Ion ROCEANU
Editor

15th International Conference eLearning and Software for Education

New technologies and redesigning learning spaces

Volume II

Bucharest, April 11- 12, 2019

eLSE 2019

Editors

Ion ROCEANU

Carmen HOLOTESCU **Lucian CIOLAN** **Anca Cristina COLIBABA**

Cătălin RADU

New technologies and redesigning learning spaces

Volume II

eLearning and Software for Education Conference

Bucharest, April 11 – 12, 2019

Publisher:
“CAROL I” National Defence University Publishing House
Director: Gheorghe MINCULETE
Panduri Street, 68-72
Bucharest
Phone: +40213194880

ISSN 2066 – 026X
ISSN-L 2066 – 026X
ISSN – CD 2343 - 7669

Further information on all eLearning and Software for Education – eLSE – events can be found at:
www.elseconference.eu

All the papers published in this book were verified for plagiarism using the Plagiat-Sistem Antiplagiat prin Internet software

eLSE 2019

The 15th International Scientific Conference
“eLearning and Software for Education”

New technologies and redesigning learning spaces

Volume II

CONTENTS

The 15th International Scientific Conference
eLearning and Software for Education
Bucharest, April 11-12, 2019
10.12753/2066-026X-19-070

The Role of an Advanced Computing Environment in Teaching and Learning Mathematics through Problem Posing and Solving

Marina MARCHISIO, Alice BARANA, Alberto CONTE, Cecilia FISSORE, Francesco FLORIS,
Dipartimento di Matematica, Università di Torino, Via Carlo Alberto 10, Torino, Italy
marina.marchisio@unito.it, alice.barana@unito.it, alberto.conte@unito.it, cecilia.fissore@unito.it, francesco.floris@unito.it

Anna BRANCACCIO
Direzione generale per gli ordinamenti scolastici e la valutazione del sistema nazionale di istruzione, MIUR, Viale Trastevere 76/A, Roma, Italy
anna.brancaccio@istruzione.it

Claudio PARDINI
ISS Carlo Anti, Via Magenta 7, Villafranca di Verona (VR), Italy
dirigente@carloanti.it

***Abstract**: Problem solving, i.e. the ability to model real life situations in mathematical terms and to solve the problems connected to them, plays an important role in teaching and learning Mathematics to and by students at every level of education and it is one of the basic skills for the education of citizens. By learning problem solving in Mathematics, students acquire ways of thinking, creativity, curiosity, collaborative skills and confidence in unfamiliar situations, from which they will benefit also outside the Mathematics class. The use of digital technologies helps in both representing and exploring mathematical tasks. Technologies also provide a range of tools and opportunities to structure and support learning environments in which students continually interact to build knowledge and solve problems. The national PP&S - Problem Posing & Solving - Project of the Italian Ministry of Education aims to enhance the teaching and learning of Mathematics and Informatics using new methodologies and technologies. One of the methodologies is problem solving through the use of an Advanced Computer Environment (ACE). An ACE is a system that allows to perform numerical and symbolic calculation, make graphical representations in 2 and 3 dimensions and create mathematical simulations through interactive components. Moreover, it is able to support students in reasoning processes, in the formulation of exit strategies and in the generalization and re-adaptation of the solution in different contexts. The goal of this paper is to discuss the results of an immersive workshop, entitled "Mathematical Exploration with Problem Posing and Solving", involving 50 secondary school Maths teachers, who were invited to reflect on the role of an ACE in learning and teaching Mathematics through problem posing and solving. During the workshop the problem solving methodology used in the PP&S project and an example of a contextualized problem solved with the use of an ACE were presented. The results emerged from the analysis of the questionnaires (initial and final) completed during the workshop and from the study of the works delivered by the teachers, who were asked to design a problem, its resolution and generalization through the use of an ACE. These results are useful to understand teachers' reflections on the methodologies proposed and on the impact of new technologies on teaching.*

***Keywords:** Advanced Computing Environment; Learning Mathematics; New Technologies; Problem Posing; Problem Solving; Teaching Mathematics.*

I. INTRODUCTION

According to the "The Future of Jobs Report 2018" report, among the skills continuing to grow in prominence by 2022 there are creativity, analytical thinking and innovation, active learning and learning strategies, technology design and programming, complex problem-solving, critical thinking and analysis, reasoning, problem-solving and ideation [22].

