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articoli

The augmented reality in the professional development: a systematic map

La realtà aumentata nello sviluppo professionale: una rappresentazione sistematica della letteratura

Sergio Miranda[a], Antonio Marzano[b,1]

[a] *University of Salerno, semiranda@unisa.it*
[b] *University of Salerno, amarzano@unisa.it*

Abstract

The augmented reality is an emerging and constantly evolving theme in the educational field. Technological applications enrich information with sensorial data, adding new digital resources from a mobile device or from vision devices. Reliable studies report how the structuring of a hybrid, virtual and real space promotes *augmented* learning of an experiential and participatory nature. This paper represents the state of art of literature, with the reference to the augmented reality and the professional development. The objectives of this systematic map are the following: identifying the main areas or professional sectors that use the augmented reality; identifying the topics most addressed in the selected proposals and investigating how to use this technology. Despite the objective limits, the analysis of the evidences gives an overall positive picture of the potential offered by technological applications in the training courses.

Keywords: augmented reality; professional development; systematic review; learning.

Sintesi

La realtà aumentata rappresenta un tema emergente e in continua evoluzione in campo educativo. Le applicazioni tecnologiche arricchiscono di informazioni il dato sensoriale, traendo nuove risorse digitali da un dispositivo mobile o da dispositivi di visione. Studi accreditati riportano come la strutturazione di uno spazio ibrido, virtuale e reale, favorisca un apprendimento *aumentato*, di natura esperienziale e partecipativo. Il lavoro propone una rappresentazione sistematica della letteratura internazionale con riferimento alla realtà aumentata ed allo sviluppo professionale. Gli obiettivi-guida della revisione sono stati orientati ad individuare i principali ambiti o settori professionali che ricorrono alla realtà aumentata, a cogliere i topic maggiormente affrontati nelle proposte selezionate e a indagare le modalità di utilizzo della tecnologia. Pur nei limiti oggettivi, dall'analisi delle evidenze scaturisce un quadro complessivamente positivo delle potenzialità offerte dagli applicativi tecnologici nei percorsi formativi.

Parole chiave: realtà aumentata; sviluppo professionale; revisione sistematica; apprendimento.

[1] Even though the authors have jointly conceived the paper, Marzano edited par. 1 and par. 2, Miranda edited par. 3. Both the authors wrote par. 4.

1. Introduction

Among the emerging research lines in the field of educational technology, there is the Augmented Reality (AR), a technological system that allows a consolidated perception of the environment, thanks to the mixture of virtual and real contents, digitally manipulated (Milgram & Kishino, 1994). It is often assimilated to virtual reality, an artificial environment in which to immerse the user. The AR, however, while increasing our perceptive abilities, does not replace the physical reality but extends and integrates it with additional information drawn from the virtual (Mann, 2002). To create an AR system, you need a dedicated software, characterized by different devices, functional for rendering and tracking in order to trace the real objects, placing them in connection with the virtual content in real time. AR is a hybrid space that includes all the experiences – digital and real, public and private – experienced by the subject in his daily life (Riva, 2012). De Kerckhove (2010) calls it *an epochal change* for the new generations, dominated by innovative ways of communication, interaction and entertainment, to increase sensory perception thanks to modern digital devices (Bronack, 2011). *The sea of data and information* presupposes the need to review the didactic action or to imagine learning, transmission and conservation strategies of knowledge capable of containing the probable risks and optimizing the concrete opportunities of an unpublished AR (Ferri & Moriggi, 2016).

The advantages of the AR in educational processes refer in particular to the development of creativity and the construction of meanings (Diegmann, Schmidt-Kraepelin, Van Den Eynden, & Basten, 2015). These advantages include possible improvements in the learning contexts, as the implementation of the AR allows an innovative reading of the specific discipline enriching with animations or details, topics of mathematics or physics (Bini, 2017). The large amount of information gives rise to an extended perception of reality, resulting in a quantum correlation (Guazzaroni, 2015), or a tangle of real and virtual elements. This coexistence creates new spatial relationships with synthetic objects, favouring authentic, situated learning of a practical nature (Wu, Lu, & Chang, 2017). To structure an AR experience, it is necessary to have a mobile device that fits between the perceptive organs of the learner and the visible stimulus present in the environment. In this way, the AR mobile learning mediates between the learning subject and the interpretation of the cultural content (Petrucco & Agostini, 2016). In this sense, new and creative methods are experimented and the AR is an active technology that offers opportunities for immersion and involvement on the cognitive, emotional and relational level (Panciroli & Macauda, 2018). Beyond the possible potentialities encountered, an AR system could determine cognitive overload and dispersion if not properly reinforced by reflective and abstract moments (Bonaiuti, Calvani, Menichetti, & Vivanet, 2017), in support of an effective cognitive experience.

