# Distance education in Fire Departments: A Systematic Literature Review

## A Educação a Distância no Contexto dos Corpos de Bombeiros: uma Revisão Sistemática de Literatura

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## Abstract

Fire departments are institutions responsible for a number of complex operational services and the challenge is to be able to transmit knowledge to their staff in an efficient and far-reaching manner. Distance learning is an option for solving this problem. This paper presents a Systematic Literature Review aimed at verifying how distance education has been applied by Fire Departments and what impacts it is having on teaching, providing an overview of how institutions are positioning themselves in remote digital teaching over time. To this end, after applying the inclusion and exclusion criteria, 22 studies were selected and analyzed according to the 5 research questions. It was possible to see that corporations, predominantly traditional with a focus on face-to-face instruction, are gradually introducing distance education, with a tendency towards hybrid training, managing to shorten distances and reduce costs. It was also observed that this theme still needs to be explored more by corporations and for this to happen, personal and organizational resistance needs to be broken down. The panorama presented here aims to provide a general and current view of distance education in the context of fire departments and contribute to future implementations.

**Keywords:** Distance education. Firefighters. Fire department. Systematic literature review. SLR.

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*Resumo*

*Os Corpos de Bombeiros são instituições responsáveis por diversos serviços operacionais complexos e o desafio é conseguir transmitir conhecimento ao efetivo de maneira eficiente e com alcance. A educação a distância mostra-se como uma opção de solução para essa problemática. Este trabalho apresenta uma Revisão Sistemática de Literatura que teve por objetivo verificar como a educação a distância tem sido aplicada pelos Corpos de Bombeiros e quais impactos ela está proporcionando no ensino, fornecendo um panorama de como as instituições estão se posicionando no ensino digital remoto no decorrer do tempo. Para tanto, após a aplicação dos critérios de inclusão e exclusão, 22 estudos foram selecionados e analisados de acordo com as 5 questões de pesquisas elaboradas. Foi possível verificar que as corporações, predominantemente tradicionais com o foco nas instruções presenciais, vão aos poucos introduzindo a educação a distância, com tendência por formações híbridas, conseguindo encurtar distâncias e reduzir custos. Observou-se também que essa temática ainda precisa ser mais explorada pelas corporações e para isso resistências pessoais e organizacionais precisam ser rompidas. O panorama aqui apresentado visa proporcionar uma visão geral e atual da educação a distância no contexto dos corpos de bombeiros e contribuir para implementações futuras.*

***Palavras-chave:*** *Educação a distância. Bombeiros. Corpo de bombeiros. Revisão sistemática de literatura. RSL.*

## 1. Introduction

Fire departments are organizations that specialize in fire prevention, firefighting, civil defense actions and offer a wide range of emergency services. On a daily basis, they are obliged to respond to various incidents within their scope of action (REIS; NEVES, 2019) and the nature of firefighter operations requires a multidisciplinary approach, involving different areas of knowledge, skills and complex decision-making (WONG; XIE, 2014), where the decision-maker must act normally in situations of pressure and stress (KLEIN *et al.*, 1986) (KLEIN, 2008) (MILEN, 2009).

Fire brigades usually offer training programs to prepare their professionals for the many emergency situations and responsibilities they may encounter (SCHULTE; THIELSCH, 2018). These programs can vary according to the region and the structure of the organization. A common fact is that fire departments are traditional institutions (ZHANG *et al.*, 2022) and historically training has been face-to-face, where the most experienced pass on their teachings to those with less operational experience.

In this context, training firefighters can present challenges due to the distance between training centers and fire stations, and with teams getting smaller, it is difficult to organize the release of professionals for training.

In the sum of these factors, Distance Education (DE) has emerged as an option to overcome these teaching obstacles. Given the large number of public employees who need to be continuously trained at

local, regional and national levels, the use of online courses for training in the public sector is not just an option, but a necessity (SANCHEZ-GORDON *et al.*, 2015).

