OPEN PROFESSIONAL DEVELOPMENT OF MATH TEACHERS THROUGH AN ONLINE COURSE

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ABSTRACT

The professional development of teachers is a task recognized by the European parliament and pursued by many institutions, both national and international ones. The support to teachers in STEM disciplines was one of the aims of the Erasmus+ SMART (Science and Mathematics Advanced Research for good Teaching) project, born in a European context, which developed as its main intellectual output two open online courses called Mathematical Modelling and Observing, Measuring and Modelling in Science, in order to help teachers in their continuous professional development. Both courses contain interactive problem-based materials ready to be downloaded, modified, used in the classroom and redistributed to the community. This paper gives an overview of the structure of the course Mathematical Modelling and analyzes its instructional quality, taking into account some measurables obtained in two years of operativity.

KEYWORDS

Continuous Professional Development, Digital Education, E-learning, Mathematical Modelling, Problem Solving, Teacher Training

1. INTRODUCTION

The training of teachers, especially in disciplines such as Science, Technology, Engineering and Mathematics (STEM), is essential for the development of society in Europe. In this respect, in 2006, the EU member states developed the "key competences for all" as part of their learning strategies and "Key competences for Lifelong Learning – A European Reference Framework" was approved as Recommendation of the European Parliament and the Council (European Parliament and Council, 2006). These policies, shared by the community, spread in all European countries. These guidelines were taken into account in Italy through a national action, born in 2012, involving secondary school teachers of STEM disciplines, called the "Problem Posing and Solving" project (Brancaccio et al., 2015b, 2014; Demartini et al., 2015, 2013). In this context, the European Erasmus + SMART Project was born. SMART, which stands for "Science and Mathematics Advanced Research for good Teaching", was coordinated by the "Carlo Anti" Italian high school in cooperation with an international partnership composed of other vocational schools, universities and corporate representatives of the countries: Italy, Germany, Hungary, the Netherlands and Sweden. This large partnership aims at developing initiatives addressing different fields of education and training and at promoting innovation, the exchange of experiences and know-how between different types of organizations. (Brancaccio et al., 2015a, 2016).

This project has many different aims: the first one is to improve professional competences of teachers and to support innovation in teacher training system. Secondly, another objective is to develop skills which can be used in order to contribute to a cohesive society, in particular to increase opportunities for learning mobility and strengthening cooperation between the world of education and training and the world of work, formulating and solving complex problems autonomously, consciously and constructively. Finally, yet importantly, one last task is to provide teachers with an online environment where to find teaching materials that are validated and ready for use in the classroom.

The project operated in these directions through pedagogical solutions and innovative practices based on the new computer and multimedia technologies in order to provide tools and methodologies to facilitate the acquisition of STEM skills - mathematical competence and basic competences in Science and Technology. All those involved took advantage of discussion and sharing with European partners, and of the introduction of advanced technological tools in the teaching of Mathematics and Science to support learning.

The expected results arising from this experience are the definition of common educational models, the development of a European database on training needs, the development of a European database containing Best Practices, the implementation of a dedicated international website report on the results of the experimentation of laboratory modules, the delivery of two open online courses for teachers: one called "Mathematical Modelling" for teachers of Mathematics, and one called "Observing, Measuring and Modelling in Science" for teachers of Physics and Science.

This paper analyzes and discusses the open online course Mathematical Modelling both from the perspective of structure, of organization of resources, instructional quality, and from the point of view of measurables obtained in two years of operativity. Section 2 explains the state of the art of teacher training and instructional design in different contexts, especially the online ones. Section 3 presents the methodology adopted for the analysis of the open online course Mathematical Modelling. Section 4 and 5 present the results and the discussion of the outcomes of the analysis.

2. STATE OF THE ART

Teacher training play a very important role in the development of good practices in schools and in many other contexts of contemporary society. It is clear that teachers need a follow-up during their first years of work. That is why Murray and Male (Murray and Male, 2005) analyzed the path of 28 new teacher educators for their first three years. The study shows that, despite the previous successful teaching careers. It took them between two and three years to adapt to their new professional profile.

Teacher training is usually given in person, even though online contexts seem to be the most suitable according to the condition of teachers, who work fulltime at school and find it hard to attend scheduled meetings (Barana et al., 2018a). With a blended modality, teachers can follow synchronous online meetings and interact with the tutors in an asynchronous way, sharing materials in a virtual community, which is peer supported and facilitates the building of new professional competences and knowledge.

