

INTRODUCING NEW HORIZONS IN TEACHING SCIENCE

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ABSTRACT. Preface to the AAPP supplementary issue collecting the proceedings of the international conference on “New Horizons in Teaching Science” (18th-19th June 2019; Messina, Italy).

1. Introduction

In the last decades research in teaching science has developed a wide range of methods, approaches and applications to constitute an autonomous disciplinary field, distinct from reference scientific disciplines and from pedagogy, even if strictly connected with them. This new knowledge has posed a set of relevant challenges for the training of new graduates as well as for the re-skilling of current workers through lifelong learning programs. According to most of these approaches, students learn in a more efficient way when they are strongly involved in their learning course activities and when they build, especially through a personal effort, an integrated knowledge. On this regard, in a scenario of mutual learning between different disciplinary fields, it is appropriate to share objectives, concepts and methods, to promote multidisciplinary pluralism and interdisciplinarity as well as the interaction and integration between different disciplinary points of view. This dialectical tension between disciplinary focus and interdisciplinary openings increases in the transdisciplinary perspective; transdisciplinarity strives to reach a “through” and a “beyond” - a transversality and a transcendence of disciplines - to acquire a global, integrated and “transgressive” understanding that reorganizes the disciplinary knowledges in a total system, without stable borders, and integrating them with practical and professional knowledge. The aim of this special issue titled “New Horizon in Teaching Science” is to deal with new trends in Science teaching/learning approaches and to put into evidence the key role played by laboratory activities in different fields of Science, to stress the importance of interdisciplinarity and to promote the dialogue among disciplines and scientific dissemination. On that score, the issue examines methodological and epistemological topics concerning research in science education presenting some constructive annotations through different discipline. A specific attention is paid to innovative and integrated didactic approaches addressed to reorganize well-known teaching methods outside the single discipline classroom and to promote student-centred approaches. This includes a huge number of learning strategies

as, for example, those based on flipped classroom methods and active learning activities carried out mainly in groups. The issue is divided in 43 chapters. More specifically, Chapter 1 addresses the need to consider the cultural aspects and the semantic dimension of Physics, discipline in some cases reduced to a pure mathematical game or to technological manipulations, in order to obtain a deeper understanding of the discipline and to avoid reducing the teaching of Physics to a mere technical training (Giannetto 2021). In Chapter 2 the author analyzes life and works of the physicist Giambattista Placiani, with particular reference to his concordist program aimed to reconcile the biblical account of the creation of world with scientific results that came from studies on natural cosmogony (Mantovani 2021). In Chapter 3 the authors treat the question of “five simple machines”, following a multifaceted and innovative learning-functional teaching approach, as motivating element for students and as a learning facilitator tool (Ferriello and Magazù 2021). In Chapter 4 it is shown how it is possible to analyze the results of large-scale survey on mathematics and science learning, with conceptual tools of mathematics education, in order to look beyond statistical data of performances for individual students or group (Bolondi 2021). Chapter 5 offers an example of interdisciplinary approach aimed to highlight the link between mathematics and the “Drawing and History of Art” based on use of drawing as a tool for formal analysis (Serpe and Frassia 2021b). In Chapter 6 the importance of adopting a joint approach between Philosophy and Physics is highlighted in order to clarify the internal structures of Physics itself, in relation to the close connection between ancient naturalistic speculation and modern Physics (Gambetti and Magazù 2021). The author of Chapter 7 illustrates a teaching methodology, called pedagogical anthropology, based on the nature of man and its connection with scientific method; the methodology is explained following a path crossing the life of Giuseppe Sergi, ideator of the approach (Sergi 2021). Chapter 8 describes the most relevant scientific contributions inherited by Joseph Fourier, following a historical approach that draws parallel paths between scientific production and life, works and personality (Semprebello *et al.* 2021). In Chapter 9 the authors present accurate reconstructions of extinct organisms, such as endemic elephants and hippos that lived in Sicily during the Quaternary; furthermore, the importance of Paleoart as a didactic tool in Paleontology is underlined (De Francesco and Marra 2021). Chapter 10 traces the evolution of clay extraction and processing, addressing the theme of linking industrial Archeology and didactic paths closely linked to educational tourism (Spinnato 2021). In Chapter 11 the authors identify a didactic path inside a learning model based on the study of the territory, referring to the clay quarries located in the Province of Messina which, together with the development of methodologies aimed at improving the properties of materials based on clay, have represented and still are an important cultural and economic resource for the territories involved (Franzone *et al.* 2021). The authors of Chapter 12 describe an online course on differential equations held at Polytechnique of Montreal, presenting conclusions related to comparison of results obtained by online students compared to classroom students (N’Dri and Lefebvre 2021). Chapter 13 shows the results of an experimental didactic activity that interested primary school students involved in a mathematics path, set up in Catania, thanks to the MatCityMap-Project which provides a web portal and a mobile app (Ariosto *et al.* 2021). In Chapter 14 the author treats the advantages related to the use of softwares, *e.g.*, MAPLE, in computational teaching, giving some examples based on representation of the objects and algebraic manipulation commands (Ionescu 2021).