One of the fundamental skills in Mathematics is the ability to solve problems in everyday situations, which include the ability to understand the problem, devise a mathematical model, develop the solving process and interpret the obtained solution [19]. The term "problem-solving" includes all mathematical tasks that have the potential to provide intellectual challenges for enhancing students' mathematical understanding and development [17]. In "The Future of Jobs Report 2018", problem solving is described as the ability to "identify complex problems and review related information to develop and evaluate strategies and implement solutions", especially in dynamic real world situations that require responsive actions [22]. By solving mathematical problems, students acquire ways of thinking, habits of persistence, curiosity and confidence in unfamiliar situations, that are some of the most important skills in the education of citizens who can contribute to the development of economy and society and who can succeed in life [11]. Problem solving skills are both a main objective of education and one of the main activities of Mathematics teaching and learning [13], which are now supported by the use of new technologies, such as an Advanced Computer Environment (ACE) that are revolutionizing teaching and learning.

This paper discusses a teaching training experience which took place during an immersive workshop entitled "Mathematical Exploration with Problem Posing and Solving", lasting two hours at the Didacta Italia 2018 Fair. The workshop is included in the activities proposed by the Italian PP&S Problem Posing and Solving Project of the Ministry of Education [2].

II. STATE OF THE ART

Modern students live in a technology-rich environment and are great users of technology; their ways of communicating with teachers and peers, interacting with learning materials and demonstrating knowledge of mathematical concepts have changed over the last years [21]. As for the role of technology in the teaching and learning of Mathematics, the National Council of Teachers of Mathematics [18] states the following: "It is essential that teachers and students have regular access to technologies that support and advance mathematical sense making, reasoning, problem solving, and communication. Effective teachers optimize the potential of technology to develop students' understanding, stimulate their interest, and increase their proficiency in Mathematics. (p. 1)".

2.1 New technologies for problem posing and solving

The use of digital technologies in problem solving activities makes teachers and learners become active participants in the learning process generated within the mathematical working space. These instruments offer a precious diversity of ways to represent and explore the tasks [20]. Kuzniak et al. [12] argue that the use of digital technology offers teachers and learners an opportunity to extend and deepen ways of reasoning about the mathematical strategies involved in solving problems. In addition, representing and exploring mathematical tasks mediated by digital technologies bring in new challenges for teachers. These challenges include the appropriation of the instruments provided by these technologies in order to identify and analyze what changes to mathematical contents and teaching practice are fostered through its use. It is not the tool itself that produces this transformation: it is the process of appropriation led by the teacher and the students that eventually transforms the digital artefact into a mathematical instrument [16].

The technologies for problem solving are: electronic spreadsheets, graphic calculators such as Graphing Calculator 4.0 [1], online computational engines such as Wolfram Alpha [8], dynamic geometry systems such as Geogebra or Cabri Geometry [10], Virtual Learning Environments (VLE) such as Moodle. Technology can foster conjecturing, justifying and generalising by enabling fast, accurate computation, collection and analysis of data, and exploration of multiple representational forms (e.g., numerical, symbolic, graphic) [9]. The increasing availability and power of electronic devices such as computers and graphic calculators offer new opportunities for students to communicate and analyse their mathematical thinking, since the objects generated on the screen can act as a common referent for discussion [17]. They can be tools that free students from calculation, allowing them to focus on more interesting activities, such as exploring, conjecturing, searching and concluding, which can lead to a deeper understanding of mathematical concepts. Graphic calculators can be used as exploratory tools but also to verify the solution to a problem [15]. Dynamic geometry systems provide learners with a set of affordances to represent and dynamically explore mathematical problems. By moving objects within the dynamic model, students can identify and examine mathematical relations that emerge [16]. According to Caprotti et al. [7], technologies are also used to enhance teaching materials in Mathematics by adding java illustrations or animated graphics and allowing students to experiment with mathematical statements. Tools like Maple [23] and Mathematica [24] can easily produce sophisticated animations and the materials can be used without needing to install the software [7]. Finally, a VLE encourages social interactions in problem solving: through discussions in a community of practice, the construction of knowledge and awareness of learning is encouraged [2].

