being autonomous, open to new ideas, reflective, creative, patient, collaborative, and critical. During the interviews, most students presented distorted views of Science, such as a decontextualized and neutral view, as well as an unproblematic and ahistorical view. During the course, students satisfactorily completed several assignments addressing various teaching strategies, with an emphasis on ICTs, according to the formative needs for the training of Science teachers for Higher Education, in order to plan and reflect on teaching and learning. All interviewed students stated that the various activities and reflections developed in groups and individually contributed significantly to reflecting on the teaching and learning of Science, as well as lesson planning and the use of teaching resources, such as ICTs. Student 04 stated: “The use of the WebQuest teaching method, which requires group work, debate, and consensus for the construction of products; the use of computers and navigation through different pages, websites, and platforms, knowing how to identify and search for information in reliable sources, and reading different types of information, such as text, infographics, figures, etc., contributes to digital literacy and critical thinking regarding the information found.” The deepening of pedagogical knowledge promoted important reflections by the students, leading them to rethink their classroom profile as future university professors, as well as reflect on their own conceptions. The study highlights the need to promote pedagogical studies for the innovative training of university professors, with a view to developing scientific and digital literacy.

O33 - Exploring teachers' dispositions to facilitate digital equity in multicultural classrooms

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Societal changes and digital transformations increase the importance of teaching technical subjects, such as Maths and science, within STEM education. However, the rapid adoption of digital technology in education has underscored the importance of addressing digital equity, particularly in multicultural classrooms. In Malta, a diverse country, teachers face the challenge of ensuring equitable digital practices while teaching the primary school curriculum to address the migrant students' unique needs. During the COVID-19 pandemic, when teaching was being carried out online, inequalities were felt even more. Some students did not thrive during the online lessons, and teachers felt uncertain about how to address these challenges revealing a critical gap in their dispositions and practise to facilitate digital equity and inclusion.

Specifically, the research asks:

1. What opportunities influence teachers' dispositions toward facilitating digital equity and inclusion?
2. Which challenges influence teachers' dispositions toward facilitating digital equity and inclusion?
3. How do teachers' dispositions manifest when they recognize students' differences in digital access?
4. How do teachers' dispositions manifest when they use digital technology for teaching and learning?
5. How do teachers' dispositions manifest when they facilitate inclusive practices?

Framed within the metaphor of the educational ecosystem, the interactions occurring within the education system at the macro, meso, and micro levels are analysed. Where Multiculturalism requires (1) recognising differences, (2) interacting with others, and (3) facilitating inclusive practices. It is based on three learning theories: Vygotsky's (1978) social constructivism, Siemens' (2004) connectivism, and Papert's (1991) constructionism.

The research methodology employs qualitative methods to collect online data, involving 11 primary class teachers through narrative scenarios and 21 through individual interviews. 10 migrant students and their parents participated in the individual interviews. Narrative scenarios illustrated the teacher and student's interactions when using digital technology during a Maths activity.

Data were inductively analysed using thematic analysis, to identify the opportunities and challenges influencing the teacher's dispositions to use digital technology and corroborated with the migrant students and their parents' experiences.

These include digital affordance to learn and live together, the school's support in organising activities in heterogeneous schools, teachers' expectations from parents, and forming partnerships through social media, and students' diversity and uniqueness in acting as a broker between the school and home.

From these determinants, the teachers' dispositions were analysed. Dispositions evolve from empathy to caring and take risks to learn, collaborate, share, trust, and persevere while mutually interacting and being flexible and resourceful to facilitate meaningful and personalised activities toward the student's integration.

These identified teachers' qualities are essential to nurture during STEM education to ensure student inclusion and participation in a digitised and changing world.

The rapid advancement of technology, particularly the integration of artificial intelligence (AI) alongside the green economy, has made STEM education more crucial. In our diverse and digital societies, teachers and students can work together to nurture these qualities that promote equitable digital practices and inclusion.

O34 - STEAM implementation and connections within the Portuguese high school mathematics curriculum

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Interdisciplinarity, especially through STEAM, has been a recurring topic in literature, with many researchers underscoring its advantages. STEAM emphasizes the interconnection of Science, Technology, Engineering, Arts, and Mathematics. More than simply promoting links among knowledge areas, STEAM promotes learning through collaborative and authentic real-world problem-solving scenarios, enabling students to develop cognitive, interactive, and creative problem-solving skills. This approach requires a classroom environment different from the traditional one, however, the change in teachers' behavior needed to successfully implement STEAM in classrooms can sometimes be hindered by the guidelines and teaching standards they are required to meet. In the Portuguese context, the high school mathematics is guided by the 'Aprendizagens Essenciais', which constitutes the official national curriculum guidelines that define mandatory content and expected learning outcomes for each school year, as well as recommended teaching strategies. Based on this premise, the purpose of this study is to evaluate whether the principles presented in the 'Aprendizagens Essenciais' can support teachers in implementing STEAM in their classrooms. More specifically, the study seeks to: (i) identify references to STEAM-oriented recommendations in the mathematics curriculum; and (ii) examine how connections between mathematics and other STEAM areas are articulated across curriculum documents. The study adopts a qualitative and interpretative approach through the analysis of the Portuguese high school mathematics curriculum, focusing on how STEAM is portrayed in this curriculum, using STEAM-related dimensions as analytical categories. Additionally, it includes a review of curricula from subjects related to STEAM areas that students might study, to examine how they are interconnected across these documents. The results highlight that elements consistent with STEAM are present in current Portuguese guidelines for mathematics teaching, particularly through the promotion of interdisciplinary activities, collaborative or project-based work, real-world problem-solving tasks and technological integration. However, teachers may experience difficulties in identifying connections between the mathematics content and topics from other STEAM areas on which they could build, as even when overlaps between standards exist, they are chronologically misaligned. As STEAM remains an emerging concept in the Portuguese educational landscape, the conclusions of this study have significant potential for mathematics education. They may support teachers in implementing STEAM aligned with current national guidelines and contribute to reflections on future changes to the Portuguese curriculum across STEAM areas. The analytical approach adopted in this study may also be transferable to other educational systems, since the STEAM approach has been receiving attention worldwide.

O35 - Perspectives on the STEAM approach from two teachers of different educational cycles

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This study examines teachers' perceptions of implementing the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach, with the aim of identifying key dimensions that can inform its broader application across different educational contexts. Although the empirical work involved two teachers from different educational levels, one elementary school teacher and one middle school mathematics teacher, the study seeks to contribute to a wider understanding of professional development processes that support integrated and innovative pedagogical practices.

The STEAM approach is grounded in the integration of disciplines at multidisciplinary, interdisciplinary, or transdisciplinary levels, often enacted through active methodologies such as project-based or problem-based learning. The theoretical framework combines perspectives on STEAM education with teachers' pedagogical content knowledge and the articulation of content, pedagogy, and technology to foster meaningful mathematics learning and the development of 21st-century competencies, including creativity, critical thinking, and collaboration.

Adopting a qualitative research design, data were collected from the final written reflections produced by the teachers after completing a 25-hour professional development workshop on STEAM. Participants were intentionally selected based on similar professional trajectories while teaching at different educational levels. The workshop combined face-to-face and theoretical–practical sessions, including readings, collaborative planning, classroom implementation, and reflection, promoting dialogue among teachers, trainers, researchers, and master's students in teacher education.

Data were analysed through content analysis, resulting in four categories of analysis: (i) integration of knowledge; (ii) competencies developed; (iii) evaluation of the STEAM project; and (iv) reflection on practice. Coding was conducted independently by two researchers, with discrepancies resolved through discussion to ensure reliability.

Findings reveal convergences in the value attributed to active methodologies, interdisciplinary integration, digital technologies, and formative assessment as central elements in STEAM implementation. Differences emerged mainly in the perceived ease of practical application, with the elementary school context offering greater curricular flexibility. Importantly, the study highlights that structured professional development, grounded in collaborative planning and reflective practice, plays a crucial role in supporting teachers' confidence and capacity to implement STEAM across levels.

The main conclusions indicate that effective STEAM implementation depends on (i) sustained professional development; (ii) opportunities for interdisciplinary integration that preserve the conceptual rigor of mathematics; and (iii) reflective processes that connect theory and classroom practice. These dimensions may serve as reference points for replicating similar training models in diverse educational settings. While limited by its focus on two teachers' written reflections, the study provides insights into key conditions that can inform broader STEAM initiatives in mathematics education and beyond.

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O36 - Numbers don't lie? The ethics and responsibility of mathematical modeling in the digital era

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Mathematics is frequently perceived as an objective, culturally neutral, and value-free language - a view Paul Ernest characterizes as the "myth of neutrality". However, in the digital era, mathematical applications have entered like a "daemon" into all aspects of life, serving simultaneously as the intellectual source for technological marvels and catastrophic failures. This presentation challenges the notion that mathematical modeling is a purely descriptive exercise, asking: How do hidden value judgments and the limitations of mathematization impact the "truth" of numerical outputs, and what are the resulting ethical obligations for educators and practitioners?

The theoretical framework is grounded in the intersection of the philosophy of mathematics and critical education theory. It draws on Gregor Nickel's analysis of the "normative function" of mathematics, which argues that mathematical models do not merely describe the world but actively shape social realities by establishing norms that are often invisible to the public. Furthermore, the study integrates Paul Ernest's call for an "ethical audit" of mathematics, rejecting the separation of "intra-mathematical" correctness from "extra-mathematical" consequences. This perspective is contextualized within Ulrich Beck's concept of the "Risk Society", highlighting how modern mathematization creates risks that are often incalculable yet treated as manageable certainties.

To ground these theoretical claims in empirical reality, the presentation analyzes specific case studies of "simple errors" detailed in Bátkai and Nickel's recent work. These include the 2003 Laufenburg Bridge incident, where a coordinate system mismatch led to a 54-centimeter construction error, and the tragic legal case of Sally Clark, where the misuse of statistical independence principles led to a wrongful conviction. These examples demonstrate that modeling failures are rarely purely technical; they are often failures of "translation" where context, units, and semantic meaning are stripped away during the mathematization process.

The findings suggest that "intra-mathematical due diligence" - simply calculating correctly - is insufficient for ethical practice. True responsibility requires acknowledging the "monstrosity" of the model: its potential to override human judgment and obscure the inherent uncertainty of reality. The implications for science and mathematics education are profound. Moving beyond technical proficiency, educators must foster "ethical literacy" by teaching students to identify what is ignored in a model. We must equip future citizens to question the authority of the number, recognizing that while numbers may not lie, the models that generate them carry the weight of human choice, bias, and potential error. This approach shifts the focus from a pedagogy of perfection to a pedagogy of responsibility, essential for navigating a digitized world.

O37 - Homework with sound and image: using student-generated videos in higher mathematics education

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In higher mathematics teacher education, particularly in abstract courses like Linear Algebra, traditional written homework often leads to a mechanical "copying" culture rather than deep conceptual engagement. There is a pressing need for digital formats that foster individual expression and active participation among students. This research focuses on replacing standard written assignments with the creation of student-led explanatory videos.

The primary purpose of this study is to understand the contribution of video production to the learning of Linear Algebra and the professional development of future mathematics teachers. Specifically, the research aims to determine how the self-confidence and self-concept of students regarding mathematical explanation change through this format, and how they perceive the long-term utility and learning effect of video creation compared to traditional homework.

The intervention is built upon Self-Determination Theory, which posits that autonomy and perceived competence are primary drivers of motivation, and incorporates Constructionism, where learning is viewed as most effective when students actively create a public artifact. Additionally, the method utilizes the "Learning by Explaining" paradigm to stimulate metacognition and deeper cognitive processing of mathematical structures.

To evaluate this approach, a mixed-methods study was conducted within a Linear Algebra course involving 12 teacher-training students. Data collection included quantitative pre- and post-semester surveys using a 6-point Likert scale to measure changes in self-perception and utility, alongside qualitative semi-structured interviews with both students and the instructor to explore individual experiences and practical tensions of practice.

The findings indicate a significant, quantitative increase in students' self-confidence when explaining mathematical content. Furthermore, the perceived utility of the video format improved over the semester, with students recognizing it as a valuable pedagogical tool for their future careers. Qualitative interviews revealed that creating videos forced students to penetrate the material more deeply to ensure clarity and avoid "filler words" for potential viewers. Students also reported that the low-threshold nature of video recording allowed for multiple attempts, significantly reducing the performance anxiety often associated with live blackboard presentations.

Ultimately, this research demonstrates that student-generated videos are a viable, high-impact alternative to traditional homework in STEM education. For teacher training, the format not only reinforces mathematical content but also develops essential digital and communicative competencies. By transitioning from a "copying" culture to a "creation" culture, universities can better support the development of a professional self-image in future educators. These results suggest that integrating multimodal tasks can significantly enhance cognitive activation and student agency in high-level mathematics.

O38 - The semiotic potential of robotics for mathematical modelling: towards an analytical framework for mathematics education

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Modelling plays a central role in science and mathematics education, supporting learners in constructing, testing, and refining representations of phenomena. Recently, educational robotics gained increasing attention as a powerful tool for learning that combines physical artefacts, programming languages and environments, as well the possibility of active-learning STEM approaches. Prior research has documented motivational and cognitive benefits of robotics-based activities; however, less attention has been paid to how robotics functions as a semiotic tool when incorporated into mathematics modelling tasks.

Understanding the specific semiotic processes offered by robotics is crucial for explaining how learners make meaning when engaging in mathematical modelling tasks. This theoretical paper aims to articulate what we conceive as the *semiotic potential of educational robotics for modelling* and to propose an analytical framework to investigate this potential in science and mathematics education. The guiding question is: How does robotics exhibit its semiotic potential in mathematical modelling activities through instrumental genesis processes?

The paper is grounded in a semiotic perspective on learning, drawing primarily on theories of semiotic mediation and mathematical modelling. From this viewpoint, learning is understood as the progressive appropriation and transformation of signs, representations, and artefacts. From the perspective of instrumental genesis, educational robotics is initially a tool whose mathematical relevance is not intrinsic, but it's constructed through learners' activity. We conceptualize *semiotic potential of educational robotics for modelling* as the capacity of the tool-activity system to support the emergence and transformation of signs, enabling learners to articulate personal meanings and progressively align them with institutional mathematical signs during modelling activities. This paper offers a theoretically coherent account of how robotics can support mathematical modelling. The proposed framework provides a mean to make visible the processes through which learners construct meaning and develop mathematically relevant representations and competences. This analytical framework has important implications for both research and teacher education, once it offers a theoretically grounded tool for analyzing classroom interactions and students' modelling activity involving robotics, highlighting the importance of designing modelling tasks and orchestrations that foster instrumental genesis and the emergence of productive semiotic processes.

O39 - Makerspaces in Greek schools: trends, impact and challenges

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Maker Movement is a educational trend that fosters learning through blending DIY (Do-It-Yourself) with technology. Makerspaces are physical collaborative, hands-on workspaces or creative hubs that promote active participation, experimentation, construction, problem-solving and development of 21st-century skills. Such places are typically equipped with tools including 3D printers, laser cutters, robotics, Arduino, and extended reality. The current situation in Greece does not provide a national policy that mandates makerspaces in Greek schools. As a result, only a limited number of schools have such infrastructure for dedicated labs, while the majority of them visit external centers, collaborate with universities, and participate in relevant projects such as Erasmus+ initiatives. Taking the above into consideration, this study employs a systematic literature review in the Scopus database following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework. The review aims to synthesize the current evidence on the use and organization of emerging makerspaces in Greek primary and secondary schools to identify their role, trends, impact and challenges.