2. Objectives and research method

A systematic map of the scientific literature was depicted to understand how the AR fits into vocational training and to report on current research advances in the field (Grant & Booth, 2009). The survey method outlined is based on the analysis of the results of primary studies (Cooper, Hedges, & Valentine, 2009), which refers to the principles of systematicity and rigor of the Evidence Based Education (EBE) perspective. According to this orientation, a reliable and spendable knowledge is reached in both policies and operational teaching practices (Calvani, 2013) since it often emerges that the research

resembles declarations of faith rather than scientific reports (Pellegrini & Vivanet, 2018) and therefore the intent is precisely to bring research closer to teaching practices. By following the PRISMA approach (Moher, Liberati, Tetzlaff, Altman, & The PRISMA Group, 2009), the phases that characterize our study are:

- *identification* of papers, after having identified research application, investigation protocol and databases of sources;
- *screening* of papers, by getting or excluding records on established criteria;
- *eligibility* of papers, by going into details of full-text available;
- *included* papers are treated into a meta-analysis, are compared to each other in order to summarize the results.

This approach has made it possible to direct research from a corpus of generic knowledge to more specific details (Pellegrini & Vivanet, 2018). The main objective of this work is to conduct a narrative analysis of the literature on the use and potential of AR in the various disciplinary fields in the international context.

The guiding questions, at the base of the survey, were the following:

- DG1. What areas are using the AR to enhance training?
- DG2. Which topics emerge from the analysis of the selected proposals?
- DG3. How does the AR fit into professional development?

To answer these questions, research has been carried out on the two main citation databases: Scopus and Web of Science (WoS). The searches were carried out through two queries. Firstly, by using the following queries:

- Q01. *augmented reality* AND *professional development*;
- Q02. *augmented reality* AND *professional development* AND *education*.

Since a few sets of documents were collected, these queries were kept wider by avoiding the AND operator and using the following directly:

- Q1. augmented reality professional development;
- Q2. augmented reality professional development education.

Both queries without any brackets and any logical operators become searches including all terms in a comprehensive logical AND (*augmented AND reality AND professional AND development*).

The Q1 query identified 100 articles in Scopus and 53 in WoS. The Q2 query identified 44 articles in Scopus and 23 in WoS. The choice of the keywords *professional development* and *education* is justified by the fact that the first term reference is made to the path of personal and formative growth, while the second term refers to the set of actions related to training processes and to teaching practices (Ajello, Cevoli, & Meghnagi, 1994). For each database, the research was limited to the publication period from 2014 to 2018, to all types of work (articles in journals, conference proceedings, abstracts, etc.), to the English language[2].

The Figure 1 represents the synoptic table relating to the articles identified and classified on the basis of:

[2] Last consultation of the databases: December 31, 2018.

- year of publication;
- number of jobs identified during the year;
- research topic;
- scientific-disciplinary field.

Year	N.	Wos	Scopus	In common	Topic	Field	Reference
2018	23	8	15	4	Continuous professional development (4)	Medical (2) Engineering (1) Various (1)	- Zhu, Fors, & Smedberg (a;b) - Juraschek, Bueth, Cerdas - Balendr, Komarnytska,, Bloshchynskyi
					Innovative training approach (6)	Engineering (1) Pedagogical (1) Industrial (1) Medical (2) Sciences (1)	- Schiffeler, Abdelrazeq, Stehling, Isenhardt, & Richert - Tham, J., Duin, A. H., Gee, L., Abdelqader, B., McGrath - Issa - Antoniou, & Bamidis - Lima, Beltrame, Niquini, Barbosa, & Davis - Bessa, Santos, & Duarte
					Teacher training (5)	School (2) Engineering (1) Sciences (2)	- Okada, Kowalski, Kirner, & Torres - Velychko, Fedorenko, & Kassim - Zhu & Tang - Lasica, Meletiou-Mavrotheris, Katzis, Dimopoulos, & Mavrotheris - Mavrotheris, Lasica, Pitsikalis
					Student training (4)	Engineering (3) Various (1)	- Nelson & Ahn - Ivanov, Pavlenko, Trojanowska, Samokhvalov, & Bun - Tkachuk, Shchokin, & Tron - Limbu, Jarodzka, Klemke, Wild, & Specht
2017	20	6	14	2	Continuous professional development (4)	Medical (1) Engineering (1) Sanitary (1) Various (1)	- Wang et al. - Zhu & Tang - Umoren & Rybas - Pecina & Sladek
					Innovative training approach (9)	School (1) Nursing (2) geographical (1) engineering (1) Medical (1) Various (3)	- Rezende, Albuquerque, & Ambrosio - Chao et al. - Wu, Lu, & Chang - Chatel & Falk - Nesterov, Kholodilin, Shishkov, & Vanin - HCIBGO - GALA - ICCE
					Survey (1)	Various (1)	- Hein, Jodoin, Rauschnabel, & Ivens - Vasylevska, Podkosova, & Kaufmann - Nobre & Moura - Hu et al.
					Student training (4)	Master (1) Languages (1) engineering (2)	