Technologies play a fundamental role not only in problem solving but also in problem posing. According to Singer et al. [21], the technology can facilitate and foster skills in formulating problems. The authors explained that most of the studies have been conducted on the developing of conjectures in dynamic (or partially dynamic) geometry environments and on mathematical problem posing in web-based learning environments. Singer et al. presented the use of modern tools of digital technology such as electronic spreadsheets, computer-based Graphing Calculator, Maple and Wolfram Alpha in facilitating and advancing skills of preservice teachers in mathematical problem posing. Their research shows that the success of the teachers with technology-enabled problem posing requires practical experience with mathematical modelling and problem solving as well as theoretical preparation in pedagogical issues. This is important for the development of skills in formulating new problems and modifying the existing ones. They also explained that the use of technology in problem posing encourages open-ended classroom pedagogy, fosters mathematical reasoning and thinking skills of preservice teachers, and, consequently, has great potential to make K-12 students better problem solvers.

The interventions of a teacher in a problem solving activity using the technologies can have different purposes: to help use the tools, to support the students in understanding the mathematical concepts (for example solving an apparent contradiction between the solutions returned by an Equation Editor, graphic methods and spreadsheets), to encourage students to conjecture and justify (for example by presenting their results to their peers) and to support a peer discussion in developing a deep understanding [9].

2.2 An Advanced Computing Environment for problem posing and solving

An ACE allows to perform numerical and symbolic calculation, make graphical representations (static and animated) in 2 and 3 dimensions, create mathematical simulations, write procedures in a simple language, programming, and finally elegantly connect all the different representation registers also with verbal language in a single worksheet (Barana e Marchisio 2017). An ACE can help develop problem solving competences because it offers various types of representations and it enables the resolution of a problematic situation. Starting from mental thinking, the solving process can be carried out through several modalities, such as words, graphics, algebra, and experimenting through computerized simulations. Being able to properly combine those modalities is a crucial aspect in problem solving, and the fact that they can be used in a single environment promotes high levels of clarity and understanding. Students can choose among different modes of resolution and this forces them to validate and constantly justify the reasoning: the effectiveness of their resolution strategy is as important as the clarity of the expression of their resolution process. One of the most evident ACE features is that it helps deal with computations that would be hard to be done by hand. This has a double effect: students can focus on solving the problem rather than on calculating, and the variety of problems that can be proposed to be solved via an ACE is wider [4].

A very important aspect of an ACE for problem solving is the design and programming of interactive components. They enable to visualize how the results change when the input parameters are changed and therefore they allow to generalize the solving process of a problem. Generalizing is an important process by which the specifics of a solution are examined and questions as to why it worked are investigated [14]. This process is synonymous with the verification and elaboration stages of invention and creativity. In this sense, technology can be an amplifier of a mathematical activity, which extends to a new dimension of problem posing, solving, and reformulating activities in a way that it is hard to realize without the support of technology.

III. THE METHODOLOGY OF PROBLEM POSING AND SOLVING PROPOSED IN THE PROJECT PP&S

The PP&S Project promotes the training of Italian teachers of lower and upper secondary schools on innovative teaching methods and on the creation of a culture of Problem Posing and Solving with the use of ICT. The PP&S Project adopts the following technologies as essential tools for professional growth and for the renewal of teaching and learning: a Virtual Learning Environment, VLE, a Moodle-learning platform, available at www.progettopps.it, integrated with an ACE, that is Maple, an automatic Assessment System (AAS) and a web conference system. The asset developed and proposed has proved to be an essential tool both to enable collaborative learning among teachers and to promote problem posing and problem solving as learning methodologies [2].
The innovative methodologies proposed by the PP&S project are:

- problem posing and solving using an ACE that supports problem formulation, presentation, resolution and generalization [4] [5];
- automatic formative assessment with adaptive questions aimed at teaching students how to solve problems, guiding them step-by-step with interactive feedback in the solving process, through an ACE and an AAS [3];
- collaborative learning among teachers in a community of practice for the exchange of ideas, strategies and materials;
- collaborative learning among students in a learning community.