The findings indicate that makerspaces assume a mainly educational informal role through STEM labs, robotics clubs, project work, or flexible zones. Existing initiatives in Greek schools focus on the fields of STEM/STEAM, robotics, and 3D printing. Within the formal curriculum, maker education is integrated differently across educational levels, particularly through the subject of Informatics and interdisciplinary project-based approaches. Programming environments such as Scratch, Python, and Algorithmic Language are mainly used. At the domain of robotics, it looks that apply at all levels of education through the use of systems such as Bee-Bot, micro:bit, and Arduino.

In recent years, a series of innovative curricula have been introduced, with two key examples: (a) the “Active Citizenship Actions”, which combine learning through DIY practices and contemporary technologies with the Sustainable Development Goals, aiming to cultivate students’ critical thinking, collaboration, and social responsibility, and to develop them into active and critically engaged citizens; and (b) “Skill Labs” workshops, which integrate STEM, Robotics, and Maker Education across all school levels under the thematic axis “Creating & Innovating”. These workshops are fully aligned with Informatics and ICT subjects, promoting hands-on learning, creativity, and interdisciplinary STEAM projects.

Despite these developments, there are challenges that need to be addressed. The cost of the equipment limits the possibility of acquiring infrastructure in schools. Many teachers emphasize the need for specialized training and mentoring to be able to implement innovative pedagogical approaches, as well as support effectively students with their hands-on projects. Moreover, they claim that long-term effects of maker depend on teacher capacity building and effective curricular integration. Therefore, existing and future curricula require careful planning to create impactful learning experiences and combined with time constraints, adds complexity. Although makerspaces in Greek schools are expected to impact students’ engagement, STEM/STEAM skills, and problem solving, the study reveals a lack of empirical data to justify these expectations.

O40 - Project-based STEM learning in elective high school courses: engineering design, productive failure, and authentic assessment in an international school context

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This paper examines project-based STEM learning (PBL) in standalone elective high school courses at an international school in Hanoi, Vietnam. In contrast to integrated PBL curricula, these electives operate as small "mentored studio" classes (typically 15-17 students) in which each learner develops an individual project, enabling differentiated pathways across grade levels and prior experience. Cohorts include STEAM Lab (grades 9-12), Big Data (grades 10-12), and a small, selective Machine Learning course (grades 11-12). The contribution is contextual design considerations, grounded in student-voice evidence, about the supports and dispositions that sustain iterative STEM work, including bounded generative AI use.

Learning follows iterative engineering and data cycles - problem framing, designing/building (e.g., Arduino/sensor-based prototypes or data/ML pipelines), data collection/analysis, and communication to authentic audiences - culminating in a student-led international research conference and a community STEAM showcase (authentic assessment). Constructivist and experiential commitments are enacted through student choice, repeated cycles of making-and-reflection, and explicit normalization of productive failure and iteration. Generative AI is permitted only for bounded support (e.g., explanation and writing revision), not for generating solutions or interpreting results, so that decision-making, debugging, and evidencing remain student work.

Drawing on constructivist and experiential learning, engineering design, and authentic assessment, the study asks: (1) What course features do students perceive as most supportive of learning in these PBL electives? (2) What habits/mindsets do students report as enabling success in iterative design and data work? (3) What implications follow for STEM learning in digital contexts, including responsible AI use?

Data comprise anonymous end-of-course student feedback surveys (2023-2025; N=80; STEAM Lab n=33; Big Data n=33; Machine Learning n=14) with Likert (1-5) items on instructional support and two focal open-ended prompts ("class factors" and "habits/mindsets"). Likert responses were summarized descriptively; open responses were thematically coded. Alumni reflections are included as illustrative examples only with explicit permission. Student data are reported in aggregate in accordance with institutional/school ethics guidance: participation is voluntary, responses are anonymous, and no identifying information is collected.

For "class factors", the most frequent themes were teacher availability and one-to-one meetings/feedback, project-based making, and explicit instruction in research, data, and writing practices. For "habits/mindsets", students most often emphasized time management/starting earlier, help-seeking, sustained focus/use of class time, and persistence through difficulty. Alumni reflections suggest increased confidence in tackling unfamiliar technical problems because students experienced failure and learned through iteration.

The paper contributes contextual design considerations for elective-course PBL resembling authentic STEM practice - scaffolded autonomy, individualized formative feedback, and explicit normalization of iteration - alongside bounded AI use, emphasizing epistemic agency by keeping core decisions, debugging, and evidentiary claims with students while using AI only for bounded support in digital learning contexts. Limitations include a single-site context, self-report data, cohort differences, and a teacher-researcher stance; claims are interpretive, not causal.

O41 - High-stakes assessment of mathematics in the senior cycle of secondary education: challenges and affordances at a time of curriculum change in Ireland

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The digital era offers affordances but provides challenges for assessment across all subject areas. In Ireland, changes currently being made to national curricula (including assessment) for the senior cycle of secondary education - notably for the high-stakes Leaving Certificate, chief gateway to third-level education - need to take these into account. A major issue is the new requirement that forty per cent of the marks in every subject be allocated to "additional assessment components" (AACs): components other than traditional written examinations. In some areas, such components already exist; examples include practical and oral tests and project work. For projects, however, affordances in the digital era - in particular the advent of GenAI – have exacerbated acknowledged ethical problems; reconsideration may be necessary.

Leaving Certificate Mathematics has always been assessed only by traditional, end-of-cycle examinations. While their formats have changed at intervals to address varying goals, other types of assessment were not widely discussed until now, and finding appropriate and acceptable forms for AAC(s) is proving very challenging. Thus, the paper has two main aims:

1. To review changes over time in the summative assessment of Mathematics in Ireland, for both junior and senior cycle, seeking to identify planned benefits and actual outcomes;
2. Against this background, to critique approaches that might be used for the Mathematics AAC(s).

The argument draws on the familiar model of *curriculum* that differentiates between three levels: intended, implemented, and attained. The concept of *multiple-objective assessment* - with different forms of assessment targeting different learning outcomes - provides a lens for examining past intentions, implementations, and attainment, and considering future options for Leaving Certificate Mathematics. The author's involvement as an observer or participant in Irish and international curriculum change from the 1960s contributes a unique historical perspective. It frames her analysis of archival and recent curriculum-related material (curriculum specifications, examination papers, and contemporary commentaries), academic research, and teacher surveys by the Irish Mathematics Teachers' Association.

For aim 1, consequences of successive changes for curriculum coverage and student attainment are reported. Of note is the recent incorporation into junior cycle Mathematics of investigative projects in the form of "Classroom Based Assessments" (CBAs): controversial as currently implemented because of the time they take, their openness to misuse of GenAI and other tools, and - for some people - their perceived non-alignment with goals of mathematics education. For aim 2, options are discussed. Some, such as a test of algebraic fluency mid-way through the cycle, appear popular with teachers but might be classified as - unacceptable - traditional examinations. Investigative or problem-solving projects would require a formulation avoiding the difficulties encountered for CBAs, say with work sessions time-limited and proctored to obviate ethical abuses. The concept of oral assessment is gaining traction internationally and interest nationally; an apparent affordance is its ability to focus on the much-desired but elusive goal of conceptual understanding, but large-scale implementation would be challenging.

National-level discussions continue. These, and the eventual outcome, may provide lessons for mathematics education and teacher education about broadening assessment while maintaining ethical and curricular integrity in the digital era.

O42 - STEAM projects and assessment in initial teacher training: evidence from an umbrella review

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The Bologna Process has consolidated a model of education in European higher education that focuses on skills development, requiring more integrated, formative, and autonomous learning-oriented teaching and assessment practices. In this context, the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach has been playing an important role in initial teacher training by promoting interdisciplinary practices, active methodologies, and the articulation between scientific, technological, and artistic knowledge. However, the assessment of these approaches remains one of their main challenges. This paper is the result of research based on a systematic review of second-level literature (called an umbrella review or review of systematic reviews), guided by the question: what concepts and practices link STEAM projects and assessment in initial teacher training? It followed the guidelines of the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guide and was conducted in the Scopus database. Systematic reviews and scoping reviews, peer-reviewed, published between 2020 and 2025, in English, Portuguese, or Spanish, were included. The selection process resulted in the inclusion of eight reviews. The analysis adopted a cross-sectional and comparative approach, focusing on: (i) assessment practices; (ii) assessment methodologies and instruments; (iii) the cross-curricular and specific skills targeted in STEAM projects; and (iv) recommendations and implications for teacher training. The results show a significant shortage of studies that explain integrated and coherent assessment models for STEAM projects in initial teacher training. Despite widespread recognition of the value of these approaches for developing cross-curricular skills such as critical thinking, creativity, collaboration, digital literacy, and artistic sensitivity, assessment remains largely focused on isolated, fragmented, and predominantly summative approaches. This tendency is manifested in an excessive emphasis on the final product of projects, to the detriment of valuing learning processes, critical reflection, and self-regulation. The literature analyzed, involving articles from various countries, converges in identifying structural obstacles, namely the curricular fragmentation of teacher training courses, organized by scientific areas and isolated curricular units, as well as the persistence of institutional cultures oriented towards certification and quantification of results. These constraints hinder the implementation of integrated assessment practices capable of capturing the complexity of learning developed in STEAM projects. On the other hand, clear recommendations emerge in favor of a focus on formative assessment, conceived as a continuous, regulatory, and reflective process. Tools such as portfolios (preferably digital), self- and peer assessment, as well as narrative and reflective tools, are identified as appropriate strategies to support meaningful learning and the professional development of future teachers. These proposals are in line with European benchmarks, such as the European Qualifications Framework and DigCompEdu, which emphasize assessment in complex interdisciplinary contexts and the pedagogical integration of digital technologies. This communication highlights the need to overcome curricular and assessment fragmentation in initial teacher training, proposing integrated practices that link pedagogical assessment and STEAM projects. In doing so, it contributes to raising awareness among teacher trainers of the importance of formative assessment models capable of supporting deep learning, autonomy, and future reflective and transformative teaching practice.

O43 - InMath - early results of the trial of accessible and inclusive problem-solving activities for intellectual disabilities

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InMath project has been designed to facilitate access to mathematical problem-solving (M-PS) activities for primary school pupils with intellectual disabilities (IDs) by developing accessible teaching proposals.

PS is a central element of mathematical competence and a key competence for participation in contemporary digital societies, supporting autonomy, self-determination and active citizenship. Despite its importance, encouraging M-PS activities among pupils with IDs is a challenging task for teachers, and there is limited research on this topic. Notwithstanding the heterogeneity of cognitive and adaptive profiles among people with IDs, certain typical characteristics of their functioning - lack of abstraction, rigid thinking and difficulties with executive functions - can affect competence development. Furthermore, contexts, materials and teachers themselves are often ill-equipped to address the specific needs of these students.

InMath adopts an Educational Design Research approach, within a multiple comparative case study, involving 7 primary school classroom (132 pupils, 7 with mild IDs).

InMath consists of: 1) systematic review and interviews; 2) observation of school contexts; 3) design and initial testing of M-PS teaching proposals and related materials, developed starting from the learning characteristics of pupils with IDs and implemented with the whole class; 4) initial analysis of outcomes; 5) redesign and second testing, focused exclusively on pupils with IDs; 6) analysis and dissemination of results.

A theoretical framework on M-PS and IDs has been identified and defined; moreover, an innovative teaching kit is to be developed, accompanied by operational guidelines and illustrative examples, with the aim of supporting teachers in designing M-PS activities for pupils with IDs.

The aim of this contribution is to understand whether (RQ1) and how (RQ2) PS-M activities can be designed and implemented that are accessible to all students, including those with IDs. It focuses on the results of the first experimental activities (phases 3-4), which were intended for the whole class and developed based on data collected in phases 1-2. These activities revealed high levels of engagement, active participation and motivation among all pupils through specially designed observation rubrics, as well as the activation of M-PS strategies among pupils with IDs. The decision to structure the proposals in a gradual and modular way, according to the “low floor, high ceiling” approach, while enhancing the narrative and playful dimension, proved effective in responding to the educational needs of each pupil. Nevertheless, these preliminary results emphasise the necessity of further analysing the effectiveness of the adopted adaptations - such as the use of concrete materials, simplified language and dynamic assessment - in facilitating access to and promoting M-PS among pupils with IDs. In consideration of this necessity, phase 5 of the project concentrated on pupils with IDs to observe their learning processes in greater detail and clarify which strategies are most effective in these specific cases.

O44 - GiroGiraMente: integrating maker education principles for computational thinking development in science education

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In contemporary digital societies, Computational Thinking (CT) has become a key competency for all citizens. GiroGiraMente is a Learning Resource (LR) created to foster this competency through gear based mechanical systems. This LR promotes CT by challenging learners to determine the rotational direction of the final gear when the first gear rotates clockwise, while simultaneously encouraging mathematical and physical analysis of how motion and speed vary across gears with different diameters. It is well known that spatial skills and CT abilities are closely intertwined. It is available in two complementary formats: a physical manipulative version, using eight cardboard gears of varying sizes mounted on a perforated styrofoam-reinforced cardboard base, and a digital interactive application for simulation, accessible at https://girogiramente.epl.di.uminho.pt. This dual format supports the need for hands-on learning - the basis of Maker Education - while also taking advantage of digital tools in mathematics and science education (SE). This communication is concerned with a research work that aims at answering the following question: can a LR like GiroGiraMente support Maker Education and simultaneously foster CT in the context of SE? To answer the question, the project followed a design-based methodology to create four progressive challenges of motion analysis, for students aged 10–18 years, spanning from 6th to 12th grade (with Challenge 4 extending to upper secondary), in the format of quizzes with immediate feedback: 1. how do gears move; 2. why doesn't the gear system work; 3. predicting the gear movement; 4. mathematical gear challenges (size, direction, speed). A first experiment was conducted in which the LR was implemented and evaluated in a real classroom setting (around 20 students) through an empirical study involving lower and upper secondary students. The study employed a collaborative learning structure where students worked in small groups of 2–4, with rotating roles (Assembler, Observer, Reporter and Validator) to ensure balanced participation and develop both cognitive and socio-emotional competencies. Each challenge was designed to be completed in approximately 8–10 minutes, with the full activity lasting around 40 minutes. Learners interacted autonomously with the digital version of GiroGiraMente without prior training, completing the progressive challenges. Data collection comprised direct observation, task performance analysis, and the System Usability Scale (SUS). The evaluation yielded a mean SUS score of 77.5, indicating "good" usability and confirming the resource as pedagogically appropriate. Students showed their ability to break down complex problems (Decomposition), recognize mechanical and mathematical patterns (Pattern Recognition) - including parity-based patterns where an even number of gears inverts the final rotation direction, design step by step resolution schemes (Algorithmic Thinking, Logical Reasoning), and understand and overcome incorrect predictions (Evaluation, Analysis, Debugging and Persevering). Summing up, it is possible to state that classroom implementation showed that the resource supports the development of the core CT competencies. The combination of physical and digital formats proved especially effective. The physical materials encourage concrete exploration - make it with your hands to learn deeper, while the digital version offers unlimited configurations, immediate feedback, and space for independent experimentation. Mathematical reasoning also improves, particularly in proportional reasoning, sequential analysis, and geometric calculation, as students engage with authentic problem scenarios. GiroGiraMente represents a significant pedagogical innovation for physics education, particularly in the domain of Dynamic Mechanics where abstract concepts of mechanical advantage, torque transmission, and rotational motion often challenge learners. Overall, this work shows that CT can be developed through concrete, intuitive tasks provided by Makerspaces, and that digital environments can extend accessibility and scalability. GiroGiraMente offers a model for hybrid LR suited to the demands of the digital era in SE.

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O45 - Exploring pre-service chemistry teachers' difficulties in introductory Arduino-based activities for chemistry laboratory applications

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Integration of low-cost microcontrollers and sensors into science education is increasingly being promoted to support STEM learning and improve practical work in school laboratories. In chemistry education, platforms such as Arduino offer the chance to collect real-time data, automate measurements, and connect abstract chemical principles with practical experimentation. However, successfully integrating these technologies into educational contexts largely depends on teachers' preparation and confidence. Therefore, understanding the difficulties experienced by pre-service chemistry teachers when first engaging with Arduino-based activities is essential for designing effective teacher training programmes.