							- Majgaard
2016	7	2	5	1	Professional development (1)	Various professions (1)	- Antoniac, Pallot, & Pulli
					Innovative training approach (3)	Engineering (1) Various (1) Sciences (1)	- Chin, Lee, & Hsieh - eLEOT (2015) - Craciun & Bunoiu (2016)
					Student training (1)	Computer science (1)	- Hobbs & Holley
					Teacher training (1)	University (1)	- Holley & Howlett (2016)
2015	10	5	5	4	Professional development (3)	Medical (3)	- Buń, Górski, Wichniarek, Hamrol, & Zawadzki - Mitrasinovic et al. - Tarng, Ou, Yu, Liou, & Liou
					Innovative training approach (3)	Engineering (1) Sciences (2)	- Contreras Bravo, Tristancho Ortiz, & Vargas Tamayo - Garrett, Jackson, & Wilson - Crowley et al.
2014	7	2	5	1	Professional development (2)	Medical (2)	- Duxbury - Nifakos, Tomson, & Zary
					Innovative training approach (2)	Various (1) School (1)	- Riva, Waterworth, & Murray - Boulind, Mendez Coca, & Conde Vilar
					Student training (1)	Engineering (1)	- Ayer, Messner, & Anumba

Figure 1. Summary of the papers analysed in the review.

Most of the articles were published in 2017 and 2018, mainly in the engineering and medical fields. The other sectors concern education, scientific and humanistic disciplines, nursing and various professional fields. Among the topics, the use of AR is predominant as an *innovative training approach*, understood in terms of good practice adopted to improve procedures or to implement new techniques and continuous professional development, bringing together the set of studies and research that make use of increased sensory perception to enrich work contexts with a view to lifelong learning. The other topics concern the *teacher training* (initial and in-service) and that of the *students* during the university period or in the moments of school-work alternation.

The next step was to verify how each article dealt with the topic in reference to the set guide questions. It should be noted that of the 55 contributions considered, as reported in Figure 2, not all of them are fully accessible (full text), which is why the content analysis is heterogeneous, given the impossibility to go into the issues beyond the abstract present.

Year	N.	WoS	Scopus	In common	Full texts	Abstracts
2018	23	8	15	4	13	6
2017	20	6	14	2	7	11
2016	7	2	5	1	5	1
2015	10	5	5	4	5	1
2014	7	2	5	1	2	4

Figure 2. Breakdown of full text and abstract articles.

Instead, two contributions that could not be ascribed to the established criteria were excluded. Among the 53 studies examined there are also five Conferences that deal with the subject in different sectors. Below, the flow chart (Figure 3) shows the procedural

process and the relative phases that have characterized the systematic review after defining the inclusion criteria and the Boolean operators.