This article focuses on the first methodology: problem posing and solving with an ACE. In the PP&S Project, the Problem Posing is conceptualized through the following fundamental components:

- a real and challenging situation;
- a theoretical content relevant to the applications and possibly involving other disciplines;
- a contextualized request that allows mathematical skills to be implemented, that does not limit to a unique solving approach and that requires a generalization;
- a resolution, conceived as a learning process, in which students can choose different solving strategies and even obtain different results.

The problem solving includes the ability to understand the problem, devise a mathematical model, develop the solving process and interpret the obtained solution. To these main phases we have added the request to generalize the solution process through programming interactive components. As specified in the theoretical framework, it is important that the problem offers several possible solving approaches that can be explored and presented through an ACE using different modes of representation. By solving the problem with an ACE, students can deal with contextualized problem situations, invent new resolution procedures by reasoning outside conventional schemes, create the solution to the problem and explain and justify it in a single working environment (in which to alternate accounts, procedures, charts, textual explanations and interactive components). The additional choice of the PP&S Project to use contextualized, real life problems was made with the goal of creating a bridge between school and extracurricular Mathematics, bringing out realistic considerations and developing modelling skills [6]. The PP&S Project offers various training activities that allow teachers to reconsider their teaching using technologies: face-to-face training, online training modules, weekly online tutoring, online asynchronous collaboration and collaborative learning within a learning community [2]. In this case, we proposed an immersive experience, in the form of a workshop, entitled "Mathematical Exploration with Problem Posing and Solving” to increase teachers’ awareness of the use of problem posing and solving supported by technologies. The 50 teachers who participated work in schools from primary to upper secondary level (students aged 6 to 18) and they teach Mathematics or other scientific subjects.

IV. METODOLOGIES

The experience was developed in three different moments: compilation of an initial and a final questionnaire; presentation of an example of a contextualized problem; individual step-by-step creation of contextualized problems by the teachers following the abovementioned phases through stimulus-based questions. Through the example of contextualized problem, entitled "The journey", we explained the four phases of the problem posing and solving process:

- problem design: it concerned the choice of the argument (direct and inverse proportionality), of the context (travel between two Italian cities) and of the data (some data and some open to explore);
- text formulation, respecting the principles explained above, was as follows: <<Marco lives in Turin and he has chosen Florence as his holiday destination. He decides to go drive there but, being alone, he does not want to drive for more than 4 hours in a row and, in order to consume as little fuel as possible, he wants to maintain a constant speed throughout the journey. Will he be able to reach his destination without taking breaks and without exceeding the speed limits? Suppose that with his car Marco can travel 100 kms with 4.2 liters of fuel (petrol). How much fuel will he spend on the trip? Provide a graphic representation of the situation. What speed should Marco keep during the journey if he varied the route? What speed should he keep if he covered the same route in a different time?>>;
- construction of the solving process: it entailed the exploration of the choice of the route, the computation and graphic representation of the speed, the computation of the necessary fuel, the exploration of the fuel cost and the computation of total expenses. Through the ACE, it was possible to graphically represent the situation and to carry out conversions of units of measurement, alternating them with textual explanations;
- generalization of the resolution to abstract the solving process: it included the study of the link between space, time and speed, analysing how the speed varied if Marco decided to take a different amount of time to cover the same route or if he decided to change the chosen route. This can be observed through a system of interactive components, in which a slider controls the amount of time taken and makes the graph that models the situation change (Figure no. 1), and through an animated graph in which, for example, the graph changes as the distance varies (Figure no. 2).