This study explores difficulties reported by pre-service chemistry teachers when performing introductory Arduino-based activities designed to familiarize them with the potential applications of this technology in the implementation of integrated STEM teaching in the chemistry laboratory. Based on this, a qualitative case study methodology was adopted to answer the research question: What difficulties do pre-service chemistry teachers report when engaging in introductory Arduino tasks? The research involved 21 pre-service chemistry teachers who were students in a master's in Physics and Chemistry Teaching programme. They participated in an introductory practical session on connecting and controlling sensors using Arduino UNO microcontrollers. Four tasks were proposed to be carried out: blink a LED light; collect temperature measures over time with a DS18B20 temperature sensor; measure pressure, temperature and humidity with a BME 280 sensor; combine two sensors or a sensor and an LCD display. Despite they work in groups of two or three, each student, whenever the availability of materials allowed, carried out their own assembly. The circuit assembly diagram and respective code for programming Arduino board were provided, by the instructor, whenever students were unable to obtain them through an internet search or in the examples provided in software Arduino IDE or by other means. Qualitative data was collected through an open-ended questionnaire in which participants were asked to report the difficulties they encountered during the Arduino-based tasks. Data were analysed using content analysis.

Three categories of difficulties were reported by most of the 21 participants: technical, programming and software. In technical difficulties the most prevalent difficulty was related with translating connection diagrams into physical circuits on breadboards. The main difficulty with programming was loading the correct libraries necessary for the sensors and display to work properly. Difficulties with software were related to the use of Arduino IDE software and the installation of the Microsoft Excel® Data Streamer add-in. Most of these challenges are straightforward and can be overcome during training. However, it is likely that using a new sensor will present some challenges when it comes to finding and loading the correct library.

This study highlights that teacher education programmes should provide structured and scaffolded opportunities for trainee teachers to develop technological competencies alongside disciplinary understanding, moving from guided to independent tasks. It also provides empirical evidence of the initial challenges that pre-service teachers face with microcontroller-based technologies, offering insights that can improve professional development and support digital technology integration in STEM education.

O46 - STEM definitions over the digital era

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STEM (Science, Technology, Engineering, Mathematics) is widely used in academia, education, policymaking and everyday conversation. Although the widespread use of the term could suggest that it has a well-established definition, that's not the case.

Contributing to the ongoing discussion about the various definitions of STEM and the landscape over the years, this study sought to answer the research question - What patterns can be observed in the construction of the theoretical-empirical landscape in STEM fields, diachronically? - by conducting a bibliometric analysis of approximately 8000 scientific articles, review articles, books and proceeding papers from Scopus and Web of Science databases, using R Studio to conduct quantitative and textual analysis.

A content analysis of a corpus of articles focusing on definitions revealed that the origin of the STEM acronym is commonly associated with the *National Science Foundation* in the late 1990s to cluster educational and occupational categories, despite studies suggesting that the acronym STEM emerged prior to this reorganization with articles referencing STEM in educational curricula in early 1990s.

Furthermore, the acronym STEM has several definitions, ranging from the fields included, to the links between these fields, and to whether STEM is considered to be integrated, unitary or a simple collection of fields. As this definition of STEM is blurred, the results are difficult to analyse in a generalised and reproducible way, which also contributes to the ambiguous application of STEM activities in educational contexts.

Therefore, to analyse the STEM publications' themes, a divisive hierarchical clustering technique for text analysis was conducted and a cluster related to education was prevalent. Within this cluster, the analysis revealed STEM activities involving digital tools, with terms like "virtual reality", "mobile", "robot", "programming", "game", "arduino". These results suggested the presence of digital tools in the implementation of STEM educational activities, seeking to promote STEM in the digital era where the use of digital tools is encouraged to showcase STEM fields and concepts.

In conclusion, the bibliometric analysis revealed that, despite the widespread use of the STEM acronym, its definition remains conceptually diverse. Meanwhile, the textual analysis revealed a connection with digital tools and skills associated with the STEM approach. A presentation of the various definitions of STEM can provide more information about STEM educational activities, including those that combine digital skills.

O47 - Enhancing preservice primary teachers' STEM self-efficacy: perceptions from adapted SETIS

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Recent literature shows many primary preservice teachers feel underprepared for integrated STEM teaching, lacking both content knowledge and pedagogical confidence. Self-efficacy instruments like the Self-Efficacy for Teaching Integrated STEM (SETIS) help monitor teacher education programs impacts and identify key development areas in teacher preparation. These tools are particularly valuable as integrated STEM demands teachers navigate complex interdisciplinary connections between science, technology, engineering, and mathematics, requiring both technical competence and innovative pedagogical approaches that many teacher education programmes have yet to fully address. The research was conducted within a Master's in Preschool and Primary Education and a Master's in Primary Education and Mathematics and Science for Lower Secondary at a Portuguese higher education institution. It aims to analyse changes in preservice teachers' self-efficacy for integrated STEM teaching over one semester. The study is theoretically grounded in Bandura's social cognitive theory, emphasizing mastery experiences, vicarious experiences, verbal persuasion, and affective states as sources of self-efficacy, and in Mobley's SETIS model, which identifies three latent dimensions of self-efficacy for integrated STEM teaching (Social, Personal, and Material). A Portuguese-adapted, 19-item SETIS (4-point Likert scale) was administered using a one-group pre/post quasi-experimental design. The sample comprised 28 preservice teachers enrolled in a STEM-focused methods course (mean age 23-24 years), who completed the questionnaire before and after participating in a semester combining planning and implementing STEM activities with children during classroom practice, alongside structured reflection. Internal consistency and validity analyses (e.g., factor analysis) were performed, and the results were deemed adequate. Descriptive analysis revealed consistent self-efficacy gains across all 19 items, with marked shifts from low-confidence responses ("cannot do at all"/ "would have difficulty") to high-confidence categories ("mostly confident"/ "very confident"). The largest improvements occurred in summative/formative STEM assessment development, meeting institutional evaluation equirements, applying integrated STEM knowledge effectively, and accessing/utilizing resources and technologies. There is also a clear increase in the perception of preservice teachers' to promote enthusiastic, interest and motivation in their pupils. No regression was observed in any item. Overall, the data point to concurrent gains in the Social, Personal, and Material dimensions identified in previous works on the positive impact of integrated STEM methods experiences on preservice teachers' self-efficacy. These results carry important implications for teacher education, highlighting the need to (a) embed authentic, supervised planning and implementation of STEM activities within school placement, (b) explicitly address the concept and models of integrated STEM teaching in coursework, and (c) ensure access to technological and material resources that underpin a robust sense of capability for teaching through an integrated STEM approach. Furthermore, STEM learning experiences assume an operational rather than merely instrumental role. Instead of serving as an approach with support tools, they function as mediators of knowledge construction. Pre-service teachers noticed their pupils more interested/motivated and actively prepared to work in collaborative environments not only to support (inter)disciplinary integration but also foster the development of twenty-first-century skills (e.g., critical thinking, creativity, collaboration). Future research should also include qualitative data on the specific sources of self-efficacy preservice teachers perceive as most influential during their STEM-focused learning experiences.

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O48 - Science and maths education with digital technologies: what does open access research tell us?

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As we have been advocating and experiencing, digital technologies are impacting our lives, including the way we interact and communicate. To some extent, digital technologies seem to be inevitable in educational contexts too. But how have they been integrated in science and maths teaching and learning processes? To address this question, inspiring our research, we designed a qualitative case study and conducted a systematic review using the Meta-model to Analyze and Explore Scientific Knowledge® (MAECC®), grounded in contemporary approaches to systematic reviewing in educational research. Conceptually, our work is informed by socio-constructivist and inquiry-based perspectives on learning, by views of technology as a cultural and epistemic tool, and by international agendas that link digitalisation in education to the United Nations Sustainable Development Goals (in particular SDG 4 - Quality Education, SDG 5 - Gender Equality, and SDG 10 - Reduced Inequalities).

Methodologically, following MAECC®, we combined configurative and aggregative logics of synthesis to map how digital technologies are theorised and enacted in science and maths education. We defined our corpus through an advanced search in the Scientific Repository of Open Access of Portugal (RCAAP), selecting open-access documents published between 2010 and 2026 that explicitly address science and/or mathematics education and the use of digital technologies in teaching, learning, curriculum, or teacher education. Transparent inclusion and exclusion criteria guided screening and selection, and structured analytic categories were iteratively developed to code: (i) the envisioned pedagogical role of technologies, (ii) the targeted educational levels and actors, (iii) the methodological characteristics of the studies, and (iv) the connections made to broader societal and policy agendas.

The analysis of 30 documents shows that digital technologies are mainly integrated in three ways: as core tools for computational modelling and simulation in science and mathematics (bringing school practice closer to contemporary scientific inquiry); as key components of interactive, inquiry-based and STE(A)M learning environments, including science/maths clubs and other non-formal contexts; and as explicit curricular and competence targets in initial and continuing teacher education programmes. At the same time, the results reveal an uneven and often under-specified use of technology, with limited longitudinal and comparative evidence about learning gains, scalability across contexts, and implications for equity and inclusion. Issues such as gender and diversity, assessment and evaluation practices, and the pedagogical status of digital tools (central, supportive, or optional) are clearly underrepresented, despite their relevance to SDG 4, SDG 5 and SDG 10. We argue that future studies should explicitly address these gaps, clarify when, how and for whom digital technologies are indispensable in science and mathematics education, and systematically relate their findings to the SDG framework. Such theoretically and methodologically research can support more informed, equitable and sustainable teaching and learning processes in science and mathematics with digital technologies, and provide evidence-based guidance for teacher education, curriculum design and policymaking.

O49 - PCK of pre-service physics teachers when involved in a lesson study

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Lesson study is a teacher education model that originated in Japan and results from the translation of the Japanese term kenkyuujugyo, in which kenkyuu means research and *jugyo* means lesson. A lesson study usually consists of four phases - preparatory study, planning of the research lesson, research lesson, and post-lesson reflection - which together constitute a lesson study cycle. Its application to initial teacher education has attracted growing interest from the scientific community in recent years.

However, research studies on the applicability of lesson study (LS) in initial teacher education still need to be better understood. This study aims to contribute to this field. More specifically, the present investigation aims to examine the effect of LS on the development of pre-service Physics teachers' (PSTs') pedagogical content knowledge (PCK) related to the topic of the 'gravitational field and electric field' in the 12th grade.

The participants in this study were thirteen pre-service teachers, eight male and five female, aged between 27 and 52 years. Only two of the pre-service teachers had no prior professional experience. The lesson study was carried out within the curricular unit Initiation to *Professional Practice II*, which the pre-service teachers attended. In total, the lesson study lasted 12 sessions, each with a duration of two hours. The preparatory study and planning phases were the longest, while fewer sessions were allocated to the research lesson phase (two sessions) and the post-lesson reflection phase (two sessions). This lesson study included two research lessons. The university professor was in some sessions held at the secondary school, namely those related to the research lessons and post-lesson reflections. Data were collected through video recordings of the sessions and written reflections produced by the participants. The qualitative data were analysed and led to the creation of analysis categories.

The results showed that PSTs improved their knowledge of how and why to teach the topic in terms of depth, breadth, and accuracy of topic knowledge, connections with the nature of science (NOS), and fluency with multiple modes of representation. However, for both aspects - depth, breadth, and accuracy of topic knowledge, and connections with NOS - the majority of PSTs did not reach an understanding of the importance of including both aspects in the teaching of the topic. The results also showed that the PSTs developed their PCK regarding the implications of teaching strategies based on students' results and strategies to promote students' examination of their own learning. This research deepened knowledge about PSTs' PCK in two ways: from the science educators' perspective, by highlighting the feasibility of including lesson study in initial teacher education programmes; and from the researchers' perspective, by contributing to expanding academic knowledge on PCK development through lesson study.

These findings have important implications for science education, reinforcing the importance of integrating lesson study into initial teacher education, enabling PSTs to develop the pedagogical content knowledge essential in the digital era and encouraging further exploration of how the model can be adapted to incorporate digital tools and address challenges in digital learning environments.

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O50 - Contributions of a STEM education professional development program to the PCK of physics and chemistry teachers

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In the current digital era, STEM education has gained international significance for its ability to enhance student learning and foster interest in scientific careers. Nevertheless, the implementation of integrated STEM (iSTEM) is hindered by substantial challenges, particularly the misalignment between conventional teacher training and the requirements of integrated pedagogical approaches, as well as the complexities introduced by technology-enhanced classrooms. The present research examines the impact of a professional development program in iSTEM (PDP-iSTEM) on the pedagogical content knowledge (PCK) of Physics and Chemistry teachers. Specifically, it analyzes the development of enacted PCK (ePCK) and identifies program characteristics that support this development within a digital context.

The research is grounded in the Refined Consensus Model (RCM) of PCK, focusing on the enacted cycle (ePCK), which includes planning (ePCKp), teaching (ePCKt), and reflection (ePCKr). It further utilizes the Topic-Specific PCK (TSPCK) model, linking digital tools directly to components such as "Representations" and "Teaching Strategies", where digital simulations function as essential cognitive supports for students.

This investigation adopted an interpretive qualitative research methodology. Participants included five middle school Physics and Chemistry teachers involved in a 50-hour PDP-iSTEM focused on "Electrical circuits". Data were collected through interviews based on the Content Representation (CoRe) instrument, naturalistic observations of training sessions and classroom implementation, and written reflections.

Results demonstrate that all teachers achieved higher ePCK scores during reflection (ePCKr) than in planning (ePCKp). However, a high individual variability emerged during the transition from planning to teaching (ePCKt). While "curricular relevance" and "teaching strategies" (leveraging digital simulations) showed consistent development, there was a significant difference in teachers' ability to identify "students' prior knowledge" and "what is difficult to teach" in real time. Five facilitating characteristics of the PDP-iSTEM were identified: theoretical component, provision of resources, collaborative work, classroom implementation, and systematic reflection.

The results confirm the multidimensional nature of ePCK, proving that it cannot be assessed through a single phase but requires an integrated analysis of the full plan-teach-reflect cycle. Furthermore, this research provides practical guidance for designing effective teacher training programs that bridge the gap between theory and practice, preparing educators for the digital future of science education. Regarding its relevance, this work is essential for understanding how teachers develop specialized pedagogical knowledge in STEM, which is crucial to the success of innovative, integrated, and digitally mediated STEM approaches.

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O51 - Digital learning environments as a support for addressing mathematics anxiety in STEM education

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Mathematics anxiety is defined as pervasive feelings of fear, tension, and apprehension that negatively influences learners' engagement, performance, and task persistence not only in mathematics, but also in science and interdisciplinary STEM learning, where mathematical reasoning is often required. As science and mathematics education in the digital era is increasingly mediated through digital platforms, game-based environments, virtual laboratories, and AI-supported learning programs, new possibilities arise for addressing emotional learning barriers, but also risks when they are poorly designed.

This conceptual paper addresses how digital learning environments can support science and mathematics teachers in addressing mathematics anxiety as part of the interdisciplinary STEM approach. The paper argues that mathematics anxiety should be conceptualized as a shared STEM challenge and that digital technologies can function as pedagogical anxiety interventions when aligned with evidence-based psychological theory and instructional design.