The author of Chapter 15 proposes an innovative didactic approach, that involves the use of technological artifacts, aimed to teaching trigonometry, the difficulty of which, both for students and teachers, has been ascertained by a research (Serpe and Frassia 2021a). Chapter 16 provides a lesson on techniques used to prevent the effect of an earthquake and discussing basic concepts of seismic isolation and the main models and devices used as seismic insulators (Failla 2021). Chapter 17 has the aims to recall, adopting an innovative approach, some fundamental concepts on Generalized Induction Principle, as the Recursion Theorem; in the latter part some elements of NGB set theory and preliminary tools to study the classical notion of Dedekind completeness are treated (Devillanova and Molica Bisci 2021a). In Chapter 18 the authors show a concise introduction to the construction of the real field as the unique Dedekind complete totally ordered field; furthermore, it is shown the equivalence between Dedekind's completeness property on totally ordered fields and other notions, *e.g.*, the completeness of Cauchy on fully ordered Archimedes fields (Devillanova and Molica Bisci 2021b). In Chapter 19 the author proposes a linear theory for magnetizable media in the scope of classical irreversible thermodynamics (CIT); the results offer possible applications in many fields: from medicine to biology, from physics to chemistry (Restuccia 2021). The authors of Chapter 20 highlight, by means of a statistical approach, the advantages, in term of health and longevity, linked with Mediterranean diet, in relation to its crude fibre and vitamin C content, in accordance with medical standards and directives of international nutritional organizations (Di Bella *et al.* 2021). In Chapter 21 the authors illustrate how to realize, using readily available tools and applying thermodynamics concepts, a transparent tank and a stable refractive index gradient, with the aim of using it to perform practical experiments on light refraction and related topics in classroom (Wanderlingh *et al.* 2021). The authors of Chapter 22 suggest some significant experimental activity that the partners-student performed with smartphone and low-cost equipment on sound, acceleration, optics and spectroscopy (Buongiorno and Michellini 2021). In Chapter 23, the authors verify the applicability of the Rayleigh-Lamb equation to drops having different diameters and, specifically, with diameters of the order of magnitude of centimeters (macro drops), millimeters or micrometers (micro drops) (Catalano *et al.* 2021). Chapter 24 presents a new, effective method of education where the body and emotive sensations encouraged the spheres of learning (Ruello and Capodici 2021). In Chapter 25, the authors propose a conceptual map that may stimulate the exploration of new approaches for the integration of knowledge and skills both from the experimental and theoretical point of view (Lombardo *et al.* 2021a). The author of Chapter 26 takes into account an approach, based on a 5E teaching model, that opens up to an active and dynamic discussion phase of problem solving that can be effectively extended in wider contexts (Calabrese 2021). In Chapter 27 the author shows an interdisciplinary approach used in developing a new material for biomedical application by means of innovative teaching methods (Khaskhoussi 2021). The authors of Chapter 28 report a didactic multiscale approach for drone modeling taking into account the drone structure at both macroscopic and microscopic scales, by making use of finite element and atomistic simulations (Raffaele *et al.* 2021a). In Chapter 29 the author suggests that the use of imagination is essential in educational research as well as the use of different skills in interdisciplinary works in order to better understand some scientific topics (Salvador *et al.* 2021). The authors of Chapter 30 sustain that the experiential learning method can be properly designed and delivered, with particular respect to the use

of bio- and nanotechnology, and in ways that help the learners to efficiently develop the knowledge and skills needed in the modern age (Lombardo *et al.* 2021b). In Chapter 31 the authors propose a forensic-based learning methodology in teaching geochemistry using the fluorine compounds and their chemical, mineralogical and geochemical properties (Spoto *et al.* 2021b). The author of Chapter 32 describes the main techniques and approaches employed for the investigation of biological membranes under a multidisciplinary point of view focusing on multi- and trans-disciplinary methods that combine the expertise coming from the different disciplines (Lombardo 2021). The author of Chapter 33 proposes a didactic approach to use the Machine Learning protocol in order to perform weather forecast (Raffaele *et al.* 2021b). In the Chapter 34 the author sustains that interdisciplinarity is a key ingredient which can surely emerge from the scientific activities and propose a flipped classroom approach for thinking experiments, interpreting their results and preparing novel materials (Calandra 2021). The authors of Chapter 35 provide an alternative teaching approach on environmental issue and show how thanks to a flipped classroom approach it is possible to appreciate new eco-friendly (Mottese *et al.* 2021). The authors of Chapter 36 describe their university experience with the flipped classroom approach, reporting real examples (Spoto *et al.* 2021a). Chapter 37 proposes modern approaches to explain students what radiation is and how it can help researchers in understanding the structure of materials in a clear and simple way (Calandra *et al.* 2021). In Chapter 38 the authors cover several physical and historical aspects from EM waves to particles (Marrara *et al.* 2021). The authors of Chapter 39 describe the contents for an introductory university course conceived in a multitask program (Romano *et al.* 2021). Chapter 40 addresses to an introductory university course on the correlation existing between radon emission and earthquakes processes held following a flipped-class approach (Di Stefano *et al.* 2021). The authors of Chapter 41 suggest possible brief activity on how to explore gas sensor employment and operating features in a classroom (Latino and Neri 2021). In Chapter 42 the author presents a textbook of Invertebrate Paleontology following an innovative approach (Marra 2021). Finally, the authors of Chapter 43 propose an approach to increase the interest of students towards the significant aspects that affected the social-economic growth of the Messina's territory and on the importance that geo-materials had in the technological evolution of its civilization process (Sabatino *et al.* 2021). In conclusion, science knowledge and applications have a key role for social, economic and industrial developments. However, although the importance of science, students and citizens at all the level often encounter difficulties in learning science and develop negative attitudes towards science subjects. The learning paths reported in the special issue show positive synergies among different discipline knowledge and education approaches, reflecting recent research efforts addressed to face the challenges triggered by the explosion of new communication media, new student generations and differences in student interests for promoting a more homogeneous and non-static teaching model.

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