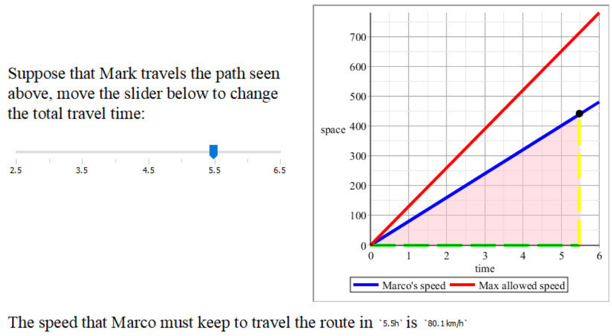

Figure no. 1. Example of an interactive component that generalize the solution

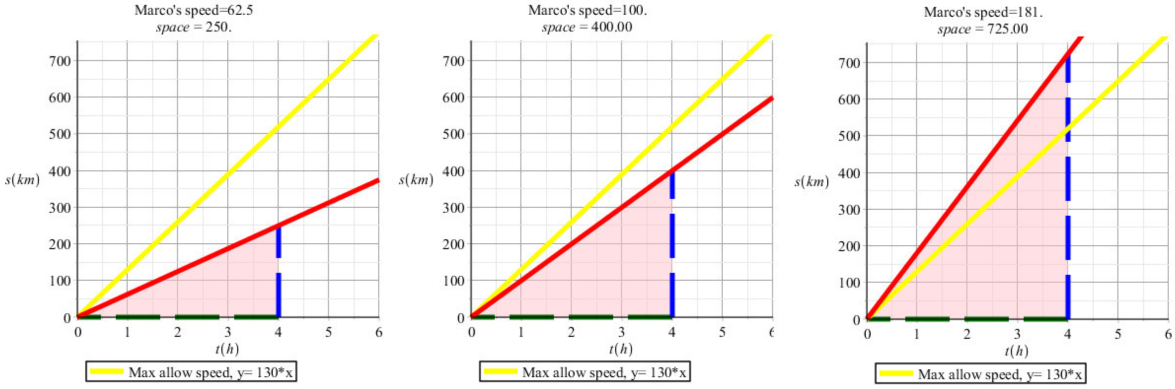

Figure no. 2. Example of an animated graph that generalizes the solution

Teachers were asked to create a problem on the same topic but freely choosing context and data; they were asked to think about a very specific class for which to create a problem. During the individual step-by-step creation of a contextualized problem we asked teachers to reflect on the use of technologies in problem solving. To analyze the considerations of the teachers we used the following tools: initial and final questionnaire, resolution and generalization of the problem created by teachers and teachers' answers to stimulus-based questions of the third and fourth phase. They were respectively: "How do you think that the technologies shown can be useful for solving the problem?", "How do you think the technologies shown can be useful for generalizing the problem?".

V. RESULTS AND DISCUSSIONS

Of the 50 teachers who participated in this experience, 7 taught at primary school, 24 at lower secondary school (one of which was a support teacher) and 19 at upper secondary school. Primary teachers taught various subjects (including Mathematics and Science), while secondary teachers taught: Chemistry (1), Physics (1), Mathematics (16), Mathematics and Physics (5), Mathematics and Science (20); except for 13 teachers, all had been teaching for more than 10 years. Most of the teachers said that they regularly used problem solving as a teaching strategy during their lessons, and only 3 teachers (from secondary school) never or rarely used it. As shown in Figure no. 3, almost all teachers use technologies in teaching Mathematics: most of them use them in the classroom, with students, but a good part of them is also used in the classroom through students' devices and computer labs, or as homework.

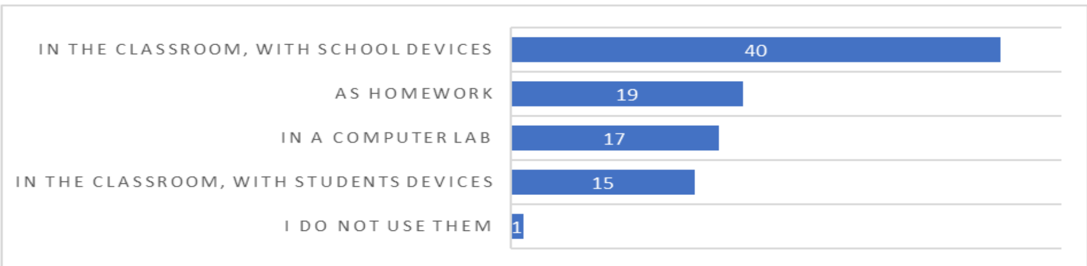

Figure no. 3. Situations in which teachers use technology with students for Mathematics

Table no. 1 shows the self-reports of the frequency with which teachers use different types of software with students for teaching Mathematics, expressed with a numerical value between "1 = never" and "6 = very frequently", and of the software that they use. Teachers use Dynamic geometry software and Spreadsheets/Statistical software very often, and with a sufficient frequency they use tools for programming or computational thinking, software that supports symbolic calculation and advanced computing environment. The programs teachers mentioned are manifold.