The paper integrates perspectives from educational psychology and science education in order to examine how digital environments may reduce anxiety and support learning. For instance, exposure-based cognitive training frameworks highlight that anxiety is reduced through repeated low-stakes engagement with mathematical tasks in game-based settings. Moreover, self-efficacy theory states that perceived competence is a key mediator between digital support and reduced anxiety, while the growth mindset and math resilience approaches emphasize the role of technology-enhanced feedback and AI tutors in metacognitive scaffolding and in reframing errors as learning opportunities. Another conceptualization comes from the motivational and self-determination approaches, which explain how autonomy, engagement, and intrinsic motivation promoted through game-based and immersive environments can make mathematics be perceived as less threatening. These perspectives conceptualize anxiety as emerging from individual, environmental, and academic antecedents that digital tools can address through scaffolding and representations.

By summing up these approaches, the paper highlights the strengths and limitations of digital learning environments. For instance, well-designed tools can support the reduction of anxiety through exposure, feedback, and motivation, while poorly designed digital learning may increase cognitive load and emotional stress. Additionally, the study showcases the multi-component digital interventions and supportive teaching practices as important for raising self-efficacy in STEM learning.

The paper underlines the importance of teacher competence in selecting, designing, and employing digital tools, as well as in embedding scaffolding, collaboration, and feedback within learning management systems. Future research is required to address investigations of how emotions, cognition, and digital pedagogy interact across STEM domains, focusing on design quality and classroom practice. This contribution is highly relevant to contemporary discussions on digitalization, interdisciplinary STEM education, and teacher education for a digital future, the paper aligning with conference themes by addressing motivation, digital tools, assessment and the emotional dimensions of STEM learning in the digital era, showcasing mathematics anxiety as a shared concern in science and mathematics education.

O52 - Bridging teacher knowledge frameworks through a global integrative model

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The central role teachers play in the process of technology integration, along with the persistent difficulties associated with that integration, underscores the importance of gaining a more comprehensive understanding of the types of knowledge teachers need to teach with technology. Drawing on previous research and a systematic review of the literature, we identified three knowledge models that are frequently employed in this field: TPACK, KTMT, and PTK.

TPACK - *Technological Pedagogical Content Knowledge* is the most well-known knowledge model focused on technology integration, developed by Mishra and Koehler, and applicable across all disciplinary areas. KTMT - *Knowledge for Teaching Mathematics with Technology* is a model developed by Rocha with a focus on mathematics education, but applicable to different subject areas, intending to integrate in a knowledge model the results from research on technology integration. PTK - *Pedagogical Technology Knowledge* is a model with both a general and a mathematics-specific version proposed by Thomas and Hong, characterized by its intention to include elements of technology instrumental genesis within a knowledge model.

The aim of this study is to examine the points of convergence and divergence among these models and to introduce what we call a *Global Model*. This *Global Model* does not constitute a new theoretical proposal; rather, it is a framework developed from the existing models, with the purpose of bringing together, in a single structure, the knowledge domains that each model articulates. Beyond the model itself, the model makes evident the central characteristics of each base models.

As a method for this network of theories, we use a literature review based on Scopus database and an analysis of the similarities and differences of the existing knowledge models looking to the knowledge domains but also to their conceptualization.

The Global Model makes visible the domains that the three models share and the common conceptual foundations on which they are built. At the same time, it clarifies the differences among them, differences that arise not only from the distinct interpretations of particular knowledge domains or from the inclusion or exclusion of certain domains, but also from the ways in which each model conceives the development and interrelation of teacher knowledge.

The integration of TPACK, KTMT, and PTK into a *Global Model* holds significant relevance and implications for mathematics education and research. By unifying the shared and distinct knowledge domains proposed by these frameworks, the model provides a clearer and more comprehensive understanding of the knowledge required to teach mathematics with technology. This integrated perspective not only offers a coherent conceptual reference for researchers and teacher educators but also supports the development of more targeted professional development, and analytical tools for studying teachers' knowledge. Moreover, it helps align and consolidate findings across studies, identify gaps in teacher preparation, and highlight promising directions for future research in technology-enhanced mathematics teaching.

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O53 - Maths in STEM learning for sustainability

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This study explores the role of mathematics within an integrated STEM approach to sustainability, drawing on the voices of early childhood educators and primary school teachers. It addresses the following question: In what ways do early childhood educators and primary school teachers conceptualise the role of Mathematics in integrated STEM education for sustainability? In the digital era, mathematics stands as the structuring language of STEM, enabling critical data literacy, complex problem-solving, and informed decision-making in technological and sustainability-driven contexts. The research was developed within the framework of the OleaChain - Skills for sustainability and innovation in the value chain of traditional olive groves in Northern Portugal project, which aims to strengthen links between education, local culture, and sustainable development. In this context, mathematics is understood not as an isolated discipline, but as a transversal and mediating component supporting the articulation of science, technology, and engineering in meaningful learning experiences connected to children's everyday lives. A long-term professional development workshop was conducted with nine participants, including seven kindergarten teachers and two primary school teachers. The workshop supported the exploration, implementation, and reflection on STEM-based learning experiences centred on olive growing as a culturally and environmentally relevant theme. Emphasis was placed on designing activities that integrate mathematical thinking with real-world sustainability issues, fostering children's engagement in inquiry-based, problem-oriented learning. Adopting a qualitative interpretative approach, the study analyses documentation, reflective records, group discussions, interviews, and pedagogical productions generated throughout the training process. Content analysis examined educators' conceptions of STEM, sustainability, and the olive value chain, as well as changes in their pedagogical practices and understandings of mathematics within integrated contexts. Findings indicate that mathematics emerged as a central structuring element of the STEM approach, supporting children's engagement in measurement, estimation, comparison, classification, data collection and representation, and proportional reasoning. These practices were embedded in authentic contexts related to olive cultivation, production, and sustainability, enabling children to make sense of quantities, relationships, and variations while addressing real-life problems. Rather than through formal or decontextualised instruction, mathematics functioned as a tool for reasoning, decision-making, and communication across STEM domains. Although participants initially expressed limited expectations and some uncertainty about STEM implementation, the workshop contributed to reconceptualising STEM education and mathematics exploration. Educators increasingly recognised mathematics as a flexible, integrative language facilitating interdisciplinary connections and supporting children's holistic development. The collaborative nature of the workshop, combined with experimentation and reflection, strengthened participants' confidence in designing integrated STEM experiences grounded in sustainability and local contexts. Overall, the study highlights the potential of mathematics to act as a connecting bridge within STEM education, enabling integration across disciplines and supporting education for sustainability from early childhood. It underscores the importance of sustained professional development in helping educators move beyond fragmented approaches towards pedagogical practices that value inquiry, contextual relevance, and children's active participation.

O54 - Integrated STEAM activities in primary teacher education: insights from supervised teaching practice

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STEAM education has increasingly assumed a central role in primary education, promoting curricular integration, real-world problem-solving, and the development of twenty-first-century skills in contemporary educational contexts where digital tools are increasingly present. In the context of initial teacher education, it is particularly relevant to understand how pre-service teachers conceive and implement STEAM activities in authentic teaching situations, namely during Supervised Teaching Practice.

This study analyses how pre-service teachers design and implement STEAM activities in third- and fourth-grade Primary Education classes, identifying patterns and challenges in the integration of the different STEAM areas.

The research is grounded in the integrated STEM conceptual framework proposed by Roehrig et al. (2021), which characterizes STEM proposals through dimensions such as real-world problem focus, engineering design, contextual and content integration, authentic STEM practices, and the promotion of twenty-first-century skills. This framework enables an examination not only of the presence of multiple disciplines but, above all, of the coherence and degree of integration of the activities developed.

A qualitative and interpretative approach was adopted, focusing on 12 STEAM activities designed and implemented by 29 pre-service teachers during Supervised Teaching Practice, across 15 third- and fourth-grade classes, involving approximately 150 pupils. Data were collected from activity guides and academic posters presented at the institution's Professional Practice Conference. Content analysis was conducted according to six of the seven dimensions of Roehrig et al.'s model.

Findings show that all activities were structured around socially relevant real-world problems close to pupils' experiences. Engineering design was explicit in activities involving artefact construction and more implicit in others. All activities promoted interdisciplinarity across STEM areas. Technology was present in several, though not all, activities, through videos, digital platforms and simulations, supporting research and communication.

Context integration was consistently observed, ensuring coherence across activity phases. Content integration focused primarily on the articulation between Science and Mathematics, while Technology and Engineering functioned mainly as means of operationalizing learning. The Arts generally assumed an instrumental or communicative role. The promotion of twenty-first-century skills and formative assessment practices were transversal across the activities analyzed. The STEM careers dimension was not addressed.

The findings suggest that initial teacher education constitutes a privileged space for developing contextualized and pedagogically intentional STEAM practices. However, they also indicate the need to strengthen conceptual integration between disciplines, particularly regarding the role of Mathematics, Engineering and digital technologies, as well as the pedagogically intentional use of digital tools in STEAM activities.

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O55 - From gravity to the Earth's internal structure: how students construct boundary knowledge between physics-chemistry and natural sciences

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In teaching and learning contexts, both empirical research and international education policy documents have increasingly emphasised the importance of interdisciplinary science education as a response to complex real-world problems. Within this framework, the articulation between Physics-Chemistry and Natural Sciences - a domain that integrates content traditionally associated with physical geography - can be understood through the theoretical lens of boundary crossing, which conceptualises interdisciplinarity as a productive traversal of epistemically distinct disciplinary boundaries. These domains are grounded in complementary epistemologies: Physics-Chemistry privileges mechanistic and causal explanations, whereas Natural Sciences mobilise integrative and systemic models oriented towards understanding natural structures and dynamics. In particular, the Earth's gravitational force and the organisation of its internal layers illustrate how physicochemical models provide fundamental causal principles, while geoscientific models integrate these principles into explanations at a systemic level. Interdisciplinarity is thus understood as a hybrid space of knowledge, situated between permeable disciplinary boundaries, in which the integration of knowledge and conceptual reconstruction are fostered through explicit cognitive processes. Empirical studies further indicate that understanding complex natural phenomena requires interdisciplinary approaches that coordinate different modes of scientific reasoning. However, recent literature shows that such articulation remains underexplored, both at the curricular level and within didactic research, particularly in lower secondary education. Studies that examine students' reasoning at the epistemological boundary between Physics-Chemistry and Natural Sciences, making visible the processes through which knowledge is constructed, are still scarce. Against this backdrop, the present study aims to examine which forms of mechanistic and systemic knowledge emerge in students' explanations and classroom-based models of Physics-Chemistry and Natural Sciences phenomena, and how these forms are integrated in the construction of epistemic boundary knowledge across levels of epistemic integration. The research questions are: (i) which modes of mechanistic reasoning and forms of epistemic knowledge are mobilised by students; and (ii) which levels of epistemic integration between Physics-Chemistry and Natural Sciences emerge from this interdisciplinary articulation? The research was conducted in a formal educational context and involved 44 students from two 7th-grade classes in lower secondary education at a public school in the Lisbon district. The choice of this educational level is justified by the integrated nature of the Natural Sciences curriculum, which supports the development of interdisciplinary reasoning prior to the formal establishment of autonomous scientific disciplines. The study was implemented through classroom teaching and learning situations. The researcher and a Natural Sciences teacher acted as naturalistic observers. The tasks consisted of an interdisciplinary modelling activity focused on the relationship between gravitational force and the Earth's internal structure, aligned with curricular aims related to the understanding of physical and geological phenomena. The task was collaboratively designed by Physics-Chemistry and Natural Sciences teachers together with a science education researcher, and included guidance for the use of PhET simulations, enhancing the pedagogical role of digital technologies as mediators of causal and systemic reasoning. Ongoing data analysis draws on interdisciplinary rubrics grounded in theoretical frameworks on mechanistic reasoning and systems thinking, enabling the identification and characterisation of different levels of epistemic boundary integration. The study points to relevant implications for the design of modelling tasks, teacher education, and curriculum development in science education.

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O56 - Lesson study with STEM tasks: the professional development of natural sciences and physics-chemistry teachers

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This study is based on the implementation of a lesson study integrating STEM tasks (Science, Technology, Engineering and Mathematics), grounded in an interdisciplinary approach to Natural Sciences and Physics-Chemistry, conducted in a School Cluster belonging to a Priority Educational Intervention Territory (TEIP) in the municipality of Sintra. Two Natural Sciences teachers and one Physics-Chemistry teacher from lower secondary education (7th grade) participated in the study. Their selection was based on their recognised professionalism, scientific competence, and the fact that they taught 7th-grade classes.

The study aimed to analyse the effects of lesson study with STEM tasks on the professional development of Natural Sciences and Physics–Chemistry teachers, particularly regarding personal and professional challenges, professional learning, and collaborative practices.

The theoretical framework addresses key aspects of teacher professional development and interdisciplinary lesson study with STEM tasks, conceptualised as a collaborative model of professional development for Natural Sciences and Physics–Chemistry teachers.

The lesson study structure was validated by a Higher Education lecturer in the field of Education, specialising in Science Education, an expert in lesson study, with several publications in the *International Journal for Lesson and Learning Studies*. It comprised eleven sessions designed to support participants' professional development across the different stages of collaborative work.

The interdisciplinary STEM task was organised into two sequential and interdependent parts. In Part I - Gravity and the Shape of the Earth (Physics–Chemistry) - students used computers as a digital technology to explore the PhET *Gravity Force Lab* simulator, manipulating variables (mass and distance) to observe the effects of gravitational force. In Part II - Internal Structure of the Earth (Natural Sciences) - students carried out a laboratory activity using liquids with different densities (water, oil, and honey) to relate the arrangement of the layers in the geochemical model of the Earth's internal structure and the role of gravity in its organisation.

This qualitative study is grounded in the interpretive paradigm and adopts a participant observation design. Data were collected through participant observation (field notes), audio recordings of working sessions, video and audio recordings of the research lesson, a semi-structured focus group interview, and participants' final individual written reflections. Data analysis was conducted using categorical content analysis.

The findings indicate that implementing lesson study entails a range of personal and professional challenges for the participating teachers. Overcoming or minimising these challenges through peer support is perceived as an opportunity for professional growth. The results highlight the potential of the lesson study process, interdisciplinarity, and the design and use of STEM tasks for participants' professional learning. Furthermore, the study evidences the contribution of lesson study to the development of collaborative practices that foster professional trust among teachers, which is fundamental for sustained teacher professional development.

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O57 - Perceptions of teachers in training on the use of artificial intelligence in formulating and solving problems

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This paper is part of ongoing postdoctoral research based on a partnership between three teacher trainers from Brazil and Portugal. It is a collaborative and participatory action research project that sought to associate problem solving and formulation with the use of artificial intelligence in the context of pre-service teacher training. It aims to address the following research question: What are the perceptions of students in a pre-service teacher training course with respect to problem formulation and solving with the support of artificial intelligence? The research was conducted in a third-year class of the Bachelor's Degree in Basic Education at the University of Minho, Portugal, in the Curricular Unit (CU) Patterns and Problem Solving, from September 2025 to January 2026.

Artificial Intelligence (AI) is present in university classrooms, with or without the consent and/or knowledge of teachers. By simulating human intelligence, AI can perform educational tasks of different kinds, from the production and organization of texts to software programming. However, when considering the context of teacher training, it is also necessary to devise ways in which AI can be used to promote autonomy, reflection and critical thinking.

Studies conducted by Kim and Ko (2023) indicate that advances in artificial intelligence - particularly the launch of ChatGPT in 2022 - have brought significant changes to the development of mathematical literacy. Drawing on empirical evidence, the authors highlight important limitations of the tool, such as information inaccuracies, misunderstandings, linguistic constraints, and the potential to generate inappropriate content. These aspects underscore the need to address the use of AI within teacher education.

