

Course proposal

Theories and research methods in STEM education

Teacher(s)

Eleonora Faggiano (1 credit - 15 hours)

Antonella Montone (2 credits - 16 hours)

Course Website (optional)

Course description (min 150, max 300 words)

The course provides an in-depth study of the epistemological foundations of Mathematics and STEM Education, through the presentation of some theoretical research frameworks discussed in international literature and the research methodologies. In particular, the first part of the course will focus on the main theoretical frameworks of the Theory of Situations by Brousseau, of the Theory of Semiotic Mediation by Bartolini Bussi and Mariotti in a Vygotskian key, with particular reference to the synergy of artifacts of different nature (manipulative and digital) and to the production of signs, of the Duval and Radford's research on objectification. The second part concerns scientific research in STEM Education, a rigorous investigation process supported by appropriate theory and framework that guides it, the methods used in conducting the research and discussing the findings, and the standards for assessing the validity of the results. For this reason, the course will introduce and discuss different notions and roles of "theory" and the origin, nature, uses, and implications of specific theories pertaining to different types of such research. In particular, the focus is the formulation of the problem to be addressed and other key roles in the research design (methods and processes). The characteristics of quantitative, qualitative and mixed methods (e.g. machine learning for education, video analysis, triangulation design) will be described through the reading and analysis of examples. The nature of appropriate and productive criteria for assessing and increasing the quality of research proposals, projects, presentations and publications in STEM education, will be analysed and discussed.

The course will be structured through seminars, in which the topics will be presented, and laboratorial activities, in which the presented topics will be directly applied to work on real examples of data and research case studies.

Course period

March-May 2025

SSD

MAT/04

Course References (optional)

Credits and Hours

3 credits, two of lectures (8 hours) and one of practice (15 hour), for a total of 31 hours.

Exam Modality

Two alternatives are available to the student to pass this exam (Teacher(s) may choose other modalities):

- 1) Paper presentation. Students present the content of 2 papers suggested by the teachers. No groups are allowed.
- 2) Project. Students implement a review of 2 papers suggested by the teacher. No groups are allowed.

Teacher(s) CV

Attach or link a max 3 pages CV for each teacher proposing the course.

Teacher(s) Main Publications

List 10 main publications in the last 15 years for each teacher.

1. Faggiano E., Ferretti F., Arzarello F. (2023) How do primary teachers interpret and use standardized assessment: the case of the crochet placemats, in Proceedings of CERME12, Bolzano
2. Faggiano E., Monaco A., Rizzo O.G., Vaccaro V. (2023) An exploratory study on the connection between INVALSI assessment and mathematics teaching and learning processes at the Primary School level, In P. Falzetti (Ed.). The school and its protagonists: the teachers. V Seminar "INVALSI data: a tool for teaching and scientific research". (pp. 9-23), Franco Angeli
3. Faggiano E. (2022) The Semiotic Bundle as a reflective tool in pre-service mathematics teachers' education, *Frontiers in Education*, Sec. Teacher Education, 13, 104371
4. Swidan O., Faggiano E. (2021) Constructing shared mathematical meanings in the classroom with digital artifacts that simulate real-world phenomena, *MERJ - Mathematics Education Research Journal*, 34, 789–811
5. Faggiano E., Rocha H., Sacristan A.I., Santacruz Rodriguez M. (2021) Towards pragmatic theories to underpin the design of teacher professional development concerning technology use in mathematics. In Clark-Wilson et al. (Eds), *Mathematics Education in the Digital Age: Learning, Practice and Theory*, (pp. 42-68). ERME Series New Perspectives on Research in Mathematics Education, Routledge
6. Cusi A., Swidan O., Faggiano E., Prodromou T. (2020) The collaborative work on scenario design as a tool to foster teachers' professional development - In H. Borko & D. Potari (Eds.) *ICMI Study 25 Conference Proceedings*. (pp. 605–612)
7. Faggiano E., Mennuni F. (2020) Constructing mathematical meanings with digital tools: design, implementation and analysis of a teaching activity in a distance education context, *IxD&A Journal -Interaction Design & Architecture(s)*, 46, 156–174
8. Faggiano E., Montone A., Mariotti M.A. (2018) Synergy between manipulative and digital artefacts: a teaching experiment on axial symmetry at primary school, *IJMEST - International Journal of Mathematical Education in Science and Technology*, 49(8), 1165–1180
9. Faggiano E., Montone A., Rossi P.G. (2017). The synergy between Manipulative and Digital Artefacts in a Mathematics Teaching Activity: a co-disciplinary perspective. *JE-LKS. Journal of e-Learning and Knowledge Society*, 13, 33–45
10. Carreira S., Clark-Wilson A., Faggiano E., Montone A. (2017) From Acorns to Oak Trees: Charting Innovation Within Technology in Mathematics Education. In: E.