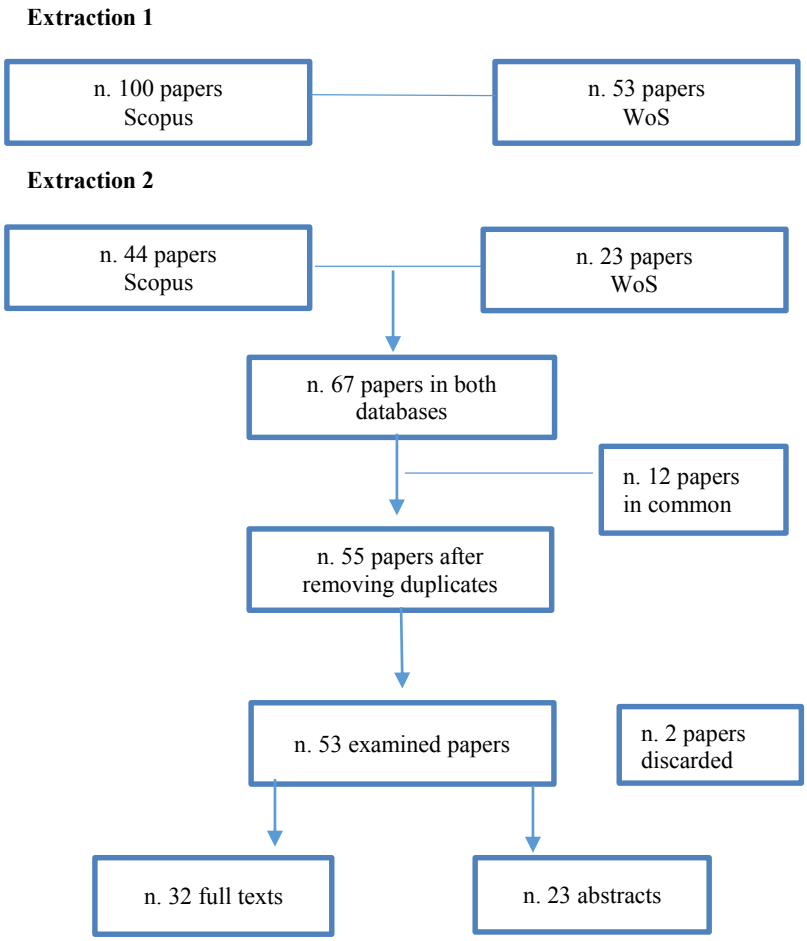

Figure 3. Flow chart of the systematic review.

3. Analysis of the results

The qualitative analysis of the selected studies made it possible to answer the question-guides of the event. With reference to the first question (DG1), Fig.1 shows the placement of the contributions in the context of which they are related. In order to answer the other two research questions (DG2 and DG3), the contents of the four emerging topics, developed in the following paragraphs, were analysed:

- continuous professional development;
- innovative training approach;
- teacher training;
- student training.

3.1. Continuous professional development

In several studies concerning health care, the AR is used as a potential tool for the training of primary care physicians in the conscious use of antibiotics. Zhu, Fors and Smedberg

(2018), through a qualitative approach, based on interviews, proposed the use of an app to eleven doctors from three different health centers, to improve the antibiotic prescription process. From the results that emerged, doctors showed themselves in favor of using this technology. In a previous study, Nifakos, Tomson, and Zary (2014) had already outlined an educational approach with the aid of AR technology to improve antibiotic prescriptions among health professionals. In the US context, the health care system focuses its attention on the training of inter-professional teams that collaborate in patient care. Umoren and Rybas (2017) analysed professional health education through various virtual training models with the aid of simulations and experiences of AR and mixed reality (representations in which both real-world observations with additional information and animations are possible superimposed on the real ones). The study argues that the training process, so structured, can be valid for the development of the team identity and for the success in collaborative inter-professional practice. Wang et al. (2017) use AR as a new application of telemedicine, to address the problem of lack of health care in rural areas. Mitrasinovic et al. (2015), through a systematic review of 71 studies, examined the main uses of smart glasses within the health sector. From the review, it emerges that the instrument has numerous uses but, at the same time, the professionals of the sector highlight the need to improve it for the specialized areas and the surgical sector. Previously, Wood, Lane, Gillespie, Baker, & Rowbottom (2014) publish their contribution about the activation of gynaecological brachytherapy with 3D guidance in a centre in the United Kingdom, while Cosentino, John, and Vaarkamp (2014) describe the use of RA and virtual reality (VR) in radiotherapy. Their system still has high costs, but it generates a realistic 3D effect that allows the effective analysis of cases and the collection of fundamental data for clinical action.

The applications of AR are also widespread in various industrial activities, in which new models and tools are constantly required to increase productivity, creativity and interpersonal communication of workers (Zhu & Tang, 2017).

3.2. Innovative training approach

Another recurring theme refers to the AR as an innovative training approach (Dunleavy & Dede, 2013). The AR helps to improve the effectiveness and attractiveness of the teaching/learning process, allowing to go beyond the classroom lesson, adding useful details to real life scenarios. Chin et al. (2016) noted the willingness of teachers to integrate mobile devices that use AR systems in their future teaching plans. Crowley et al. (2015) describe the creation of a system that, through smartphones and tablets, associates educational content with precise geographical locations, creating a combined space of real and virtual elements. In the same vein, Chatel and Falk (2017) report two case studies that use the AR to refine specific skills.