Therefore, in this research, students were asked to use AI to solve and formulate problems based on certain data. This task was carried out in groups, through cooperative work, during a practical class and under the supervision of their lecturers. After completing the task, they recorded the solution, accompanied by their reflections and comments, in a portfolio, which was analyzed by the authors. The partial results obtained indicate that some groups realised that, in order to use AI in problem formulation and solving, it is necessary to develop specific skills to validate the information obtained, the ability to filter and assess the quality of responses, and, broadly the suitability of AI in educational contexts. In addition, some groups reported that the responses provided by the AI tools used were incorrect or unclear. This entailed the need to resort to their own mathematical knowledge, elaborated from basic education or higher education curricular units, to devise specific forms of interaction with the tool in order to improve their responses. This work contributes to the analysis of AI responses obtained by students in an educational context. In broader terms, it may foster a more inclusive debate on the use of AI in education, with a particular focus in pre-service teacher training courses. In addition, the results obtained point to the need to investigate the use of AI in the development of mathematical literacy, especially in written mathematical communication in the digital age.

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O58 - The European sustainability competence framework (GreenComp) in light of TIMSS 2023 data

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Education systems are increasingly expected to prepare students not only with strong science and mathematics knowledge, but also with the competences needed to engage with sustainability challenges in digital societies. The ATEE Winter Conference 2026, under the theme "Science and Mathematics Education in the Digital Era", focuses on how disciplinary literacies can support learners' engagement with real-world problems in digital environments. This paper contributes to the conference subthemes "Science- and mathematics-related literacies for a sustainable and digital future" and "Motivating and engaging science and mathematics students in the digital era" by examining how sustainability-related engagement can be understood using international large-scale assessment data, considering also the role of teachers in shaping students' engagement.

The study draws on the European Sustainability Competence Framework (GreenComp) as a conceptual lens for understanding sustainability competence as a combination of knowledge, skills, values, and dispositions, including systems thinking, futures thinking, critical reflection and action orientation. While not designed as an assessment framework, GreenComp offers a valuable analytical perspective for interpreting large-scale assessment data. The paper analyses TIMSS 2023 grade four context questionnaire data from European Education Area countries and Western Balkan education systems, and while TIMSS is not explicitly designed to assess sustainability competences, its rich contextual data provide entry points for examining early patterns of sustainability engagement in science education.

The analysis explores three research questions: (1) How many distinct profiles of sustainability engagement can be identified among grade four students using TIMSS 2023 data? (2) How do these engagement profiles vary across education systems? (3) To what extent do parental and teacher-related factors predict students' sustainability engagement profiles?

The study applies latent class analysis (LCA) to identify student profiles based on selected TIMSS student questionnaire items mapped conceptually to GreenComp. Three profiles emerge: Highly Engaged, Moderately Engaged, and Less Engaged students. These profiles are then examined across education systems to explore cross-national variation. To investigate contextual influences, multinomial logistic regression models are used to analyse how parental environmental engagement and teachers' instructional practices relate to students' likelihood of belonging to each engagement profile.

Findings reveal substantial cross-national variation in sustainability engagement that does not typically coincide patterns of science achievement. This underscores that strong disciplinary performance alone is insufficient for fostering sustainability engagement. Importantly, teacher practices emerge as a key factor; experiential, context-rich approaches (such as outdoor learning, participation in environmental activities and research-based projects) are positively associated with higher student engagement, while more traditional classroom strategies show weaker or inconsistent relationships. These results highlight how science teaching approaches can motivate students by connecting disciplinary learning with real-world sustainability issues, particularly in digitally enriched learning environments where inquiry and action-oriented learning are increasingly emphasized.

By linking GreenComp with TIMSS 2023 data, this paper contributes to rethinking science and mathematics literacies as foundations for sustainability engagement in the digital era. The findings emphasize the important role of teachers in translating sustainability frameworks into meaningful learning experiences and provide evidence-based insights relevant for teacher education, curriculum development, and future assessment design.

O59 - The role of school organizations in promoting sustainability

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Environmental sustainability has become a central focus of science education, as students need the knowledge, skills, and dispositions to engage with complex socio-scientific issues such as climate change and biodiversity loss. Addressing these challenges requires not only scientific understanding but also critical reflection, informed decision-making, and responsible action. International large-scale assessments (ILSA) such as the Trends in International Mathematics and Science Study (TIMSS) have traditionally measured cognitive outcomes in science and mathematics, but recent cycles have expanded to include environmental attitudes and behaviours. While this broadens the scope of science education in fostering sustainability engagement, questions remain about whether such assessments adequately capture the classroom practices that promote voluntary and informed action.

This chapter examines TIMSS 2023 Grade 4 data to explore how school organizational factors relate to students' environmental knowledge and attitudes across 28 European and Western Balkan systems. The study investigates the influence of shared vision, leadership, sustainability emphasis, collective efficacy, and resource availability, framed within the ESD-effective school model and the Whole School Approach, which situates sustainability within school culture and daily practices rather than curriculum alone.

Our analysis reveals significant cross-national differences. Northern and Western European countries demonstrate higher environmental knowledge, whereas Eastern and Southeastern European countries show stronger pro-environmental attitudes despite lower knowledge scores. A weak negative correlation between knowledge and attitudes suggests that higher cognitive understanding does not necessarily translate into more favourable environmental dispositions. Intraclass correlation analyses indicate that school-level factors account for more variance in environmental knowledge than in attitudes, suggesting that organizational characteristics exert differential influence across national contexts.

Urban–rural comparisons inform that in several Eastern European systems, urban students outperform rural peers in environmental knowledge, likely reflecting greater access to educational resources, specialized instruction, and extracurricular opportunities. Conversely, some rural contexts, notably in Serbia and parts of Western Europe, exhibit higher environmental attitudes, potentially due to more frequent interaction with natural environments. Overall, disparities in attitudes are less consistent than those in knowledge, highlighting the influence of contextual, cultural, and experiential factors beyond formal schooling.

Although schools emphasizing sustainability demonstrate internal coherence, correlations with student outcomes remain modest. Similarly, perceived resources show limited associations with knowledge and minimal impact on attitudes. These results indicate that while resources and strategic emphasis can support learning, they are insufficient alone; organizational culture, leadership, and relational dynamics are critical to promoting meaningful sustainability outcomes.

By linking school organizational factors with TIMSS 2023 data, this study contributes to rethinking science and mathematics education as platforms for developing sustainability competencies. The findings underscore the role of teachers in translating curriculum objectives into inquiry-based, action-based approaches and highlight how leadership and school culture facilitate engagement with environmental challenges. These insights offer practical guidance for teacher education, curriculum development, and assessment design, aiming to cultivate students' knowledge, skills, and dispositions for responsible and informed action toward sustainable development.

O60 - Digital game design in biology teacher education: formative experiences in Brazil and Portugal

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The incorporation of Digital Game Design into initial and continuing science teacher education has been identified as a promising approach for developing professional teaching knowledge, particularly in Biology education. Within this framework, this study explores the contribution of digital game creation as a pedagogical strategy aimed at promoting formative pathways that value active, authorial, and reflective practices in Biology teaching. The research involved pre-service and in-service teachers who participated in online training initiatives delivered through the Moodle environment for teachers from southern Brazil and Portugal. The study involved 142 participants across two national contexts: 53 teachers in Portugal (45 in continuing professional development and 8 in initial teacher education) and 89 teachers in Brazil (48 in continuing professional development and 41 in initial teacher education). The training programmes comprised 60 hours of activities focused on the collaborative design of digital games using the Scratch platform. The approach positioned teachers as active designers of pedagogical resources intended for classroom use. During the activities, participants encountered challenges related to adapting disciplinary content to playful and accessible formats, which fostered pedagogical reflection and discussion. This pedagogical approach draws on the potential of Digital Game Design to increase learners' cognitive engagement, support meaningful learning processes, and promote higher-order competencies such as creativity, problem-solving, and critical thinking. Data were collected through multiple sources, including field diary records, participants' reflective written productions, and a mixed questionnaire (Likert-scale and open-ended questions) grounded in the TPACK-X model and administered before and after the training. The data were analysed through qualitative thematic analysis organised within a SWOT framework. The SWOT analysis enabled the identification of strengths and weaknesses in the experiences, as well as tensions and resistances related to limited support for continuing professional development, structural and technological constraints, and issues associated with school curricular organisation. Results indicate a significant shift in participants' perceptions regarding the pedagogical value of digital games. Strengths included increased creativity and greater integration of curricular content, whereas weaknesses were mainly related to rigid school timetables and curricular constraints that limit the integration of game-based activities. The theoretical framework of integrated teacher knowledge, articulating technological, pedagogical, disciplinary, and contextual dimensions, supported the interpretation of the transformations observed during the training process. Findings also reveal increased awareness among teachers regarding the importance of interdisciplinary work and the value of alternative learning spaces and times as responses to limitations within the school system. Changes were also observed in teachers' conceptions of the role of digital technologies in teaching, particularly when associated with authorial and collaborative practices. Although the long-term effects still require further monitoring, the analysed experiences point to the potential of Digital Game Design to strengthen teacher autonomy and promote more creative, participatory, and meaningful pedagogical practices in Biology education.

O61 - From compass to code: the role of hybrid feedback in the development of computational thinking in a 2nd cycle mathematics task

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Computational Thinking (CT) is recognized as a relevant cross-curricular skill in mathematics education, associated with problem solving and self-regulated learning. Feedback plays a central role in these processes, influencing how errors are interpreted and how strategies are adjusted. Despite growing interest in integrating CT into mathematical contexts, little research has been done on how different forms of feedback, whether human or digital, interact when the same task is performed in unplugged and plugged modes.

The study analyses the task of constructing a triangle from two angles and one side, in two modalities: unplugged and plugged into Scratch. The aim is to understand how different forms of feedback - human (teacher and peers) and digital - regulate the mobilization of CP dimensions and student performance levels. The questions focus on the differences between the modalities and the functional role of feedback in this process.

CP is conceptualized as a cross-cutting skill mobilized in problem solving, involving processes such as decomposition, pattern recognition, and abstraction. Feedback is framed in formative approaches that recognize it as a mechanism for regulating learning. Human feedback is interpretive and dialogic. Digital feedback is an immediate, functional return in computational environments. In this study, hybrid feedback refers to the integration of human and digital feedback during task performance. For example, in the plugged task, having used all the digital feedback, students requested their teacher.

A qualitative approach was adopted: an instrumental case study, focusing on a 5th-grade class with 16 students. Data collection included direct observation and analysis of student productions in the two task modalities. The analysis was performed through iterative coding, combining *a priori* categories defined by the types of feedback (teacher, peers, and digital) and the CP dimensions (decomposition, pattern recognition, abstraction, algorithms, and debugging). The CP dimensions were cross-referenced with performance indicators through triangulation of sources and cross-analysis across modalities.

The results indicate the predominance of human feedback in the unplugged task and digital feedback in the plugged task. Human feedback proved relevant for explaining geometric relationships and for conceptual reformulation, favoring abstraction. Digital feedback promoted cycles of testing and debugging, evidenced in the autonomous identification of errors and the adjustment of procedures. Hybrid feedback was observed as shown in the example.

These results suggest that intentionally combining human and digital feedback can enhance the balanced development of CP dimensions in elementary mathematics education

O62 - Empowering support teachers in mathematics: a laboratory-based training model at the University of Florence

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International surveys of logical-mathematical skills paint a discouraging picture for many countries, including Italy. To tackle educational disadvantage in STEM subjects, it is urgent to rethink teacher training. Within the Italian school system, a pivotal role is played by the support teacher. Regardless of their initial university background, these professionals specialize in implementing the full inclusion model in mainstream schools, and work in a co-teaching approach with all colleagues. A support teacher is assigned to each class that includes a learner with a disability.

This study examines how a laboratory model grounded in inductive methods can transform the stance of future support teachers. The research questions are: a) in what ways can the physical teaching mediators support teachers who do not have a scientific academic background? b) how does this type of training facilitate the co-design of inclusive STEM activities?

The framework is grounded in the pedagogical legacy of Emma Castelnuovo, a leading Italian figure in mathematics education. Her constructivist approach, used here as an andragogical tool, involves exploring reality at each learner's own pace, and using teaching mediators made from recycled materials to facilitate the transition from the concrete to the abstract. This method is consistent with the principles of UDL and the TPACK model.

This study was carried out in the 'Special Education: Codes of Logical and Mathematical Language' laboratory, part of the Specialization Course for Support Teachers at the University of Florence (N=131). Prospective support teachers personally experienced the pedagogical pathways designed for children and adolescents. The intervention was structured into three phases: i) elicitation and deconstruction of prior experiences through the sharing of a word cloud, providing an opportunity to express any emotional discomfort; ii) cognitive restructuring through artifacts made from simple materials, to physically experience geometry before transitioning to digital abstraction; iii) metacognitive reflection aimed at overturning a performance-based paradigm in favour of an exploratory one. To assess progress, the learning logs produced by the trainees during the lessons, the anonymous final evaluation questionnaires, and the results achieved in the final exam were analysed.

Initially, several participants showed signs of math anxiety and a sense of inadequacy in relation to the subject. Final examinations and laboratory monitoring demonstrated the effectiveness of the adopted method. In their learning logs, participants highlighted how the laboratory offered an opportunity to strengthen their logical-mathematical skills and rebuild their relationship with the subject. Analysis of the questionnaires indicated excellent satisfaction levels (exceeding 82% across all indicators). Furthermore, 75% of the trainees obtained the highest grade in their final exams.

The inductive approach allows teachers to overcome anxiety, by valuing logic and creativity, to broaden the ways of accessing content, and to acquire the skills needed to build inclusive learning environments, while developing a new agency in STEM design that enables real synergy with curricular teachers. Castelnuovo’s model acts as a catalyst for this innovation, and the laboratory has become a space for practicing a new pedagogical posture.

Poster Abstracts

P1 - Integrating digital technologies and research-based approaches in biology teacher education: a TPCK-informed program in a master's degree in biology and geology teaching

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The rapid evolution of digital technologies and the societal need for scientifically literate citizens demand that biology teachers develop advanced competencies in integrating technology, pedagogy, and content in meaningful and transformative ways. Research highlights the need to incorporate scientific content, research-based pedagogical approaches, and technological resources, supported by action research, reflective practice, and collaborative learning among pre-service biology teachers. In response to this challenge, two curricular units of a Master's in Biology and Geology Teacher Education for Middle and Secondary Schools from a public Portuguese university were purposely redesigned to foster this integration: Didactics and Digital Technologies in Biology Education and Didactics and Research in Biology Education. This study is guided by the following research objectives: (i) to analyse how a Technological Pedagogical Content Knowledge (TPCK)-based training program supports the development of pre-service biology teachers' competencies in this scope; and (ii) to examine how research-based, reflective, and action-oriented learning tasks contribute to the meaningful integration of digital technologies in biology teaching. This oral communication presents the structure, implementation, and preliminary outcomes of a redesigned training program aimed at developing future biology teachers using the Design Framework for Science Teachers' TPCK. During the first semester, the Didactics and Digital Technologies in Biology Education unit introduces future biology teachers to various digital tools, including simulations, data loggers, modelling software, online collaboration platforms, and informal learning spaces. These tools are used to help correct common misconceptions in biology. The unit also explores how technology can support students in building, expressing, and sharing scientific knowledge. Pre-service teachers learn to critically evaluate digital resources to ensure they meet Portuguese curriculum standards and design inquiry-based and problem-based activities connected to authentic and real-life biological issues. In the second semester, the Didactics and Research in Biology Education unit deepens pre-service teachers' TPCK by emphasising research-based inquiry and experimental work in biology. Through case-based learning, participants design research-informed teaching sequences that use digital technologies as cognitive tools. Both units culminate in an action-research project in which student teachers implement, evaluate, and reflect on a technology-enhanced didactic intervention. The program adopts a practice-focused model grounded in research-based pedagogy, digital competence development, collaborative action-research projects, and iterative cycles of design, implementation, and reflection. This study follows a research and development methodology, drawing on participant observation and analysis of the projects produced by pre-service teachers throughout both semesters, conducted by two teacher educators. Collected data were examined through content analysis, with each project evaluated for the meaningful integration of digital technologies into authentic, inquiry-based, and socially relevant biology learning contexts. Preliminary results indicate that the TPCK-informed program supports the capacitation of reflective, research-oriented, and technologically competent novice biology teachers. Participants demonstrated increased confidence in selecting and adapting digital tools, planning inquiry-based lessons, and using technology with explicit pedagogical and conceptual intent. Evidence from project analyses suggests improved alignment between technological choices, learning objectives, and biological content. In conclusion, the study suggests that a TPCK-based framework, combined with action research and structured reflection, strengthens initial biology teacher education by promoting coherent integration of technology, pedagogy, and content. These findings underscore the potential of research-informed, practice-oriented training models to address contemporary challenges in biology education, while highlighting the need for further research with larger cohorts and longitudinal designs.