Faggiano F. Ferrara A. Montone (Eds). Innovation and Technology Enhancing Mathematics Education. (pp. 9–35), Springer

Eleonora Faggiano - Curriculum Vitae

ACADEMIC POSITION:

Associate Professor in Mathematics Education, since 2021, at the Department of Mathematics, University of BARI ALDO MORO (Italy)

Assistant Professor in Mathematics Education, from 2005 to 2021, at the Department of Mathematics, University of BARI ALDO MORO (Italy)

EDUCATION:

1999: Master's **Degree** in Mathematics – University of Bari

2001: Mathematics and Physics **Qualification for High School Teaching** - SSIS Puglia – University of Bari

2003: **International Summer School in Educational Technology** - Mekrijärvi Research Center - University of Joensuu - Finland.

2004: **II YESS Summer School in Mathematics Education** (Working Group on the use of Technology - chair C. Laborde) - European Society for Research in Mathematics Education - Pödebrady – Czech Republic.

2005: **PhD** in Computer Science - University of Bari. Supervisor: prof. V.L. Plantamura

Research topics: e-learning and educational technologies with application in mathematics education

Title of Thesis: A framework for supporting Web-based Cooperative Learning

2017: **National Scientific Qualification to be employed as Associate Professor** – SSD MAT/04 Complementary Mathematics – Mathematics Education

INTERNATIONAL PROFESSIONAL ACTIVITIES:

- **Editorial Board Member** - Mathematics Education in the Digital Era (MEDEra) Series - Springer
- Member of the **International Program Committee** of the following conferences:
 - 16th International Conference on Technology in Mathematics Teaching (ICTMT 15) - Athens (Greece), June 2023.
 - 13th ERME Topic Conference Mathematics Education in the Digital Age (MEDA 2022) - Role: **Conference Co-chair** - Nitra (Slovakia) – 7-9 September 2022.
 - 15th International Conference on Technology in Mathematics Teaching (ICTMT 15) - Copenhagen (Denmark), September 2021.
 - 10th ERME Topic Conference Mathematics Education in the Digital Age (MEDA 2020) - Role: **Conference Co-chair** - Linz (Austria) – online, September 2020.
 - 14th International Conference on Technology in Mathematics Teaching (ICTMT 14) - Essen (Germany), July 2019.
 - 5th ERME Topic Conference Mathematics Education in the Digital Age (MEDA 2018) - Role: **Conference Co-chair** - Copenhagen (Denmark), September 2018.
 - 13th International Conference on Technology in Mathematics Teaching (ICTMT 13) - Lyon (France), July 2017.
 - 12th International Conference on Technology in Mathematics Teaching (ICTMT 12) - Faro (Portugal), July 2015.
 - 11th International Conference on Technology in Mathematics Teaching (ICTMT 11) - Bari, July 2013.
 - Second International GeoGebra Conference – Role: **Co-chair** (with D. Kobal University of Lubiana) of the **Working Group** on Primary Education - Hagenberg (Austria) - August 2011.

- **Team Member** del **Thematic Working Group 16** on Learning Mathematics with Technology and Other Resources and **Editorial Board Member** of the Proceedings - 10th Congress of the European Society for Research in Mathematics Education (**CERME10**), Dublin (Ireland), February 2017 - 11th Congress of the European Society for Research in Mathematics Education (**CERME11**), Utrecht (Netherlands), February 2019 - 12th Congress of the European Society for Research in Mathematics Education (**CERME12**), Bolzano (Italy), February 2022, 13th Congress of the European Society for Research in Mathematics Education (**CERME12**), Budapest (Hungary), July 2023.
- **Co-Editor** of the following books:
 - “**Mathematics Education in the Digital Age: Learning, Practice and Theory**”, New Perspectives on Research in Mathematics Education Series - Routledge (with A. Clark-Wilson, A. Donevska-Todorova, J. Trgalova, H-G Weigand), 2021.
 - **Proceedings** of the 10th ERME Topic Conference Mathematics Education in the Digital Age (**MEDA 2020**), Johannes Kepler University, 2020.
 - **Proceedings** of the 5th ERME Topic Conference Mathematics Education in the Digital Age (**MEDA 2018**), University of Copenhagen, 2018.
 - “**Innovation and Technology enhancing Mathematics Education**”, published by Springer - MEDEra Series (with F. Ferrara e A. Montone), 2017.
 - **Proceedings** of the 11th International Conference on Technology in Mathematics Teaching (**ICTMT 11**), University of Bari, 2013.
- **Guest Co-Editor** of the following Journal Special Issues:
 - **IJRUME** “Digital Experiences in University Mathematics Education: Advances and Expectations” - Springer
 - **EDUCATION SCIENCES** “Methodological issues in STE(A)M Education” - MDPI
 - **TEAMAT** “Teaching Mathematics and its Applications” - Oxford University Press, Vol. 33 (1) (2014).
- **Ad hoc referee** and/or **reviewer** for **Journals, Books, Conferences**:
 - Journal of Mathematical Behavior (JMB) - Elsevier
 - Journal for Research in Mathematics Education – NCTM
 - Mathematics Education in the Digital Era (MEDEra) - Springer - **Book Series**
 - International Journal Mathematics Education Science Technology (IJMEST) - Taylor & Francis
 - International Journal for Technology in Mathematics Education (IJTME)
 - International Journal of Educational Research Open (IJEDRO) - Elsevier
 - **International Conferences** Frontiers In Education 2005, FIE 2006, Information Technology Education Joint Conference InSITE from 2006 to 2009, Congress of the European Society for Research in Mathematics Education CERME6 (TWG7), CERME10 e CERME11 (TWG16), International Conference on Education and Information Systems, Technologies and Applications EISTA since 2005, Informing Science Institute (since 2005).
- **Head of the GeoGebra Institute of Bari** (since 2010)
- **International activities and responsibilities** within the University of Bari Aldo Moro:
 - **Research and Teaching Advisor** for the research and teaching activities of Osama Swidan (Ben Gurion University of the Negev in Israel) as Visiting Professor at the Department of Mathematics - May/September 2019, July/December 2021, July/September 2022.
 - **Departmental Coordinator of Erasmus Agreements** with: University of Würzburg (since 2015), University of Duisburg-Essen (since 2018), Johannes Kepler University of Linz (since 2019), Norwegian University of Science and Technology (since 2019) and University of Frankfurt (since 2020).