The study by Tarng et al. (2015) is indicative which refers to the development of a system strengthened by the AR, in support of scientific teaching in the various school orders, returning positive results regarding both participation and learning.

From an experimental point of view, the relationship between AR and learning environments, in which students are called to share and manage knowledge in complex situations (Craciun & Bunoiu, 2016; Schiffeler et al., 2018) must still be verified.

Since Industry 4.0 represents a further step towards industrial automation through new production technologies aimed at improving working conditions and increasing productivity and production quality, the technological applications of the AR are in line

with this trend. For this reason, the professional development paths must be adapted to the demands from the labour market, in order to contrast the inconsistency between the training received and the technological changes (Nesterov et al., 2017). The AR could facilitate the transformation of working contexts with the use of technological infrastructures. In this regard, the studies of Wu et al. (2017) are significant, which show positive and motivating attitudes on the part of the participants.

3.3. Teacher and student training

The introduction of the AR in the disciplines related to applied mechanics (graphic engineering, descriptive geometry) that use 3D graphics in the industrial field is particularly significant (Ivanov et al., 2018). From a methodological point of view, the most used mediators for programming AR games are the video tutorials that replace the paper and the associated problems (Majgaard, 2017). In the field of electronic engineering, for example, the smart glasses of AR may be able to visualize the steps to be followed in a procedure as it is implemented and therefore become an application potential to be used to make teaching and learning design techniques more effective (Zhu & Tang, 2017). The methodological approach of project-based learning, integrated with the AR has been tested in the linguistic and engineering field. In the first case, adopted in foreign language teaching, it promotes language skills and soft skills (Nobre & Moura, 2017); in the second case, used for medical training, it promotes the formation of specific skills such as problem solving or creativity (Hu et al., 2017).

The AR is preferred because it facilitates the link with the outside world, moving the axis from the training environment to the extra-training one (Holley & Howlett, 2016).

The AR is also found in the initial training courses for future teachers or in professional development for in-service teachers. Specifically, some papers (Lasica et al., 2018) report the training program for lower and upper secondary school teachers in the context of the European Erasmus + project (EL-STEM). From the research of Okada et al. (2019) aimed at 18 secondary school teachers, it emerged that AR is useful to promote specific skills in students in making sense of new approaches, implement them and self-evaluating their own practice. The didactic efficacy of AR is also proven by a pilot research project in nursing sciences; in this sector, this technology allows refining practitioners' professional skills during laboratory activities and, in this way, not only is the theory-practice nexus welded but the advantages of the experiential approach are adopted (Garrett et al., 2015).

4. Discussion and conclusions

This paper presents a systematic map on the AR and the professional training. The AR is particularly effective for designing and structuring training courses that involve the overlap of digital content to the perceived reality. This environment, thus enriched, widens the vision of the real datum in support of an increased learning (Gabbari, Gagliardi, Gaetano, & Sacchi, 2017). The aim of this work was to understand how the variety and interdisciplinary nature of the papers in the reference literature deal with the topic from an educational point of view. This justifies the intention to have adopted two generalist databases, in order to draw a broader frame of reference that includes different disciplinary areas. With regard to the first research question (DG1), it was found that the present areas concern with the medical, engineering and scientific fields. With regard to the second question (DG2), the works focus on the topics of continuous professional development,

innovative training approach, teacher and student training. In this sense, it was possible to detect the prevalence of studies or research that deal with the AR within continuous professional development paths or as an educational tool to facilitate specific procedures. In recent years, the AR becomes central in training programs for teachers of scientific disciplines or in student training courses, mainly university students. Finally, with regard to the third question (DG3), from the analysed papers, a set of advantages emerges both for continuous professional development and for teaching-learning processes.

After the analysis of the reference literature, the landscape related to the application of the AR to the learning and training issues seems to be successful. The experiments on this quite new approach showed big potentialities and particularly promising results, but still underlined several huge unexplored aspects. In fact, the limits generated by an improper use of AR are not found, reference didactic methods have not been identified, nor any critical issues, risk factors and problems regarding the integration of this technology in the covered areas. Experiential enrichment could cause cognitive overload and hinder learning processes if the subject has not gained direct experience with cultural content (Bonaiuti et al., 2017).

The analysis outlines a general overview and reveals promising future developments by stimulating further investigations from pedagogical, methodological and didactic points of view.

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