	Average	Standard deviation	Which software teachers use
Dynamic geometry software	2,63	1,18	Geogebra, Cabri Geometry, Desmos
Spreadsheets / statistical software	2,27	1,24	Excel, Numbers
Tools for programming or for computational thinking	1,64	1,18	Scratch, Lego mindstorm, Arduino, Code.org, Programma il futuro, Flowgoritm
Software that supports symbolic calculation	1,43	0,94	Software di bortolato, Excel, Desmos, Graphing calculator, Derive, Aplusix
Advanced Computing Environment	1,15	0,65	Desmos, Derive

Table no. 1. Frequency of use of software and types of software used

Some teachers preferred to work individually, while others preferred to work in pairs or in groups of 3 or 4; the groups were spontaneously formed and in some cases teachers of different grades or subjects worked together. At the end of the immersive experience, 25 different problems were produced. All of them are characterized by a contextualization in the real life and familiar to the students, for example charging the phone, school trips, going to the cinema, athletic preparation of a team, cooking recipes, interpreting bills. For the resolution of their problems, the teachers have considered many solving strategies: algebraic and symbolic computations (counts, proportions, equation resolution and equation systems), tables, graphs, flow charts, unit conversions; also imagining using different sources for the exploration of open data contextualized in real life. The teachers said that an ACE can be useful to solve a problem in the following aspects: graphically simulating a proportion, schematizing the data, demonstrating the resolution, "freeing the student from the difficulty of drawing graphs and counting", creating animated graphs to see how relationships, graphical displays and chart analyses vary, finding more than one solving strategy. According to them, it can also facilitate the inclusion of students with special educational needs and specific learning disorders. According to the teachers, an ACE can be useful for the generalization of the resolution process to: visualize and simulate similar situations, be able to "play" with the software and explore the solution of the problem, solve not only a problem but a category of problems, favor general interpretation of the problem, see how the solution changes as the data change, use a slider to change the data, memorize mathematical concepts, activate processes of abstraction. According to the teachers, it can also lead to "meaningful and motivating learning", “promoting students' critical thinking and creativity”.

VI. CONCLUSION

The immersive experience led the teachers to deep reflections on the importance of using technologies, and in particular an ACE, in the methodology of problem posing and solving. During the phases of resolution and generalization of the problem they invented, teachers have reflected on the role of an ACE and what it can offer. From the results shown, it emerges that the teachers are in favor of using the technologies and the methodologies proposed by the Project. The teachers considered various types of representation that the ACE offers and that are important for the resolution of a problematic situation. Through an ACE, it is possible to extend and deepen ways of reasoning about the mathematical strategies involved in solving problems and exploring mathematical tasks. Teachers really enjoyed the ability to interactively observe how the results of a problem change when the input parameters are changed, in order to generalize the solving process of a problem. They also appreciated the possibility of significant graphic representations and animated graphs, to represent and dynamically explore mathematical problems. It could be significant to increase the training of teachers on the use of an ACE for the creation and resolution of problems, as well as the training of students to teach them the tool and enrich their skills and their educational experiences.

Reference Text and Citations

[1] Avitzur, Ron, 2011. *Graphing calculator (Version 4.0)*. CA: Pacific Tech.: Berkeley.

[2] Barana, Alice; Brancaccio, Anna; Esposito, Massimo; Fioravera, Michele; Fissore, Cecilia; Marchisio, Marina; Pardini, Claudio; Rabellino, Sergio; Online Asynchronous Collaboration for Enhancing Teacher Professional Knowledges and Competences, *The 14th International Scientific Conference eLearning and Software for Education,* 2018, Bucharest: ADLRO, pp. 167–175.

[3] Barana, Alice; Conte, Alberto; Fioravera, Michele; Marchisio, Marina; Rabellino, Sergio; A Model of Formative Automatic Assessment and Interactive Feedback for STEM, in *Proceedings of 2018 IEEE 42nd Annual Computer Software and Applications Conference (COMPSAC),* 2018, Tokyo, Japan: IEEE, pp. 1016–25.

