DOI: 10.26314/GARR-Conf19-proceedings-02

STEM Training: preparing teachers to integrate technology and problem solving in the curriculum

Alice Barana[1], Stefania Barsottini[2], Cecilia Fissore[1], Marina Marchisio[1]

[1] Università di Torino, [2] Liceo Scientifico Statale "Galileo Ferraris" di Torino

Abstract. This paper presents and discusses the design and experimentation of a teacher training course on a set of digital and methodological tools aimed at enhancing the teaching and learning of STEM in a problem solving perspective at secondary school level. The course included face-to-face lessons, online meetings, assignment submissions, group-work, laboratories, and the application of the methodologies learned in the classroom. It was attended by 39 teachers in the 2017/2018 school year. Data about appreciation and effectiveness of the training modalities and the perceived usefulness of the proposed methodologies for learning, collected through questionnaires, are analyzed and discussed, with the purpose of gaining insights into how to prepare teachers to integrate technology and problem solving in the curriculum.

Keywords. Advanced Computing Environment, Automatic Assessment, Problem Posing and Solving, STEM Education, Teacher Training, Digital Learning Environment.

1. Introduction and theoretical framework

In STEM (Science, Technology, Engineering, Mathematics) education, even at secondary level, an approach based on interdisciplinary problem solving is highly recommended: it consists of using real-world relevant problems as core units, around which meaningful contents can be developed. This teaching method facilitates the development of disciplinary competences and soft skills, such as teamwork, self-regulation and problem-solving attitude, which are more and more important for employment. Digital technologies enable students to tackle relevant problems, as they can support data analysis, modeling and exploration (Carreira et al., 2016).

Our research group, who works on digital education at the University of Turin, proposes a set of technological and methodological tools aimed at enhancing the teaching and learning of STEM in a problem solving perspective:

- the use of an Advanced Computing Environment (ACE) for problem solving. An ACE is a system able to perform numeric and symbolic computation, ge-ometric visualization in 2 and 3 dimensions, embedding of interactive com-ponents and programming (Barana et al., 2017a);
- formative assessment with an Automatic Assessment System (AAS). In par-ticular, we propose the use of contextualized tasks with an AAS, whose ques-tions are based on algorithms which support the creation of formulas, graphs, random parameters and open mathematical answers automatically assessed for their equivalence to the correct solution. Immediate and inter-active feedback elicit the development of problem solving

strategies (Barana et al., 2018);
- the integration of interactive materials into a Digital Learning Environment (DLE), where students can practice teamwork, self and peer assessment in a learning community. Italian teachers, whose average age is among the oldest in Europe, are not used to encompassing these methodologies in teaching: they need to be properly trained in order to efficiently use innovative technologies in their daily practice. One of the most widespread models for training teachers to integrate technology into teaching is the TPACK (Technological, Pedagogical And Content Knowledge) model. It suggests to assemble three kinds of knowledge in teacher training: the technical use of the tools, the pedagogical aspects related to learning with technologies, and the disciplinary sphere of knowledge (Voogt & McKenney, 2017). We believe that a deep knowledge is certainly necessary, but not sufficient in order to prepare teachers to actually integrate the technology in their lessons. They need support when putting into practice what they learned, and reflection on practice in order to analyze their actions and improve their methods. They need to feel assisted, by experts and by colleagues, they need to fill part of a community they can rely on.

2. Methodology

Bearing this framework in mind, we designed a teacher training course for STEM secondary school teachers, called "STEM TRAINING", on the use of the technological and methodological set of tools above mentioned in interdisciplinary problem solving activities. The training course was shaped according to the model of teacher training developed by our research group (Barana et al., 2017b). It includes face-to-face lessons, online meetings, assignment submissions, group-work, laboratories, and the application of the methodologies learned in the classroom. The structure of the course is the following:

- 5 face-to-face weekly meetings lasting 3 hours each, held by trainees who in-troduced teachers to problem posing, problem solving, the creation of a digi-tal environment for students, the use of an ACE for problem solving, forma-tive assessment with an AAS. During the meetings, teachers could work, in-dividually or in groups, towards the creation of didactic materials. After each meeting, teachers had to submit a didactic material related to the topic of the meeting, to be used with their students;
- a virtual community of practice was created in an e-learning platform where teachers could collaborate in the creation of digital materials, have access to the training materials and ask for the tutors' support;
- 10 weekly online meetings, lasting one hour each, aimed at deepening the topics dealt with in the course. The meetings were held through a web-conference tool which allowed tutors to share their desktop and teachers to interact through voice and chat;
- 10 afternoon laboratories, lasting 3 hours each, on specific disciplinary or in-terdisciplinary topics, such as Physics and Science experiments, program-ming languages, data base management systems or virtual simulation labs;
- experimentation of the materials produced according to the methodologies presented with the teachers' classes.

STEM TRAINING was activated in the 2017/2018 school year, from November to May. It was promoted by ReLiSPi, the scientific high schools network of Piedmont, but it was open to teachers of all lower and upper secondary schools.