The online components become essential when teacher work in very distant or rural areas, not easy to reach (Eaton et al., 2015): with this approach teachers are motivated in using technology in the classroom, with a positive effect on students, too. It is thus very important to take care of all the needs of students and teachers with careful planning. In (West and Jones, 2007), the authors prepared a framework to assist people who want to integrate technology and teacher training programs. Among the many tools available for online support, Fry (Fry, n.d.) found a discussion board and compressed video sessions to be effective in their supportive role. Beyond these basics, for STEM disciplines there is plenty in the literature about the use of an Advanced Computing Environment (ACE) (Marchisio et al., 2017). One tool which is known to be very effective and well-integrated with other tools is the Maple suite, which, besides the powerful computer engine, allows us to use an interactive online worksheet player and integrates with the Automatic Assessment System (AAS) Möbius (Barana et al., 2018b). Apart from teacher training, this environment has been proved to be effective with students, because of its interactive components and its graphics in two and three dimensions (Barana and Marchisio, 2016).

It is important then to consider Massive Open Online Courses (MOOCs) to be delivered for teacher training, which is one of the outcomes of the SMART project. The University of Torino has a long history of e-learning about e-learning with many online projects. The basis for the development of SMART mainly follows two experiences. The already mentioned “Problem Posing and Solving” project, which deals with Mathematics and Italian teachers in high school, involved in a community of practice with online meetings and asynchronous support provided by tutors and “Orient@mente” (Barana et al., 2016, 2017a), which provides open online courses for university guidance and realignment courses, created to support students in the transition from high school to university, in particular to fill the knowledge gaps in the STEM disciplines.

The design of an online course has several factors to take into considerations. In the last few years a discipline that is valid for traditional teaching as well has been associated more and more to online materials: Instructional Design (ID). According to the current situations, many MOOCs are well-packed, but they have poor instructional quality: in (Margaryan et al., 2015) the author analyzed many online courses hosted in the most famous platform, taking into account instructional parameters.

3. METHODOLOGY

The methodology of analysis of the MOOC "Mathematical Modelling" passes through several steps:

- exploring the structure and the number of users who subscribed to the course;
- observing the measurables of the course: how many problems and materials have been posted, how big the repository of question is;
- studying the materials from the Instructional Design point of view.

We decided to use the method adopted in (Margaryan et al., 2015), called CourseScan, in order to detect the presence or the absence of the main principles of effective learning: problem-centeredness, activation, demonstration, application, integration, interactivity and other further properties, like collective knowledge, collaboration, differentiation, authenticity, feedback. Moreover, teachers attending "Mathematical Modelling" were frequently asked to fill in a questionnaire about their previous experience, the expectations and their improvements: this helped to scan the usability of the course.

4. RESULTS

4.1 Structure

The course is available at https://opensmart.miurprogettopps.unito.it, whose homepage is depicted in Figure 1.

Figure1. Two captures from the platform homepage

It is an instance dedicated to the project of a Moodle platform (https://moodle.org) and it is entirely in English, managed by the University of Turin. The platform is integrated with various tools useful for learning STEM disciplines, in particular the Advanced Computing Environment Maple (https://www.maplesoft.com/) and the Automatic Assessment System Moebius Assessment (https://www.digitaled.com). The University of Turin has a great experience in the development and use of the Moodle platform for teaching (Barana et al., 2017b, 2017c). The open online course is designed for teachers of Mathematics, but access is free through any social media, so all interested people can access it.

The course is divided into 11 sections. The first module contains one section and this part is the introduction to the course. The second module contains one section about the methodology adopted by the course, namely problem posing and problem solving, including a reflection on what these competences are and how to activate them in the students. The three following modules are devoted to self-training in: Virtual Learning Environment, Advanced Computing Environment, and Automatic Assessment System, three tools considered important for teaching and learning mathematics. Then there are an explanatory and four Topic modules, which contain ready-to-use learning materials, about the four main areas of Mathematics: Quantity, Space and shape, Change and relation, Uncertainty (see Figure 2).