RELEVANT NATIONAL PROFESSIONAL ACTIVITIES AND RESPONSIBILITIES:

- **Local Academic Research Advisor.** Research topic: “The use of resources to learn and teach mathematics, also in a relationship with other disciplines” - Contributo Ordinario sui Fondo di Ateneo - 2017 - 2019
- **Member of the research group** (coordinated by I. Vannini and F. Arzarello) on the National standardized assessment system INVALSI -Seminario permanente di ricerca su Didattica Generale e Didattiche Disciplinari - Società Italiana di Ricerca in Didattica (SIRD) – since 2017
- **Involvement in PhD courses:**
 - **Teaching Member:** Dottorato di Ricerca in “Informatica e Matematica” (XXIX, XXXVII and XXXVIII Ciclo) - University of Bari Aldo Moro (from 2013 to 2017 and from 2021 to present).
 - **Course:** “Theories and research methods in STEM education” - Dottorato di Ricerca in “Informatica e Matematica” XXXVIII Ciclo
 - **Tutor and thesis supervisor:** Dottorato in “Informatica e Matematica” (XXIX Ciclo) – University of Bari Aldo Moro. Title of the thesis: “Properties of Classical Differential Geometry for camera calibration in Computer Vision”.
 - **Teaching Member:** Dottorato di Ricerca (XXIV Ciclo) in “Storia e Didattica delle Matematiche, della Fisica, della Chimica” - University of Palermo (from 2010 to 2012).
 - **Referee:** Title of the thesis: “Graphical recognition of the properties of derivatives and anti-derivatives: analysis of different strategies using an eye-tracker” (Sapienza, 2023); “Convinzioni e cambi di convinzioni degli studenti sugli errori e sullo sviluppo della conoscenza in matematica (studenti di età 14 -18)” (Palermo, 2013).
- **Teacher educators in many different in-service and pre-service professional development courses**

RECENT RESEARCH INTERESTS AND COLLABORATIONS:

- **Teacher professional development concerning technology use in secondary mathematics.** Main collaboration on this topic with: A. I. Sacristan (Mexico), H. Rocha (Portugal), A. Clark-Wilson (UK).
- **Methodological and technological resources to foster teachers’ collaboration and professional development.** Main collaboration on this topic with: F. Arzarello and O. Robutti (University of Turin), A. Cusi (University of Rome La Sapienza), O. Swidan (Israel) and T. Prodromou (Australia).
- **The use of digital artifacts that simulate real-world phenomena to construct shared mathematical meanings in the classroom.** Collaboration with O. Swidan (Israel).
- **The Method of Variation Inquiry.** Collaboration with: F. Arzarello and O. Robutti (University of Turin), A. Cusi (University of Rome La Sapienza), F. Mennuni (University of Bari Aldo Moro) and O. Swidan (Israel).
- **Mathematics Education in the Digital Age: Learning, Practice and Theory.** Collaboration with A. Clark-Wilson (UK), A. Donevska-Todorova (Germany), J. Trgalova (France) and H.-G. Weigand (Germany).
- **Innovation and Technology Enhancing Mathematics Education.** Collaboration with F. Ferrara (University of Turin), S. Carreira (Portugal), A. Clark-Wilson (UK) and A. Montone (University of Bari).
- **The synergy between manipulatives and digital artefacts to construct mathematical meanings.** Collaboration with A. Montone (University of Bari), M. A. Mariotti (University of Siena), P. G. Rossi (University of Macerata).
- **Co-disciplinary design, development and analysis of mathematical e-learning situations.** Collaboration with P. G. Rossi (University of Macerata) and G. Albano (University of Salerno).
- **Connection between the National INVALSI standardized mathematics tests and the teaching practices at primary school level.** Collaboration with F. Arzarello (University of Turin), I. Vannini (University of Bologna), and other Italian researchers.