P2 - Dialogic and reflective supervision across university and school settings: shaping pre-service biology and geology teachers

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This study examines the impact of reflective and dialogic supervision on the professional development of pre-service Biology and Geology teachers within a master's program at a Portuguese public university. To situate the study within broader educational priorities, it responds to increasing European demands for reflective, research-informed, and practice-oriented teacher education. The study is guided by two explicit research objectives: to analyse how reflective and dialogic supervision influences pre-service teachers' reflective capacity, professional autonomy, and professional identity; and to examine how structured supervision supports the articulation between educational theory and classroom practice during teaching internships. Grounded in the theoretical frameworks of Sá-Chaves (2002) and Alarcão (2020), supervision is conceptualised as both reflective and formative, fostering teacher autonomy, critical thinking, and professional identity. Sá-Chaves (2002) frames supervision as a relational, context-sensitive practice that bridges theory and action, emphasising the interplay between individual reflection, social interaction, and situational demands in professional growth. Complementarily, Alarcão (2020) emphasises the importance of collaborative dialogue and shared problem-solving in co-constructing knowledge and enhancing school practice. Empirical research further demonstrates that relational quality, structured reflection, and supervisor support have a positive influence on teacher development and academic performance. The study implemented structured supervision cycles that included lesson planning, classroom implementation, and post-teaching reflection. Pre-service biology and geology teachers engaged with university supervisors and school supervisors through reflective journals, case studies, and critical feedback. Participants included seven pre-service teachers completing internships in partner schools, enabling collaboration across institutional contexts. A key feature of this program was that teachers' outputs were research-based projects integrating theoretical rationales from science education and educational technologies studied during the first year of the Master's program. During internships, pre-service biology and geology teachers implemented these projects in classrooms and critically reflected on their impact on pupil learning. A qualitative methodology combining content analysis of reflective documents produced by pre-service teachers with supervisor observations was used to examine how supervision influenced reflective capacity, autonomy, and professional identity. Data sources included reflective journals, project reports, observation notes, and post-lesson reflections. An iterative coding process and inter-coder validation were used to ensure analytic reliability. Results indicate that reflective and dialogic supervision supported the development of deeper reflective practices, enabling pre-service teachers to critically analyse their pedagogical decisions and the theoretical assumptions underpinning them. The findings also show that dialogic supervisory interactions were associated with increased professional autonomy, as participants proposed pedagogical innovations, implemented teaching strategies, and collaboratively evaluated instructional outcomes. Furthermore, supervision facilitated engagement with contextual complexity (such as pupil diversity, curriculum demands, and school-specific conditions) supporting the co-construction of professional knowledge that links theory and practice. In conclusion, structured, reflective, and collaborative supervision with research-based projects supports professional learning, strengthens university-school partnerships, and fosters autonomous, reflective science teachers. Despite the small sample, the model provides valuable insights for enhancing teacher education across European contexts.

P3 - Developing smart ECO-iSTEM education: a conceptual framework and an education module

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Incorporating STEM into teacher education is essential to provide educators with the necessary tools for effective instruction in modern STEM disciplines. Integrated STEM education (iSTEM) is an interdisciplinary educational approach that connects at least two of the disciplines that create the acronym STEM using a real-world problem to address contemporary scientific and technical challenges. Therefore, provides learning experiences that help students develop critical and logical thinking, reasoning, and scientific thinking. However, it has been further argued that STEM education should include critical reflection and futures perspectives to promote inclusive and sustainable futures.

This conceptual poster presents the work in progress on the SMARTIVERSE project and its practical applications to answer this need. This project aims to promote sustainability awareness, entrepreneurship, digital media literacy, and civic engagement using primary STEM curriculum and approaches, at the same time accommodating the diverse needs of students.

In brief, the core of SMARTIVERSE project lies in the innovative intersection of multiple disciplines, guided by the key phases of Inquiry-Based Learning highlighting the role of action-oriented reflective dialogues and John Dewey's (1938) emphasis on experiential learning.

This study adopts a design-based research (DBR) approach with action research orientations to investigate the integration of digital media pedagogies, environmental education, and DEIB approaches within iSTEM education in primary education and initial teacher education.

Preliminary results are an innovative SMARTIVERSE Framework used to create an ECTS-recognised teacher education module with multilingual open educational resources (OER). Iterative implementation of the module will take place across partner institutions and selected primary school classrooms in seven European countries, allowing for comparative analysis. The findings illustrating the affordances and challenges of the SMARTIVERSE Framework at its initial phase will be presented.

P4 - Developing computational thinking with or without technology in 1st cycle mathematics classes through an exploratory teaching model

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Computational Thinking is characterized as a mathematical skill that requires the integrated development of the practices of decomposition, pattern recognition, abstraction, and the definition of algorithms, debugging, and process optimization.
In this work, two proposals are presented to develop CT in the 1st cycle with and without the use of technology, through the Exploratory Teaching model.
An exploratory teaching lesson is organized into four phases: (1) presentation of the task to the class; (2) completion of the task by the students and monitoring of this work by the teacher; (3) collective discussion of the task; (4) final synthesis: systematization of learning.
The educational sessions described in this work were developed within the framework of ongoing training for primary school teachers at CENFIPE (Center for Training and Innovation of Education Professionals) and aimed to answer the following research question: how can the learning model through exploratory teaching, with or without the use of technology, promotes computational thinking in primary school students?
The methodology adopted was qualitative in nature, with the data collection instruments being the documents produced by the students in response to the task, the notes from direct observation of the educational sessions, and the photographic records. Two educational sessions were analyzed: in one, a task on the theme “Algebra”, addressing the topic “regularities in sequences”, was applied in a 1st-grade class, using the educational mat and the Doc robot; in another session, a task entitled “Let's visit our friends!”, adapted from a 4th-grade textbook, was applied without the use of any technological tools.
From the first activity, it should be noted that, in addition to achieving the predefined learning objectives, students developed Computational Thinking, specifically the subcomponents of decomposition, pattern recognition, abstraction, algorithmic thinking, and debugging. The use of the robot proved to be particularly advantageous in promoting Computational Thinking among these students, as it made complex cognitive practices visible and manipulable, fostering sequential reasoning, strategy debugging, and students’ active engagement in meaningful mathematical tasks.
The fourth-grade task consisted of analysing a network of paths connecting different characters, represented by nodes and links. Based on the observation of the routes taken by one character (Zupi), students were required to identify which friends were visited, inferring the paths taken while respecting the condition that, to visit a friend, Zupi always passes through the houses of other friends. In addition to mathematical reasoning and communication, students developed Computational Thinking by extracting essential information from the task, recognising and identifying patterns in their problem-solving process, and structuring the solution into multiple steps.
The implementation of this non-technological task highlighted that Computational Thinking practices can emerge in diverse mathematical contexts, regardless of the use of technological resources, although such resources may enhance the visualisation and testing of strategies.
Exploratory teaching, with or without the use of technology, can promote Computational Thinking in primary education by engaging students in problem analysis, strategy planning, and the revision of actions. Thus, the promotion of Computational Thinking derives primarily from the exploratory nature of the tasks, with technology serving as a facilitating but non-essential element.

P5 - Mapping STEM teachers' self-perception of their hard, soft, and digital skills and competencies

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Nowadays, Portugal has seen an increase in STEM education initiatives, intending to promote STEM integration, foster context-based STEM learning and arouse students' interest in studies and careers in these areas. However, although more than 50% of the Portuguese students, at the end of the 9th grade, choose the science and technologies sector, the postsecondary paths chosen in scientific-humanistic courses are social sciences, commerce and law, which is indicative of the need to emphasise STEM education.

The main objective of this study was to map STEM teachers' self-perception of their hard, soft, and digital skills, to assess their needs regarding training, and, consequently, to inform curriculum development for STEM teachers' education in Portugal.

The research followed a quantitative, cross-sectional design. The focus was on assessing competencies related to Transversal Skills, Health, Green Deal, Digital Technology, and Inclusion. Data were gathered using a structured self-report questionnaire designed to assess teachers' perceived competencies across the five domains. The sample consisted of 80 Portuguese teachers (84% female), representing a mix of pre-service (19%) and in-service educators (81%), from primary to upper secondary level. The majority (64%) have more than 15 years of teaching. Chemistry (41.25%) and Biology (37.5%) are the most common subjects. For analysing the data, a factor analysis was conducted. The resulting factor scores were used in subsequent analyses. A Pearson's correlation analysis was performed to assess the interrelation between the different domains. Finally, comparative analyses were conducted to examine differences based on gender and teaching experience. Data were analysed using SPSS software.

In this sample of Portuguese teachers, Transversal Skills Ability is positively related to all the other factors analysed, highlighting the interconnectedness between transversal skills, health-related and sustainability-related knowledge, the use of digital tools and inclusive practices. Green Deal Knowledge shows strong correlations with both Health and Inclusion, suggesting that sustainability knowledge is linked to both scientific understanding and the ability to address diverse student needs. Digital Technology is strongly connected to Inclusion, implying that digital competencies support the management of diversity in educational settings. These findings suggest that enhancing competencies in transversal skills, digital technology, and sustainability could have a positive impact on a teacher's overall ability to manage diverse classroom environments and integrate specialised knowledge into their teaching practices. The gender comparison reveals consistent patterns where men tend to report slightly higher scores across most factors, except for Inclusion. Finally, the experience seems to play a key role in developing skills for managing diversity in classrooms.

These results showed that these areas are totally interconnected, supporting the idea that STEM teacher training must integrate all these areas, instead of working on each domain separately. This can be achieved through developing a training focused on teachers' exploration and practical implementation of learning situations based on real-world problems, and through the involvement of a multidisciplinary team of trainers. This could be possible by offering in pre-service teachers' training courses a curricular unit specifically focused on STEM education.

Note: This study was implemented within the Erasmus+ project AcaSTEMy (Teacher Academy 2023-2026).

P6 - Instrument design for the analysis of students' conceptions about agrifood systems in the digital era

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The Spanish educational framework (LOMLOE) promotes contextualised learning in Primary and Compulsory Secondary Education, emphasising connections between curriculum content and students' immediate environment. Within this framework, agrifood systems constitute a relevant socio-scientific context that integrates natural sciences, sustainability, and responsible consumption. Understanding students' conceptions about agrifood systems is essential for designing effective science education materials, particularly in a digital era characterised by abundant but often uncritical access to food-related information.

Research on students' alternative conceptions in science education shows that prior knowledge strongly conditions new learning. However, little is known about how students conceptualise local agri-food systems and their environmental, industrial, and socio-economic dimensions.

The aim of this study was to design and validate an instrument to analyse students' conceptions about agri-food systems in their local context. The research question guiding the study was: What conceptions do students aged 10-13 hold about agri-food systems in their immediate environment?

An ad hoc questionnaire was developed following a multi-phase validation process. First, four content blocks were defined based on literature on socio-scientific issues and sustainability education: (1) general understanding of agri-food systems; (2) production and industry processes; (3) food consumption and shopping habits; and (4) environmental sustainability. Content validity was established through collaboration between the research team and sector experts (agronomists, veterinarians, and agricultural technicians).

The initial version included 53 items. After expert review and pilot testing with Primary and Secondary teachers, the questionnaire resulting in a 40-item second version. A pilot implementation with students aged 10–13 (n = 350) allowed further refinement of wording and structure. Descriptive statistical analyses were conducted to examine item difficulty and response patterns, informing the final validated version.

Preliminary results from the pilot study reveal significant misconceptions regarding production processes, environmental impact and the relationship between local production and consumption. These findings suggest that students' knowledge of agrifood systems is fragmented and influenced by simplified digital narratives.

The validated questionnaire provides a reliable diagnostic tool for identifying learning needs and informing the design of science education materials adapted to the digital era. By detecting students' preconceptions, educators can develop targeted digital and contextualised resources that promote critical thinking, sustainability awareness, and scientific literacy.

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P7 - Analysis of the use of artificial intelligence for educational science assessment in higher education: a systematic review (2020-2024)

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The rapid expansion of artificial intelligence (AI) in higher education has profoundly affected teaching, learning, and assessment practices. In science education, assessment remains a complex challenge due to the need to evaluate conceptual understanding, scientific reasoning, and higher-order competencies. AI-based tools, particularly generative systems and learning analytics, have been proposed as innovative solutions to enhance assessment efficiency, feedback quality, and personalization. However, the widespread availability of AI tools has also raised concerns regarding academic integrity, assessment validity, and ethical use. Despite the growing number of studies addressing AI in education, there is a lack of comprehensive reviews focused specifically on AI-supported assessment within science education in higher education. The main aim of this study is to systematically review the literature on the use of AI for student assessment in science education in higher education between 2020 and 2024. The review addresses the following research questions: (1) What types of AI tools are used for student assessment in science education? (2) What assessment formats and purposes are most commonly associated with AI use? and (3) What benefits, challenges, and teacher perceptions are reported in the literature?

The study is framed within contemporary theories of educational assessment, particularly formative assessment, competency-based assessment, and feedback-oriented learning. It also draws on perspectives from Education 4.0, which emphasize personalization, digitalization, and the integration of emerging technologies in higher education, specifically on the impact of AI within science education contexts, detailing specific effects on assessment formats and teaching practices. Additionally, ethical frameworks related to academic integrity, transparency and equity in AI use underpin the interpretation of findings. A systematic literature review was conducted. Searches were performed in major academic databases using predefined keywords related to artificial intelligence, assessment, and higher education. Peer-reviewed articles published between 2020 and 2024 in English or Spanish were considered. After applying inclusion and exclusion criteria and removing duplicates, 34 studies were selected from an initial pool of 441 articles. Data were analyzed descriptively and thematically to identify trends in AI tools, assessment types, and reported outcomes.

The results reveal a rapid increase in publications addressing AI-supported assessment, with a predominance of generative AI tools such as ChatGPT. Open-ended and reflective assessments are identified as particularly vulnerable to AI-generated content, raising concerns about validity and authorship. In contrast, structured assessments, such as multiple-choice questions, are reported as more resistant to AI misuse. Formative and adaptive assessments supported by AI are highlighted as promising approaches due to their capacity to provide personalized feedback and support student learning. Teacher perceptions vary, with greater acceptance observed when clear ethical guidelines and training are provided. The findings highlight the need to redesign assessment practices in science and mathematics education to ensure validity and integrity in AI-rich contexts. Teacher training, ethical frameworks, and innovative assessment designs are essential to harness AI's potential while mitigating risks. This review provides a consolidated overview of current research on AI-based assessment in science education, identifying key trends and gaps. It offers evidence-based guidance for researchers and educators seeking to develop resilient, ethical, and pedagogically sound assessment practices in higher education.