Distance education makes it possible to exploit the benefits of using emerging technological tools to promote student interaction and online learning (BELDARRAIN, 2006). E-learning is an effective method for connecting with students or employees and sharing the necessary information remotely (MIKULA *et al.*, 2018).

This modality can allow firefighters to access training materials, courses and resources remotely, enabling them to acquire new skills and knowledge, without time, cost or physical location restrictions.

Based on the above, the aim of this work is to carry out a Systematic Literature Review (SLR) to see how distance learning is being used by fire departments and what impact it is having on firefighter education. That way, the main contribution is to provide an overview of how institutions are positioning themselves in remote digital teaching over time, collecting the positive aspects and challenges of the process, with a view to facilitating future implementations.

In order to present the SLR, this paper is organized in the following order. Section 2 presents the theoretical background with works related to the proposed use of distance education and firefighter training. Section 3 describes the methodological proposal with the research questions, strategies and search criteria. Then, in Section 4, the comparative analyses are carried out and, finally, in Section 5, we conclude with final considerations and suggestions for future work.

## 2. Theoretical Background

In recent years, education has undergone significant changes in the way learning content is delivered (ALHAZZANI, 2020). Studies have shown that remotely delivered instruction can be just as effective as traditional face-to-face instruction (COLLINS; PASCARELLA, 2003). In this context, it can also be observed that the use of distance learning is currently increasingly common in professional training (LITTLEJOHN; PEGLER, 2007).

However, when compared to other areas of education, current research on distance education and the use of digital technologies shows few studies on firefighter education (HOLMGREN, 2012). In other words, few authors address e-learning issues involving applications in firefighter units (MIKULA *et al.*, 2018).

This may be related to the fact that firefighters are professionals who value informal learning in the workplace (TRACEY, 2014), prioritize practice and the method of transmitting knowledge from the most experienced rescuer to the least operationally experienced. Confirming this, Holmgren (2012) says that implementing distance learning is a challenge, especially in practice-oriented vocational education, such as firefighter education. And the same author, in ongoing work, concludes that implementation depends on a continuous process of teacher negotiations with dilemmas and conflicts that arise when new technologies are implemented in a vocational training culture with fixed perceptions of how students are best educated (HOLMGREN, 2019).

Since resistance to distance learning can largely be attributed to structural and personal factors (HOWELL et. al, 2003) (HOLMGREN, 2014), in order to change this panorama, implementations can be carried out with balance, taking into account everything that has been achieved in the past.

Sometimes classes are not developed satisfactorily in the online environment because the teacher is not prepared for new types of approaches (SHAGIAKHMETOVA et. al, 2022). Instructors cannot, in the same way as in face-to-face teaching, be 'the sage on the stage', that is, be at the center of the interaction

and be the main source of information (HOLMGREN, 2014). Professionals who are more engaged in technology can help and encourage others to apply complementary methods that aim to add to the teaching and learning process (BEAUDOIN, 1990).

Understanding the trends, strategies, benefits and challenges encountered by firefighters in implementing and using distance learning can help find ways to overcome obstacles in its application.

## 3. Method

In order to find studies that address the use of distance education by fire departments, as well as to highlight different application strategies that result in benefits in the teaching and learning process, a Systematic Literature Review (SLR) was conducted following the methodology developed by Kitchenham and Charters (2007).

### 3.1. Research Questions

In an attempt to answer the questions raised by the SRL, research questions (RQ) were defined to guide the process of analyzing the results of the systematic review. Table 1 shows the research questions.