Uncertainty

Topic Uncertainty:

- Production of data (valid methods for measuring certain features; statistic survey)
- Data analysis, their visualization and graphic representation; concept of mean and median
- Probability

Problem	Assignment	Required in advance	Contents	Abilities	Competences	Key ideas
Who is right?		basics of statistics	Bivariate statistics	Conducting a statistic survey, organising data and representing it in tables, computing frequence and contingence indexes	Distinguishng and organising collected data, choosing a strategy for the analysis and drawing conclusion from the results	data analysis, production of data
The birthday paradox		Elementar probability	Conditional probability, decomposition formula, Bayes' theorem	Applying formulas of probability theory	Understanding the dependence between events, individuating the laws of probability to apply, formalising a real situation	Probability

Figure 2. A glance on the topic Uncertainty

Finally, the last part is a course evaluation module. The user can freely decide which sections to follow. Perhaps a conceptual map may facilitate a better understanding of the possible prerequisites and guide the users towards the path they wish to take. Probably a presentation of the 11 sections through Moodle grid mode would make it easier to follow the course. The open on-line course is all written with Easy Reading (http://www.easyreading.it/en/), a certified font for dyslexics, which ensures high inclusiveness.

4.2 Measurables

Up to the 21st January, 253 users have self-enrolled to the course, most of them from Italy. The number of users at the moment is not particularly high, but probably many secondary school teachers in European countries have not heard about the existence of the course through official channels. In Italy the general manager of the Direzione generale per gli ordinamenti scolastici e la valutazione del sistema nazionale di istruzione [1] has issued a note on the opening of online courses to all managers of secondary Italian schools. Probably for this reason, the number of Italian users is higher. Certainly, a further presentation of the courses could be carried out in order to reach the professors of the STEM disciplines on a nationwide basis. The course is composed by 111 activities and interactive resources, 37 of which are assessment activities of two different types. Those of the first type are formative assessment activities that the teacher can use with their students related to the interactive materials of the four areas of High School Mathematics: Quantity, Space and shape, Change and relations, Uncertainty. They are prepared with Moebius assessment because it allows immediate and interactive feedback. The tests contain algorithmic questions of different types (multiple choice, true or false, insert a

[1] The Italian Ministry of Education

formula, numerical, matching ...). Some of them are adaptive for a personalized teaching. The Maple mathematical engine behind Moebius Assessment allows recognizing the accuracy of a mathematical formula independently of the formulation chosen by the student among the infinite possibilities (Figure 3).

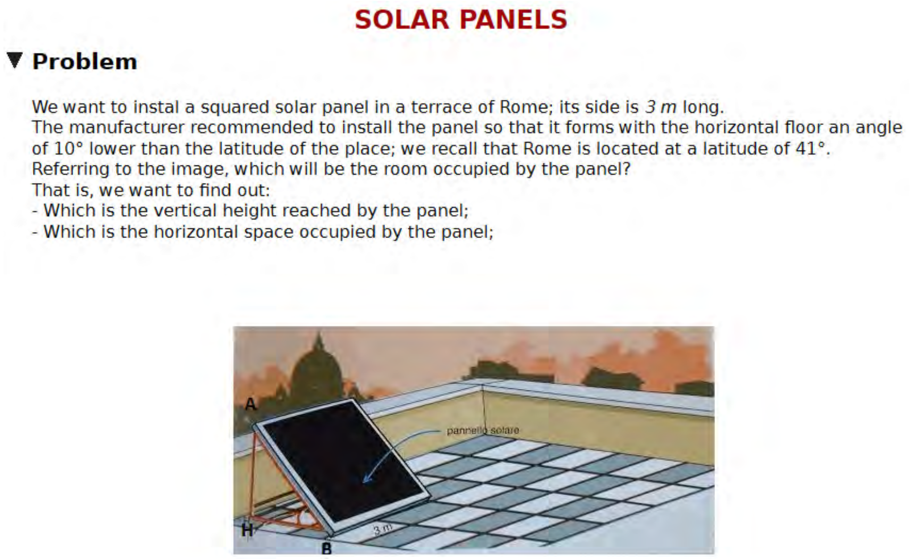

Figure 3. A problem-based approach with Maple

The evaluation activities of the second type are 10 questionnaires, which allow the user to receive feedback on the course. The course also contains videos, but it does not contain animations. The files prepared with Maple contain completely solved contextual problems, discussed through interactive components, which can be used both to develop precise mathematical skills and problem-solving skills (Figure 4).