P8 - A didactic proposal for teaching electromagnetism in a STEM sequence: evidence from a pretest-posttest study

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Electromagnetism is one of the Physics topics that poses the greatest difficulties in Secondary Education, particularly when it is taught through theoretical approaches disconnected from real-world applications. Several studies indicate that students often show poorly consolidated conceptions of electromagnetic induction and its relationship with everyday technological devices. In this context, STEAM proposals based on hands-on and design-oriented activities can promote a more functional understanding of these concepts. From a STEAM perspective, learning is conceived as an integrated process that combines scientific inquiry, technological design, artistic creativity, and mathematical problem-solving through authentic learning experiences. This research is framed within the development of a doctoral thesis on the learning of sound across different educational stages.

The aim of this study is to examine the extent to which a STEAM sequence based on the design and construction of a dynamic microphone contributes to students' understanding of electromagnetism and sound capture. The guiding research question is: How do design-and-build activities influence secondary students' learning of electromagnetic induction?

The study was conducted as a case study in Year 8 (2nd year of compulsory secondary education; n = 10), within a STEAM teaching sequence structured around phases of exploration, experimentation, design, construction, and evaluation. To analyse students' learning of electromagnetism, a multiple-choice questionnaire was administered before and after the intervention. The analysis focused on questions related to electromagnetic induction, the behaviour of magnets in conductive materials, and the function of the microphone as a transducer. Test results were complemented with evidence from students' notebooks and artefacts; however, this contribution focuses exclusively on the test data.

Initial pretest results showed a low level of correct answers on electromagnetism-related questions, particularly those concerning the fall of a magnet through a conductive tube and the role of electromagnetic induction in sound capture. After the implementation of the teaching sequence, posttest results revealed a significant improvement in these items, in some cases reaching a generalised correct response across the group. This progression suggests a better understanding of the relationship between magnetic fields, induced current, and the transformation of mechanical vibrations into electrical signals.

The observed improvement is mainly associated with two types of activities: (1) hands-on electromagnetism experiments, such as working with magnets, coils, and conductive materials, which allowed students to directly observe the induction phenomenon; and (2) the construction and functional testing of a dynamic microphone, in which students applied these principles to solve a real design challenge. These activities facilitated the connection between physical concepts and their technological and musical applications.

The test results indicate that learning electromagnetism improves when it is addressed through contextualised design and construction activities. However, difficulties were also identified regarding the stability of some learning outcomes and conceptual transfer, highlighting the need to strengthen processes of explicit conceptualisation and metacognitive reflection.

P9 – Science-society relationships in science textbooks: approaches and trends in educational research

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Contemporary science education highlights the importance of students understanding the relationships between science and society as a core component of scientific literacy. Beyond conceptual learning, it is essential to recognise how science is shaped by social, cultural, historical, and technological contexts. In this regard, textbooks remain a central resource in science education and play a key role in shaping implicit images of science and its relationship with society. Previous research has examined these representations through different theoretical approaches - Context-Based (C-B), Nature of Science (NoS), History of Science (HoS), and Science-Technology-Society (STS) - yet there is limited comparative systematisation of their respective contributions.

The aim of this contribution is to analyse how science-society relationships are represented in science textbooks, considering the relative weight of the C-B, NoS, HoS, and STS approaches in the research literature. The guiding research question is: In which approaches are science–society relationships made more or less explicit in science textbooks?

The study draws on the four aforementioned approaches as consolidated interpretative frameworks in science education research. Each approach was operationalised as an analytical category: C-B (contextualisation of content within social or everyday situations), NoS (epistemological and sociocultural dimensions of science), HoS (use of historical episodes to contextualise scientific knowledge), and STS (structural interactions between science, technology, and society). Methodologically, a systematic review of articles published between 2000 and March 2024 was conducted using the Web of Science and Scopus databases. Inclusion criteria considered empirical studies explicitly focused on the analysis of science textbooks in formal education; studies addressing other instructional materials and non–peer-reviewed publications were excluded. After applying inclusion criteria focused on science textbooks used in formal education, 71 articles were selected and analysed using a descriptive approach. The analysis combined quantitative descriptive procedures (frequencies and relative weights of each approach) with a qualitative thematic analysis of the addressed contents. The coding process was conducted using emergent categories.

The results reveal a clear imbalance among approaches. The Nature of Science approach is the most represented (approximately 60%), indicating a greater visibility of science-society relationships when addressed through epistemological frameworks, although with a predominance of cognitive dimensions. The Context-Based approach occupies a second position, with science-society relationships generally presented implicitly. The History of Science and STS approaches show a lower presence and more fragmented representations, mainly focused on historical episodes or general social implications.

These findings highlight the need to integrate science-society relationships more explicitly and coherently in science textbooks, particularly in increasingly digitalised educational contexts. This contribution provides a relevant comparative perspective for the international community of researchers and teacher educators in science and mathematics education.

P10 - Algebraic structure and symmetry in quadratic functions

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This theoretical study proposes an alternative algebraic perspective on quadratic functions grounded in symmetry and structural invariances, avoiding geometric constructions and focusing exclusively on the internal organization of the polynomial expression. Rather than restricting second-degree equations to procedural methods or the isolated use of formulas, the analysis makes explicit the structural coherence that articulates coefficients, the vertex, and roots as manifestations of a unified algebraic organization. From this viewpoint, quadratic functions are understood as structured mathematical entities whose properties emerge from invariant algebraic relations among coefficients, roots, and the vertex.

The motivation arises from the observation that, in contemporary contexts, digital tools increasingly facilitate immediate access to algebraic results associated with quadratic functions. In this scenario, the central question is no longer how to compute roots efficiently, but how such results can be interpreted as expressions of a coherent internal structure. Within the digital era, where educational practices coexist with computational resources capable of automatically producing algebraic outputs, quadratic functions may be reinterpreted as mathematical objects whose internal organization requires conceptual articulation. The emphasis thus shifts from isolated results to the structural relations that connect coefficients, the vertex, and roots.

The central aim of this work is to show that quadratic functions can be described and reconstructed from a small set of algebraic invariances. The guiding question is: how can symmetry be expressed and exploited purely at the algebraic level to reveal structural relations between coefficients, the vertex, and the roots of a quadratic polynomial?

The theoretical framework is based on the identity f(x_v + t) = f(x_v - t), interpreted as an algebraic invariance that characterizes the vertex as the structural center of the polynomial. When the equation admits two real roots, they can be written in the form x_v ± d, where d represents an algebraic parameter measuring the horizontal separation between the roots and the vertex. By rewriting the polynomial in canonical form, f(x) = a(x - x_v)^2 + y_v, one obtains the structural relation y_v = -ad^2, demonstrating that the value of the polynomial at the vertex, the leading coefficient, and the separation between the roots are coherently linked by a simple algebraic law.

In addition, the study introduces an auxiliary linear expression passing through the vertex and one root, treated not as a geometric object but as an algebraic relation connecting first- and second-degree expressions. This enables the coefficients of the quadratic polynomial to be interpreted through linear parameters, reinforcing coherence across algebraic representations and supporting connections between algebra and analytic geometry.

The concluding argument is that, in digitally mediated educational contexts, quadratic functions should not be approached merely as equations to be solved by formulas, but as structured algebraic objects organized by invariance, symmetry, and parameter relations. By making explicit the internal unity of the mathematical object, the proposal informs pedagogical practices that use technology as a means of conceptual deepening rather than as a substitute for mathematical reasoning.

P11 - Prospective mathematics teachers' initial perspectives on the teaching of mathematical modelling with technology

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Mathematical modelling (MM) is a curriculum's compulsory component in several countries, including Portugal, across different educational levels. It positions mathematics as a sense-making, decision-making, and problem-solving activity grounded in authentic contexts. Therefore, initial teacher education should include structured opportunities to engage with modelling problems while effectively leveraging technology.

This study seeks to characterise the initial perspectives of prospective mathematics teachers (PMT) regarding i) mathematical modelling problems, ii) the relevance of providing students with experiences in MM, iii) the technology's role in MM, and iv) the specific technological tools' potential in MM processes.

The theoretical framework underpinning this study discusses the concept of MM, its educational relevance, and the technology's role in solving modelling problems. MM involves a continuous transition between reality and mathematics, engaging learners in real, relevant, and authentic problems of an open nature that foster modelling sub-competencies' development. The literature identifies four main justifications for integrating MM into mathematics education: the pragmatic, the formative, the cultural, and the psychological. Technology plays a central role in MM processes, functioning either as a resource, e.g., for calculation, representation, experimentation, or as a reorganiser of the modelling process, enabling to tackle complex problems and transforming the dynamics of modelling.

This exploratory study adopted a qualitative and descriptive approach. It involved 14 PMT enrolled in a Master's degree in Mathematics Teaching. Data were collected at the beginning of a course in Didactics of Mathematics through an online questionnaire combining open-ended and closed questions (e.g., "In your view, what is a modelling problem?" and "What role can technology play in solving modelling problems?", or rating the relevance of different objectives for MM's teaching and learning). Qualitative data were analysed through content analysis, while closed responses by descriptive statistics. All necessary ethical procedures were ensured.

Regarding MM problems, participants identified several characteristics aligned with the literature: authenticity (71.4%), connection to reality (57.1%), the need to develop a mathematical model (28.6%) and relevance (7.1%). Regarding the relevance for teaching MM, formative and psychological justifications were rated quite or very important by most participants (both 92.9%), followed by pragmatic (85.7%) and cultural justifications (57.1%).

All PMT recognised technology's potential in solving modelling problems, mainly as a resource (92,9%). Only two PMT highlighted technology's transformative role, enabling otherwise impossible problem solving and broader solution processes. The technologies most frequently considered quite or very relevant for solving MM problems were dynamic geometry software and spreadsheets (both 92.9%), followed by programming environments (78.6%). In contrast, learning platforms (28.6%), learning management systems (42.9%), and artificial intelligence (AI) tools (35.7%) were most often rated as low or not relevant.

The inclusion of MM in mathematics teaching was considered quite or very relevant by most PMT, reinforcing the need for its structured integration into initial teacher education, providing MM experiences aligned with future professional demands. The engagement with the technology's transformative role in MM, including the exploitation of AI tools, should also be considered. The results confirm the importance of providing MM experiences supported by technology, aiming to develop PMT's modelling-with-technology competencies.

P12 - Opinions of biology and geology teachers on the formative needs of students in matters related to environmental ethics

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Addressing environmental challenges requires reflection that integrates environmental, social, and ethical dimensions, particularly regarding human interaction with the natural world. Environmental ethics offers diverse perspectives on this relationship (e.g., anthropocentrism, non-anthropocentrism), differing in the moral value attributed to nature and human responsibilities. Science education plays a key role in fostering this awareness; however, studies show that students are often poorly informed, while teaching environmental ethics helps develop reflective, critical, and environmentally responsible citizens. Given the crucial role of the teacher in the formation of informed, active, and responsible citizens, it was considered pertinent to investigate Biology and Geology (BG) teachers' perceptions on: the importance attributed to different areas of training at the end of elementary and secondary education; the areas of training that students effectively master after completing these levels of education; the adequacy of training in environmental ethics for the exercise of environmentally responsible citizenship. This is the first study in Portugal on the opinions of BG teachers specifically on environmental ethics and, to this end, a questionnaire was applied to 293 BG teachers who taught in public schools in mainland Portugal, that was previously validated by three science education specialists and three BG teachers not belonging to the sample. This dimension of the questionnaire consisted of 3 closed-ended and 1 open-ended questions. Data analysis involved calculating absolute and relative frequencies for closed-ended questions, with response options treated as categories. Open-ended responses and justifications were examined through quantitative content analysis using categories defined a posteriori for each question. The main results show that: teachers indicate the areas of environmental sustainability and environmental education as relevant for students completing elementary education, adding ethics and environmental ethics for students completing secondary education; teachers who predominantly teach in elementary education attribute greater relevance to environmental ethics for the education of a student completing this cycle than teachers who predominantly teach in secondary education; teachers consider that students completing each cycle of education are not prepared for the exercise of environmentally responsible citizenship, indicating as the main reason for this the lack, not enough time to teach these subjects due to the length of the curriculum. These results show that teachers recognize the importance of environmental ethics, but indicate limitations in terms of student training in these subjects. The need for enhanced training that allows for the more effective integration of environmental ethics into different science disciplines is highlighted (e.g., using digital tools for environmental ethics) as well as curriculum revision.

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P13 - Learning and teaching: insights into the use of artificial intelligence

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This paper reports on an empirical study developed within the European project MathIA - *Artificial Intelligence Model to enrich and improve mathematical skills in adolescent students*, funded by the Erasmus+ programme (KA220-SCH - Cooperation partnerships in school education). Grounded in recent PISA (2018, 2022) results, which document persistent low performance in mathematics among adolescents, the project seeks to design an artificial intelligence (AI) model to support the development of students' mathematical skills and to promote teacher professional development in this field. In fact, the literature emphasises the importance of teachers training and the development of digital literacy in their continuous professional growth and to face challenges related to AI in the classroom. Specifically, studies are being conducted on the use of AI tools in mathematics teaching and learning. So, this study is based on the premise that understanding how teachers and students perceive the educational use of AI is crucial for justifying and refining such training initiatives, anticipating potential forms of resistance, and addressing ethical and pedagogical concerns. Accordingly, the specific objective of this paper is twofold: (a) to briefly characterise the teacher training activities developed within the MathIA project, and (b) to analyse the perceptions that a group of Portuguese teachers and university students hold about the use of AI in academic contexts. A quantitative exploratory study was conducted to describe what teachers and students think about the use of AI. The data was collected through an online questionnaire and was analysed using descriptive statistics. The sample comprises 135 participants: 36 teachers from the 2nd and 3rd cycles of Portuguese basic education and secondary education, 20 university professors, and 79 university students, from different fields of study (STEAM and other domains). This diversity of profiles allows us to compare how schoolteachers, higher education teachers, and university students position themselves regarding the opportunities and risks associated with AI in education. The results indicate that both school and university teachers, as well as university students, already report using AI tools and recognise their added value for teaching and learning. Across the three groups, there is a shared perception that structured training on the pedagogical and ethical use of AI in schools and universities is urgently needed. Although exploratory, this study gives voice to key stakeholders and provides empirical evidence to inform the design and refinement of training courses and future research in STEAM education or other scientific domains. It suggests that integrating AI into teacher and student education in a critical and reflective way, is essential for developing mathematical and scientific skills in the digital era, anchored in evidence-based practice and guided by robust ethical principles.

P14 - Water literacy in science education: a Portuguese basic education curriculum analysis

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Life on Earth depends on water and the hydrological (water) cycle, but water is a finite resource. Thus, water use and management require special attention not only from politicians but also from each citizen. Principles of sustainability, related to issues like water conservation, pollution prevention, and reuse, should be acknowledged with water-efficient use principles, concerned with, for instance, reducing consumption, minimizing waste, raising awareness, and ensuring equitable access to water. European Union documents underscore the need for education systems to promote the development of systems thinking and critical reasoning skills so that people acknowledge the reduction of water demand as a priority above the exploitation of additional water resources. Schools should promote the development of water literacy, that is, water-related knowledge, attitudes, and behaviours relevant to understanding the interactions within and between natural and human dimensions of water systems to support informed decision-making regarding water use and management. Thus, a priority of any educational system should be to lead children to understand how strategic water is and how it influences our way of living, and the sustainability of our planet. However, international research suggests that when water is addressed in schools, the focus is often biophysical, with a weak relationship to citizenship. Water is a Portuguese curriculum theme. However, the consistency between curriculum and international guidelines has not yet been studied. Hence, this paper aims to find out the extent to which Portuguese basic education curriculum documents are consistent with European water literacy guidelines and have the potential to foster students' development of water literacy. Basic education includes nine grades organized into three cycles. It is guided by The Students' Profile Upon Leaving Compulsory Education, which sets the competences that should be expected from students when they complete the 12th grade; and the Essential Learnings, one per cycle of basic education, which provide information on what and how should be done, at each of the three cycles, considering the medium-term targets set in the students' profile. These two types of curriculum documents, which guide science education in basic (that is, primary and lower secondary) schools, were analysed against the European guidelines and the main dimensions of water literacy, that is, knowledge about water, attitudes towards water, and water-related behaviour. An environmental dimension was also considered. Data indicate that water is a part of the Portuguese basic education curriculum, but the focus is on the knowledge and environment dimensions. In addition, they suggest that a lower importance is given to attitudes toward water and water-related behaviours. Thus, if textbook writers and school teachers follow the curriculum guidelines without critically analysing and improving them, they may prevent students from developing a well-balanced water literacy necessary for any active and responsible citizen. Hence, this study highlights the need to find out how school science textbooks and digital resources address the water issue and to characterize science teachers' practices to better understand the state of water literacy education in Portuguese basic education.