Table 1: Research questions.

| Pergunta | Descrição da pergunta |
|---|---|
| RQ-1 | How and in what contexts has distance education been used by fire departments? |
| RQ-2 | What are the main distance learning tools and strategies used by firefighters? |
| RQ-3 | What are the benefits and positive points observed in the teaching and learning process resulting from the use of distance education by fire departments? |
| RQ-4 | What are the challenges, limitations and negative points that firefighters face when implementing distance education? |
| RQ-5 | Which research methodologies were used? |

### 3.2. Search Strategy and Research Sources

A manual search was carried out on the databases listed in Table 2. To complement the initial search, the BUSCAd software (MANSUR; ALTOÉ, 2023) and the StArt software (ZAMBONI *et al.*, 2010) were used to provide greater coverage of specific databases on the subject, to help refine the references obtained and to confirm the number of studies.

Table 2: Databases.

| Search method | Databases |
|---|---|
| BUSCAd | Capes T&D; Scielo; DOAJ; BDTD; ERIC; EduCapes |
| Manual | Web of Science; Scopus; Google Scholar; IEEExplore Digital Library; ACM Digital Library |

### 3.3. *Strings* de Busca

The search strings used covered the universe of keyword combinations related to the research topic. To do this, priority words and their common variations were established in order to broaden the search. The search strings were constructed by individually combining each term in Table 3 using the Boolean operators AND and OR.

**Table 3:** *Search strings.*

| OR | AND |
|---|---|
| Firefighter ; fire department ; fire brigade; bombeiros | distance education; distance learning; e-learning; educação a distância; EAD; MOOC |
| | learning management system; LMS; moodle; ambiente virtual de aprendizagem; AVA |

Based on the strings constructed with the terms in Table 3, the search in the databases listed in Table 2 resulted in a total of 92 studies. In order to make the final selection of studies, inclusion and exclusion criteria were established and submitted after reading the abstracts of all the studies.

## 3.4. Inclusion/Exclusion Criteria

Inclusion criteria (IC) and exclusion criteria (EC) were established to select the studies based on the research questions. The IC and EC can be seen in Table 4.

**Table 4**: Inclusion/Exclusion Criteria.

| Criteria | Description |
|---|---|
| IC – 1 | Full papers |
| IC - 2 | Articles with at least the title and abstract in English |
| EC - 1 | Works not available in full. |
| EC - 2 | Works that present a technological tool but do not practice remote/distance learning (face-to-face e-learning) |

The criteria mentioned in Table 4 were chosen in order to cover complete and international works restricting the approach to remote learning in the context of the fire department, i.e. excluding face-to-face e-learning.

## 3.5. Selected Studies

After applying the criteria, 22 complete papers were selected and the cataloged data is shown in Table 5. Most of the studies excluded were because they presented e-learning without the purpose of remote distance learning, i.e., only in person, such as simulation and virtual reality tools.