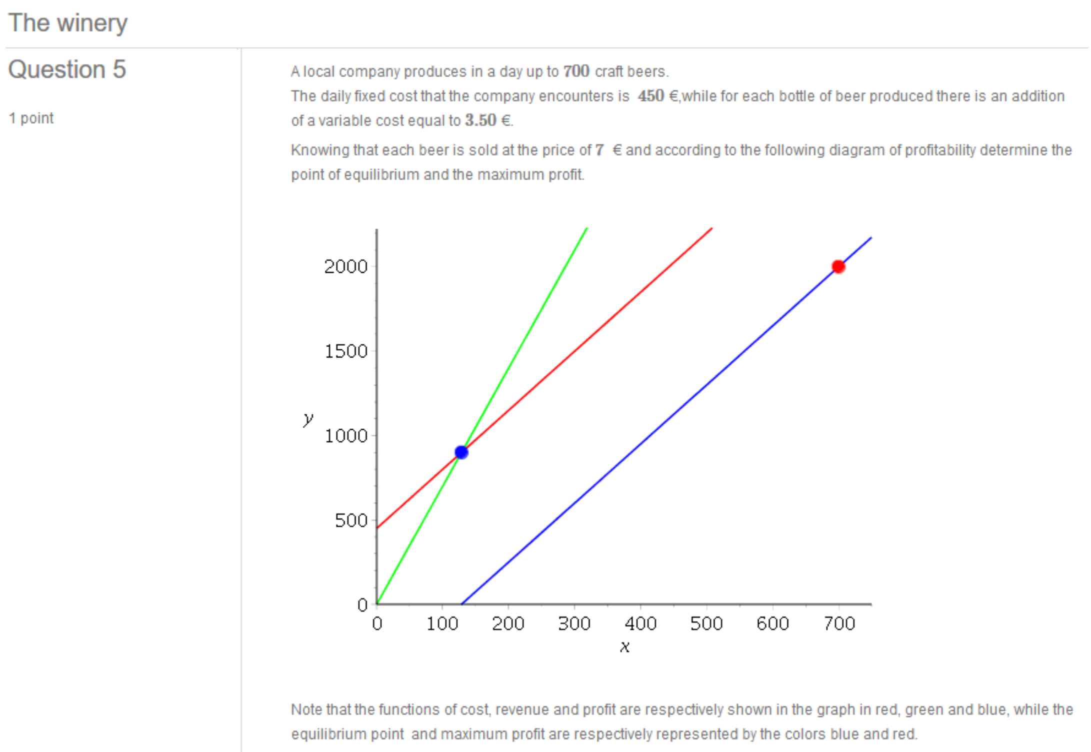

Figure 4. A problem-based approach with Möbius

For each problem, the prerequisites are declared as well as the knowledge, skills and competences that are to be developed. The variety of resources present in the course ensures a high level of effectiveness and usability. The materials were created under the Creative commons license.

From the teacher's point of view, only 18 users completed the entire course. Many users only attended a part of the course, only accessing activities deemed useful and interesting for their teaching. The completely open character of this course allows you to move in a targeted way. From the questionnaires, it emerged that 52% of teachers particularly appreciated the Problem Posing and Solving methodology proposed. They said that it was effective when applied in class, because it improved student motivation, as well as because of visualization of concepts and its connection to real life. 44% of teachers used learning materials from the course, mainly problems, with good evaluation of the materials both from the teacher's and from students' side. The teachers of the schools participating in the project with their students have tested the proposed materials. This has certainly increased the teaching effectiveness of the materials.

4.3 Instructional Point of View

The course is explained and organized quite well. It is clearly described that the main target of the course are secondary school teachers, even if anyone can attend the course. There is a first section, called "Getting started" that states which the main objectives are. There is also a complete outline of the course, which does not have a fixed but just a recommended structure. It is also specified how to get badges and certificates, and which license the materials hold. About the problem-centered approach, one has to be very precise because it is a course in problem solving and certainly there are many real-life problems, but these are related to the contents that students will face, while a problem-centered approach for teachers would be, for example, how to present a specific topic to the class or which technique to use with respect to the students. It would have been useful to study some successful and unsuccessful cases, what to do and what not to do. It must be recognized that all resource can be re-used in the work place of users and the activities plunge the teacher directly into the knowledge and skill they need for every day's life in the classroom. There are no collaboration activities, due to the nature of the course, which is completely open, and any user can attend lessons at their own pace anytime in the day. All the traits that have been considered delineate a phase of instructional design prior to the implementation of the course. The sections dedicated to learning how to use the Virtual Learning Environment Moodle, the Advanced Computing Environment Maple and the Automatic Assessment System Moebius should be accessible without prerequisites because in this way it is possible to make use of parts aimed to deepen the knowledge without forcing those who are already familiar with those tools to complete the entire required path.