[4] Barana, Alice; Fioravera, Michele; Marchisio, Marina; Developing Problem Solving Competences through the Resolution of Contextualized Problems with an Advanced Computing Environment, in *Proceedings of the 3rd International Conference on Higher Education Advances*, 2017, Universitat Politècnica València.

[5] Barana, Alice; Marchisio, Marina; Sviluppare competenze di problem solving e di collaborative working nell'alternanza scuola-lavoro attraverso il Digital Mate Training, in *Atti di Didamatica,* 2017, pp. 1–10.

[6] Baroni, Marzia; Bonotto, Cinzia; Problem posing e problem solving nella scuola dell'obbligo, 2015. 62.

[7] Caprotti, Olga; Seppl, Mika; Xambo, Sebastian; Using Web Technologies to Teach Mathematics, 2006, 8.

[8] Dimiceli, Vincent; Lang, Andrew SID; Locke, LeighAnne, Teaching calculus with Wolfram| Alpha, *International Journal of Mathematical Education in Science and Technology*, 2010, 41.8, pp. 1061-1071.

[9] Goos, Merrilyn; Galbraith, Peter; Renshaw, Peter; Geiger, Vince; Perspectives on Technology Mediated Learning in Secondary School Mathematics Classrooms, *The Journal of Mathematical Behavior*, 2003, 22(1), pp. 73–89.

[10] Hohenwarter, Markus; Hohenwarter, Judith; Kreis, Yves; Lavicza, Zsolt, Teaching and learning calculus with free dynamic mathematics software GeoGebra, *11th International Congress on Mathematical Education*, 2008, Monterrey, Nuevo Leon, Mexico.

[11] Kay, Ken; Greenhill, Valerie; Twenty-first century students need 21st century skills, *Bringing schools into the 21st century*, 2011, Springer, Dordrecht, pp. 41-65.

[12] Kuzniak, Alain; Parzysz, Bernard; Vivier, Laurent; Trajectory of a Problem: A Study in Teacher Training, *The Mathematics Enthusiast*, 2013, 10.1, pp. 407–440.

[13] Leong, Yew Hoong; Janjaruporn, Rungfa; Teaching of Problem Solving in School Mathematics Classrooms, in *The Proceedings of the 12th International Congress on Mathematical Education*, 2015, a cura di S. J. Cho. Cham: Springer International Publishing, pp. 645–48.

[14] Liljedahl, Peter; Santos-Trigo, Manuel; Malaspina, Uldarico; Bruder, Regina, 2016. *Problem Solving in Mathematics Education*, New York, NY: Springer Berlin Heidelberg.

[15] Mesa, V.; The use of graphing calculators in solving problems on functions, In *Proceedings of the 21st annual conference of the International Group for the Psychology of Mathematics Education*, 1997, 3, pp. 240-247.

[16] Moreno-Armella, Luis; Santos-Trigo, Manuel; The use of digital technologies in mathematical practices: Reconciling traditional and emerging approaches, in *Handbook of international research in Mathematics education*, 2016, New York: Taylor & Francis, pp. 595–616.

[17] National Council of Teachers of Mathematics. 2000. *Executive Summary Principles and standards for school Mathematics*.

[18] National Council of Teachers of Mathematics. 2011. *Technology in teaching and learning of Mathematics: A position of the National Council of Teachers of Mathematics*.

[19] Samo, Damianus Dao; Darhim; Kartasasmita, Bana; Culture-Based Contextual Learning to Increase Problem-Solving Ability of First Year University Student, *Journal on Mathematics Education,* 2017, 9(1).

[20] Santos-Trigo, Manuel; Moreno-Armella, Luis; Camacho-Machín, Matías; Problem Solving and the Use of Digital Technologies within the Mathematical Working Space Framework, *ZDM*, 2016, 48(6), pp. 827–42.

[21] Singer, Florence Mihaela; Ellerton, Nerida F.; Cai, Jinfa, 2015. *Mathematical Problem Posing: From Research to Effective Practice*. New York: Springer.

[22] World Economic Forum, 2018. *The Future of Jobs Report*.

[23] www.maplesoft.com

[24] www.wolfram.com/mathematica

INDEX OF AUTHORS