Teachers could attend the different parts of the course according to their interests; at the end of the course they received a certification testifying the number of hours dedicated to the training. Time spent in asynchronous work was taken into account as well: each submission of didactic materials (those required after the face-to-face meetings) accounted for 3 training hours, while the experimentation of each activity with the class accounted for 5 hours.

Before and after each training part, teachers were asked to fill in brief questionnaires, inquiring about the appreciation and effectiveness of the training modalities and the perceived usefulness of the proposed methodologies for learning. There was room for reflecting about classroom episodes, both through the questionnaires' items and in the online forums, where teachers could share their experiences and discuss them.

3. Results and conclusions

39 teachers enrolled in the course; 5 of them taught Mathematics and Science at lower secondary schools while the others taught different STEM subjects at upper secondary schools, including Mathematics, Physics, Science and Technical disciplines; moreover, 2 Philosophy teachers joined the course, as they were interested in the scientific approach to problem solving and in interdisciplinary issues.

Most of the teachers regularly attended the course's activities; the average number of training hours certified at the end of the course was 37.16 with a standard deviation of 18.20, ranging from 6 (a couple of teachers only attended 2 face-to-face meetings) to 67 (the most assiduous attenders). Data from the questionnaires show that they largely appreciated the training modalities (they evaluated them with 4 points out of 5 in a Likert-scale), in particular working with teachers of other disciplines and the possibility to create and share teaching materials. After experimenting the innovative methodologies with their students, the teachers assessed in a Likert scale from 1 to 5 the effectiveness of these kinds of activities in relation to several didactic purposes. It resulted that the DLE was considered useful to propose problems and exercises (mean: 4.2), to increase students' motivation (4.0) and their interest in studying (3.8). The ACE was considered effective especially to better understand the contents (3.7) and to develop competence (3.8), while the AAS to provide students with personalized feedback (4.3) and increase their awareness of their abilities (4.2). Problem posing and solving was appreciated for helping students develop reasoning and abstraction capabilities (4.5), critical thinking (4.3) and teamwork skills (4.3).

References

Barana, A., Conte, A., Fioravera, M., Marchisio, M., & Rabellino, S. (2018), A Model of Formative Automatic Assessment and Interactive Feedback for STEM, Proceedings of 2018 IEEE 42nd Annual Computer Software and Applications Conference (COMPSAC), 1016–1025.

Barana, A., Fioravera, M., & Marchisio, M. (2017a), Developing problem solving competences through the resolution of contextualized problems with an Advanced Computing Environment, Proceedings of the 3rd International Conference on Higher Education Advances, 1015–1023.

Barana, A., Fioravera, M., & Marchisio, M. (2017b), Teacher training: A model for introducing innovative digital methodologies for learning Mathematics, Proceedings of the 3rd International Conference on Higher Education Advances, 608–616.

Carreira, S., Jones, K., Amado, N., Jacinto, H., & Nobre, S. (2016), Youngsters Solving Mathematical Problems with Technology, Springer.

Voogt, J., & McKenney, S. (2017), TPACK in teacher education: Are we preparing teachers to use technology for early literacy?, Technology, Pedagogy and Education, 26(1), 69–83.

Authors

Alice Barana - alice.barana@unito.it

Alice Barana is graduated in Mathematics and a PhD student in Mathematics Education at the Department of Mathematics of the University of Turin. She is also a secondary school teacher of Mathematics. Her research deals with innovative methodologies for learning STEM subjects based on the use of digital learning environments and automatic assessment as means to improve learning and self-regulation. She joins several research projects on e-learning, digital education, school and academic success.

Stefania Barsottini - dirigente@liceogalfer.it

Stefania Barsottini is the head teacher of Liceo Scientifico Galileo Ferraris of Turin. She bases the management of her school on innovation and digitalization, promoting several activities aimed at improving disciplinary and cross-cutting competences, in collaboration with the University of Turin and other companies and institutions. She is the coordinator of ReLiSPi, the scientific high school network of Piedmont, which organizes actions of teacher training and innovative projects for students.

Cecilia Fissore - cecilia.fissore@unito.it

Cecilia Fissore is graduated in Mathematics and she is a PhD student in Digital Humanities at the University of Turin and Genoa. She collaborates on numerous research projects and she studies innovative methodologies for STEM education: Virtual Learning Environment for collaborative learning; Advanced Computing Environment for problem solving and Automated Assessment with interactive feedback. She has experience in the design and the management of teacher training courses.

Marina Marchisio - marina.marchisio@unito.it

Marina Marchisio is Professor of Mathematics at the University of Turin, Department of Molecular Biotechnology and Health Sciences. Her research domain is Digital Education, in particular teaching and learning STEM disciplines with new technologies. She is the scientist-in-charge of the Italian Ministry of Education's Project Problem Posing and Solving and the coordinator of several Projects of the University of Turin for digital university guidance, e-learning, school and academic success.