5. DISCUSSION

The presence of an online course for teacher training has been recognized to be useful by its users. The self-training modules helped teachers to develop new skills and competences, from didactics to the use of technology in classroom activities. One of the special features is the permanent availability of online resources. The literature confirms that this experience is in some way unique, since many experiences in teacher training mediated by technology are provided in a blended modality or by means of a MOOC that set the pace and therefore teachers are not always able to attend them for school and family commitments.

It is still to be noted that some adjustments could improve the quality of the course. The navigation through the course in some of its parts is conditional, mediated by the completion of questionnaires, making the navigation more tiring. There is a significant presence of hyper-references to activities, which is beneficial to a nonlinear navigation. The course could be enriched with further interdisciplinary characterization activities to facilitate the dialogue between the STEM disciplines and the other disciplines. In order to make the online course known to more Mathematics teachers, it could be useful to make it available on platforms like Merlot (www.merlot.org) which contains many different open educational resources. In Italy, the course can be a valid tool for implementing CLIL - Content and Language Integrated Learning - which includes teaching some content in a foreign language.

6. CONCLUSION

During the last year, the University of Turin has developed a great experience in open online designing courses in several areas. For example, 20 full online university modules were prepared with the project start@unito (Bruschi et al., 2018). This competence could be used to improve the Mathematical Modelling course to further increase its effectiveness. Mathematical Modelling could also foster the development of a similar course of continuous training for professors in Mathematics and more generally in STEM disciplines at the university, to professors that teach to students enrolled in degree courses other than Mathematics. The latter are often to be motivated and are more interested in applications than theory.

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REFERENCES

Barana, A., Bogino, A., Fioravera, M., Marchisio, M., Rabellino, S., 2017a. Open Platform of self-paced MOOCs for the continual improvement of Academic Guidance and Knowledge Strengthening in Tertiary Education. J. E-Learn. Knowl. Soc. Vol 13 No 3 2017 EMEMITALIA Conf. 2016 109–119. https://doi.org/10.20368/1971-8829/1383

Barana, A., Bogino, A., Fioravera, M., Marchisio, M., Rabellino, S., 2016. Digital Support for University Guidance and Improvement of Study Results. Procedia - Soc. Behav. Sci. 228, 547–552. https://doi.org/10.1016/j.sbspro.2016.07.084

Barana, A., Brancaccio, A., Esposito, M., Fioravera, M., Fissore, C., Marchisio, M., Pardini, C., Rabellino, S., 2018a. Online Asynchronous Collaboration for Enhancing Teacher Professional Knowledges and Competences. 14th Int. Sci. Conf. ELearning Softw. Educ. https://doi.org/10.12753/2066-026x-18-023

Barana, A., Conte, A., Fioravera, M., Marchisio, M., Rabellino, S., 2018b. A Model of Formative Automatic Assessment and Interactive Feedback for STEM, in: Proceedings of 2018 IEEE 42nd Annual Computer Software and Applications Conference (COMPSAC). Presented at the 2018 IEEE 42nd Annual Computer Software and Applications Conference (COMPSAC), IEEE, Tokyo, Japan, pp. 1016–1025. https://doi.org/10.1109/COMPSAC.2018.00178

Barana, A., Fioravera, M., Marchisio, M., Rabellino, S., 2017b. Adaptive Teaching Supported by ICTs to Reduce the School Failure in the Project "Scuola Dei Compiti," in: Proceedings of 2017 IEEE 41st Annual Computer Software and Applications Conference (COMPSAC). Presented at the 2017 IEEE 41st Annual Computer Software and Applications Conference (COMPSAC), IEEE, pp. 432–437. https://doi.org/10.1109/COMPSAC.2017.44

Barana, A., Marchisio, M., 2016. Dall'esperienza di Digital Mate Training all'attività di Alternanza Scuola Lavoro. MONDO Digit. 15, 10.