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P15 - Use of generative AI tools in practical school activities on rock types: a study with pre-service biology and geology teachers

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The advancement of generative artificial intelligence (AI) represents a significant global transformation. Within the educational context, this scenario encourages teacher training initiatives that incorporate ethical and didactic-pedagogical debates. Thus, exploring the potential of generative AI in science learning, the following research question was posed: "How do pre-service Biology and Geology teachers perceive the use of generative technologies in practical activities concerning rock types?". The study aimed to analyze the perceptions of Master's students in Biology and Geology Teaching regarding the efficacy and reliability of two generative tools used as consultative resources. Theoretically, the study is grounded in inquiry-based science education, emphasizing that generative AI should not merely replace resources but act as a "cognitive partner" that requires students to engage in higher-order thinking to validate synthetic outputs. A qualitative, descriptive, and exploratory strategy was adopted, using content analysis. Fourteen students participated during a class held within the Didactics of Biology and Geology course unit. The two-hour session followed a perspective of pedagogical isomorphism, consisting of a practical activity conceptualized for 7th-grade students, where working groups macroscopically identified rock samples using the free versions of Gemini and ChatGPT, performing a comparison between the tools. The use of generative AI in this specific context is justified by the need to develop critical evaluation skills regarding complex descriptive data in an era where digital information often bypasses scientific rigor. Consequently, the study involved: 1) considering the applicability of this activity with 7th-grade students; and 2) reflecting, as future teachers, on the didactic implications of AI use in practical activities. By completing a worksheet, the groups used keywords for prompt formulation, subsequently reflecting on the scientific quality of the generated products, as well as the didactic relevance of the activity. This critical look revealed that the tools can provide inaccurate descriptions, which, paradoxically, serves as a didactic trigger to return to the physical samples for confirmation. Preliminary results indicate that the need for prompt refinement enhances the retrieval of accurate responses. Based on the participants' prior knowledge, Gemini appeared to produce scientifically more reliable responses. Therefore, this study contributes to the implementation of generative AI as an effective active methodology for science education. Regarding the curricular integration of this theme in teacher training, considering the responsible use of these technologies is undoubtedly a didactic-pedagogical asset. This research sheds light on the inevitable movement of generative technologies in society, offering a practical model of how science learning can capitalize on this resource while preparing pre-service teachers to handle its challenges, moving beyond "how to use" toward a critical understanding of "when and why" to integrate these tools in the classroom.

P16 - Interest in contextualized science learning: opinions of experts, teachers, and students

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Research shows that students have little interest in science and in science learning, and that this interest decreases throughout their school careers. Teachers' teaching practices influence students' interest; therefore, teachers must use teaching approaches that help students understand the relevance of science in everyday life and in solving problems that emerge in their family and community contexts. Teaching for contextualised science learning may increase students' interest in learning science and promote meaningful learning. Achieving this goal requires teachers not only to master the content to be taught but also to be familiar with the school's physical and social environment. Thus, teaching for contextualized learning of science is more demanding for teachers than traditional content-based teaching. Hence, teachers need to be convinced that the former way of teaching is worthwhile for students before deciding to invest in the planning, preparation, and implementation of context-based teaching practice. Research comparing experts' and teachers' views on contextualized science learning to students' views has been underexplored. Therefore, this paper aims to compare the opinions of experts and teachers on students' interest in science, science learning, and contextualised science learning with students' reported interest in the same issues. To attain this goal, 49 international experts in contextualised science teaching, 75 Portuguese Physics and Chemistry teachers, and 197 Portuguese 9th-grade students completed a questionnaire (online for experts and teachers; face-to-face for students) which was adapted to each group of participants. The three versions of the questionnaire that resulted from that adaptation were content-validated and comprise closed- and open-ended items on the topics that are at stake. Experts and teachers were asked about students' interest in science, science learning, and contextualized learning of science; students were asked about their own interests in the same issues. Most experts stated that they had considerable or strong interest in science, science learning, and contextualized science learning; about half of the experts anticipated that teachers would have similar levels of interest in these topics. However, almost all teachers stated that teachers had a considerable or strong interest in them. Furthermore, most experts and teachers anticipated that students would have considerable or strong interest in contextualized science learning, but these percentages were much lower when it came to the interest in science and science learning that they anticipated students would have. However, about two-thirds of the students stated that they had considerable or strong interest in science, science learning, and contextualized science learning. This means that experts and teachers anticipated that students would have a greater interest in contextualized science learning and less interest in science and science learning than expressed by students. Therefore, it seems necessary for specialists and teachers to delve deeper into which science topics truly interest students and which contextualized approaches contribute to their meaningful learning of science. Currently, this may require the integration of digital tools and the context selected to approach a given topic. Digital technology, namely digital labs, virtual labs, and simulations, may enhance context-based learning of science, raise students' motivation and interest, and lead them to perceive how science is all around in our personal, social, and professional environments.

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P17 - A Maker project in an initial primary teacher education course

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Initial education of primary school teachers plays a key role in supporting the development of innovative teaching practices that address current educational challenges. In this context, it is essential to provide future teachers with learning experiences that integrate scientific and methodological knowledge while fostering transversal competences such as collaboration, creativity, problem solving, and digital literacy. One approach that has gained increasing prominence is the maker perspective. Although there are multiple definitions for "maker", in this proposal we adopt that of the TAME project: Maker is a project-based learning process characterized by agency, interdisciplinarity, creativity, social interaction, and reflection. Within this process, learners apply both analogue and digital tools in iterative design cycles to create and share meaningful physical or digital artifacts that address real-world problems, generating personal or societal value. This study is guided by the following research question: How are future primary school teachers able to respond to the interdisciplinary and socially oriented challenges proposed within a maker-based curricular unit? In particular, we sought to understand how students mobilize scientific knowledge, pedagogical reasoning, collaboration, and digital tools to design projects with educational potential. Grounded in the Maker perspective and implemented within the curricular unit Complements of Mathematics and Sciences, 40 future primary school teachers were organized into groups and challenged to design interdisciplinary projects on socially relevant scientific topics (i.e. energy-efficient housing, recycling, urban waste, and water). The aim was to foster knowledge construction through research, planning, and the development of final products with methodological potential for primary education contexts. This approach promoted meaningful connections between curricular content in elementary mathematics and sciences and everyday real-world issues. An illustrative example of the outcomes achieved is developed projects addressing the theme "water". Students demonstrated the ability to integrate scientific concepts (natural and urban water cycle, water treatment processes, environmental sustainability), pedagogical intentionality, and curricular alignment. They constructed two physical models (natural water cycle and urban water cycle) and a mini water treatment system, which acted not only as representations of theoretical content but also as didactic resources to support inquiry-based learning in primary classrooms. The project revealed students' capacity to articulate content knowledge, societal awareness, and methodological planning, thus exemplifying the type of professional competence the project aimed to foster. Digital technologies played a complementary yet significant role in the process. Students used digital tools to research information, design and document their projects, produce explanatory materials, and reflect collaboratively on their work. In some cases, digital resources were also incorporated into the artifacts themselves. In this sense, digital technologies were not treated merely as technical add-ons, but as cognitive and collaborative tools that supported design thinking, communication, and reflective practice. This integration contributed to teacher education in a digital era by preparing future teachers to critically and pedagogically integrate digital resources into interdisciplinary and project-based learning environments. Such products are aligned with the Portuguese Essential Learning guidelines for the primary school areas of Mathematics and Study of Social Environment, as well as with the Students' Profile Upon Leaving Compulsory Education, reinforcing the coherence between initial teacher education and school curricular frameworks.

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P18 - Olimpíada Matematicando: gamification and digital information and communication technologies in the Brazilian Amazon

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This research problematizes the use of Gamification and Digital Information and Communication Technologies (DICTs) within the Brazilian Amazonian context through an analysis of the "Olimpíada Matematicando" project, implemented in the municipality of Altamira in 2020. The primary objective was to identify the contributions of using gamification methodology associated with DICTs on a large scale to engage students in the use of technologies that stimulate the development of mental calculation. The theoretical framework is anchored in the concept of Gamification proposed by Nick Pelling, defined as the application of game mechanics in various contexts and Johan Huizinga's reflections on play as a structuring element of culture. These are integrated with Marcelo Fardo's discussions on learning environments and principles of neurolearning to explain cognitive processing under competitive stimuli. Additionally, the study incorporates findings from Nancy Vasconcelos regarding the potential of Gamification within the Amazonian school context.

This is a qualitative investigation based on Bogdan and Biklen, in which one of the authors had direct contact with the studied situation and where the data is predominantly descriptive. Initially, a literature review on Gamification and the use of DICTs was conducted; this was followed by the collection of quantitative data regarding the methodology and scope of the "Olimpíada Matematicando" project in the Amazon from 2014 to 2020. Finally, the perceptions of one of the authors regarding the project's execution in the municipality of Altamira were recorded.

The "Olimpíada Matematicando" is a competition in which mathematical challenges were proposed through a combination of Google Forms, the Quilgo platform, and the Matematicando app, adopting scoring and time as evaluative criteria to establish rankings and qualification for subsequent phases. Matematicando is an application created by Inteceleri that functions as a memory game, where colors are playfully associated with mathematical operations.

The data obtained indicates that the project had a significant impact on the Brazilian Amazon, reaching a total of 53,556 students between 2014 and 2020. In the 2020 Altamira edition, 2,225 students from 74 schools were registered, spanning from the 1st to the 9th year of Elementary Education, Youth and Adult Education, and students with disabilities. The findings demonstrate that the integration of Google Forms, Quilgo, and the Matematicando app simulated a "macro-level" gamification environment that integrates ranking, timing, and awards to foster the development of logical reasoning and mental calculation.

It is concluded that the "Olimpíada Matematicando" model established a scalable structure capable of promoting active student participation in the use of various technologies. When integrated with gamification methodology, these tools stimulate the development of mental calculation, thereby contributing to the teaching and learning of mathematics. The results indicate that such gamified practices can be transferred to post-pandemic contexts as a strategy to mitigate regional educational inequalities a trend that persists in subsequent years and justifies further investigation.

P19 - Awareness and action: pre-service teachers' readiness to respond to digital risks in their future professional practice

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Pre-service teachers' digital competencies are essential for the facilitation of today's increasingly digitalised teaching and learning environments, particularly in science and mathematics education, and include not only operational and instructional skills but also awareness of digital safety and digital hygiene. In primary education, teachers work with young children using digital tools, online platforms, and networked devices, incurring risks related to online interactions and technical threats, such as malware infections, inappropriate access to digital resources, and data security breaches. As the digitalisation of education continues, teachers' preparedness to recognise and respond to such risks is essential for ensuring pupils' safety and maintaining secure learning environments.

Via the following questions, this survey-based study examines the readiness of pre-service teachers to respond to digital risks they may encounter in their future professional practice: (1) What is the level of pre-service teachers' knowledge about digital risks affecting primary school-age children?; (2) What level of skills do pre-service teachers have for responding to digital risks?; and (3) What digital hygiene behaviours do pre-service teachers practise?

The study draws on three complementary frameworks. First, the digital risks children face are conceptualised using the 4Cs classification of digital safety: content, contact, conduct, and contract. Second, the NIST Cybersecurity Framework is used to analyse pre-service teachers' technical response skills across five domains - identify, protect, detect, respond, and recover - in line with the NIS2 Directive. Third, digital hygiene is understood as a set of everyday practices relating to secure and responsible use of digital technologies, including data protection and online privacy awareness.

A survey study was conducted with 117 first-year pre-service teachers studying early childhood and primary education in Poland. Data were collected using a questionnaire with 20 close-ended items assessing their self-reported knowledge of and skills in responding to digital risks that affect children, and eight open-ended questions exploring their digital hygiene behaviours. The quantitative data gathered were then analysed using descriptive statistics and qualitative responses using content analysis.

The preliminary findings indicate that the pre-service teachers self-reported having high levels of knowledge about digital risks affecting children, and moderate response skills. Analysis of the open-ended responses revealed a narrow understanding of digital hygiene, predominantly associating it with limiting screen time. Issues related to personal data protection, privacy, and online security were rarely mentioned, indicating gaps between declarative knowledge and practical readiness for managing digital risks.

Although the study focuses on pre-service primary teachers, its findings are directly relevant to science and mathematics teacher education in the digital era. As STEM education increasingly relies on digital laboratories, AI-enhanced platforms, and data-driven tools, teachers' digital safety competencies are becoming ever more important. Ultimately, the results highlight the need to strengthen digital hygiene, privacy awareness, and incident response skills in science and mathematics teacher education programmes for a digital future.

P20 - Across systems, algorithms, models and possibilities: imagination and combinatorial art in the digital age

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Within the current digital transition, science and mathematics education are undergoing a deep epistemic transformation that extends beyond technological renewal or methodological innovation. From a teaching perspective, digitalization reshapes how scientific and mathematical phenomena are represented, manipulated, and explored through models, enabling systematic variation of parameters and examination of their effects. From a learning perspective, knowledge is no longer limited to describing phenomena but involves constructing and comparing multiple scenarios generated by changing variables within formal models. This process supports students in developing relational and functional understandings, central learning goals in science and mathematics education. In a world increasingly mediated by computation, a rethinking of the aims and foundations of science and mathematics education becomes necessary.

In this frame, *T Zero* by Italo Calvino (1969) offers a productive lens to rethink science and mathematics education. It foregrounds reasoning based on variation, modelling, and combinatorial exploration that anticipates computational forms of knowledge generation. Rather than explaining scientific content, the book stages processes of generating alternative configurations under explicit constraints, mirroring how scientific and mathematical models are constructed and explored in classrooms, closely aligned with modelling practices in science and mathematics education. Far from being marginal, *T Zero* can be read as a conceptual laboratory where imagination and formal structures interact. Science and mathematics emerge not only as domains of established knowledge, but as practices oriented toward constructing, testing, and revising models in response to changing assumptions. The combinatorial logic underpinning Calvino's writing functions as an epistemic device, presenting reality as the outcome of iteration and branching possibilities, in resonance with computational modelling.

Adopting this viewpoint reframes science and mathematics education less as the execution of predefined algorithms and more as a modelling practice. Knowledge develops through the interplay between formal constraints and systematic variation, a dynamic increasingly supported by digital tools in science and mathematics classrooms. Digital environments such as simulations, dynamic representations, generative AI, and programming languages require learners not only to compute results but to anticipate outcomes, reason about uncertainty, and explore the limits of prediction, skills widely recognised as essential for scientific and mathematical literacy in the digital era. In this light, *T Zero* supports a conception of scientific and mathematical learning as combinatorial modelling that integrates formal precision with imaginative openness, prediction with acknowledged uncertainty, and calculation with the exploration of multiple possible solutions.

By foregrounding scientific thinking as combinatorial modelling, this interpretation of *T Zero* aligns science and mathematics education with the epistemic conditions of digitalization. It highlights a shift from fixed answers to model-based reasoning and from certainty to the structured exploration of possibilities, with implications for curriculum design, classroom practices, and teacher education. Thus, it offers a conceptual framework to design learning environments in which modelling, simulation, and generative exploration are treated as central components of disciplinary learning.

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