Barana, A., Marchisio, M., Bogino, A., Operti, L., Fioravera, M., Rabellino, S., Floris, F., 2017c. Self-Paced Approach in Synergistic Model for Supporting and Testing Students, in: Proceedings of 2017 IEEE 41st Annual Computer Software and Applications Conference (COMPSAC). Presented at the 2017 IEEE 41st Annual Computer Software and Applications Conference (COMPSAC), IEEE, Turin, pp. 407–412. https://doi.org/10.1109/COMPSAC.2017.211

Brancaccio, A., Demartini, C.G., Marchisio, M., Pardini, C., Patrucco, A., 2014. The PP&S computer science project in school. Mondo Digit. 13, 565–574.

Brancaccio, A., Esposito, M., Marchisio, M., Pardini, C., 2016. L'efficacia dell'apprendimento in rete degli immigrati digitali. L'esperienza SMART per le discipline scientifiche. MONDO Digit. 15, 10.

Brancaccio, A., Marchisio, M., Meneghini, C., Pardini, C., 2015a. Matematica e Scienze più SMART per l'Insegnamento e l'Apprendimento. MONDO Digit. 14, 8.

Brancaccio, A., Marchisio, M., Palumbo, C., Pardini, C., Patrucco, A., Zich, R., 2015b. Problem Posing and Solving: Strategic Italian Key Action to Enhance Teaching and Learning Mathematics and Informatics in the High School, in: Proceedings of 2015 IEEE 39th Annual Computer Software and Applications Conference. Presented at the 2015 IEEE 39th Annual Computer Software and Applications Conference (COMPSAC), IEEE, Taichung, Taiwan, pp. 845–850. https://doi.org/10.1109/COMPSAC.2015.126

Bruschi, B., Cantino, V., Cavallo Perin, R., Culasso, F., Giors, B., Marchisio, M., Marello, C., Milani, M., Operti, L., Parola, A., Rabellino, S., Sacchet, M., Scomparin, L., 2018. Start@unito: a Supporting Model for High School Students Enrolling to University. Presented at the IADIS International Conference Cognition and Exploratory Learning in Digital Age 2018, pp. 307–312.

Demartini, C.G., Bizzarri, G., Cabrini, M., Di Luca, M., Franza, G., Maggi, P., Marchisio, M., Morello, L., Tani, C., 2015. Problem posing (& solving) in the second grade higher secondary school. Mondo Digit. 14, 418–422.

Demartini, C.G., Marchisio, M., Mezzalama, M., Pardini, C., Patrucco, A., 2013. The PP&S100 Project: Process Control as an Information System Instance. 50 Congr. Naz. Aica 2013 Front. Digit. Dal Digit. Divide Alla Smart Soc. Congr. Naz. Aica 2013 Front. Digit. Dal Digit. Divide Alla Smart Soc. 10.

In DigitalEd | Online Courseware and Assessment Platform for STEM Courses. Retrieved from https://www.digitaled.com

In EasyReading. Retrieved from http://www.easyreading.it/en/

In Maplesof – Software for Mathematics, Online Learning, Engineering https://www.maplesoft.com/

In MERLOT. Retireved from https://www.merlot.org/merlot/index.htm

In Moodle - Open-source learning platform | Moodle.org. Retrieved from https://moodle.org/

Eaton, S.E., Dressler, R., Gereluk, D., Becker, S., 2015. A Review of the Literature on Rural and Remote Pre-Service Teacher Preparation With a Focus on Blended and E-Learning Models. http://dx.doi.org/10.11575/PRISM/31625

European Parliament and Council, 2006. Recommendation of the European Parliament and the Council of 18 December 2006 on key competences for lifelong learning.

Fry, S.W., 2006. A Technology Supported Induction Network for Rural Student Teachers 10.

Marchisio, M., Rabellino, S., Spinello, E., Torbidone, G., 2017. Advanced e-learning for IT-Army officers through Virtual Learning Eenvironments. J. E-Learn. Knowl. Soc. Vol 13, 59–70. https://doi.org/10.20368/1971-8829/1382

Margaryan, A., Bianco, M., Littlejohn, A., 2015. Instructional quality of Massive Open Online Courses (MOOCs). Comput. Educ. 80, 77–83. https://doi.org/10.1016/j.compedu.2014.08.005

Murray, J., Male, T., 2005. Becoming a teacher educator: evidence from the field. Teach. Teach. Educ. 21, 125–142. https://doi.org/10.1016/j.tate.2004.12.006

West, E., Jones, P., 2007. A Framework for Planning Technology Used in Teacher Education Programs that Serve Rural Communities. Rural Spec. Educ. Q. 26, 3–15. https://doi.org/10.1177/875687050702600402