**Table 5**: Selected studies list

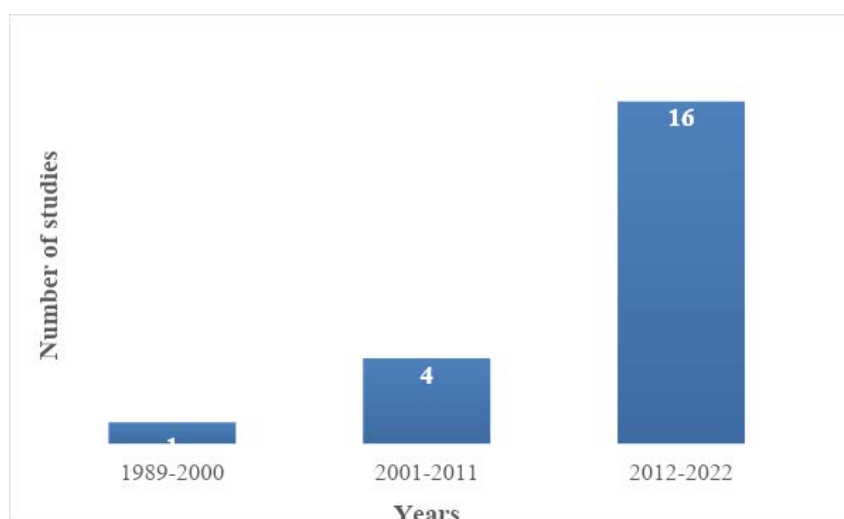| ID | Title | Authors | year | Type | Institution / journal |
|---|---|---|---|---|---|
| T01 | A hybrid approach to distance education technology: Tailor made for the United States fire service | MURPHY, D; STANTON, L | 2004 | Congresso (conferência) | 34th Annual Frontiers in Education, 2004. FIE 2004. |
| T02 | Comparison of Achievement of Students in On-Campus Classroom Instruction versus Satellite Teleconference Instruction | CLARK, B | 1989 | Congresso (conferência) | 12th National Conference on Teaching Public Administration |
| T03 | Designing and Developing Internet Reference Services to Support Firefighter Distance Learners in Illinois | RUAN, L | 2004 | Artigo | Internet Reference Services Quarterly |
| T04 | Emergency response - elearning for paramedics and firefighters - | TABER, N | 2008 | Artigo | Simulation & Gaming Journal |
| T05 | Firefighter learning at a distance – a longitudinal study | HOLMGREN, R; HAAKE, U; SÖDERSTRÖM, T | 2017 | Artigo | Journal of Computer Assisted Learning |
| T06 | Firefighter training in Sweden: from face-to-face learning in training grounds to distance learning – a challenge for exercise instructors? | HOLMGREN, R | 2014 | Artigo | Technology, Pedagogy and Education |
| T07 | Firefighting training at a distance - a longitudinal study | HOLMGREN, R; HAAKE, U; SÖDERSTRÖM, T | 2019 | Artigo | Journal of Vocational Education & Training |
| T08 | Harnessing MOOCs for the Practice of science | MAK, H | 2017 | Artigo Editorial | Cell Systems |
| T09 | Innovative Approaches to Emergency Medical Services fellowship challenger | WESTON, B *ET AL.* | 2020 | Artigo | Western Journal of Emergency Medicine |
| T10 | New ways of learning to fight fires Learning processes and contradictions in distance and on-campus firefighter training in Sweden | HOLMGREN, R | 2015 | Artigo | Australasian Journal of Education Technology |
| T11 | Preparations for practical exercises in vocational education: Can ICT-based distance instruction be an alternative to face-to-face instruction? An empirical contribution | HOLMGREN, R | 2012 | Artigo | Procedia - Social and Behavioral Sciences |
| T12 | Remote Training for Firefighter Group Commanders | KLINGER, T | 2021 | Artigo de livro | Educating Engineers for Future Industrial |
| T13 | ICT as a Catalyst in Problem-Based Learning Processes?: A Comparison of Online and Campus-Based PBL in Swedish Fire-Fighter Training | HOLMGREN, R | 2013 | Artigo | International Journal of Adult Vocational Education and Technology |
| T14 | Proposal of testing process of firefighters on the issue of air accidents to increase the competence of Fire and rescue services members | TOBISOVÁ *ET AL.* | 2019 | Artigo | IEEE New Trends In Aviation Development |
| T15 | Draft of Firefighter Education Process Through Distance Learning; Draft of Firefighter Education Process Through | MIKULA, B *ET AL.* | 2018 | Congresso (conferência) | ICETA 2018 • 18th IEEE International Conference on Emerging eLearning Technologies and Applications |

| ID | Title | Authors | year | Type | Institution / journal |
|---|---|---|---|---|---|
| T16 | Learning on Campus and Learning at a Distance A Randomized Instructional Experiment | MURPHY, D; STANTON, L | 2003 | Revista | Research in Higher Education |
| **Brazilian works** | | | | | |
| T17 | A Gestão da Educação a Distância no Corpo de Bombeiros Militar do Distrito Federal | SOUZA, E. *ET AL.* | 2017 | Artigo | Revista EAD em Foco |
| T18 | Curso *Online* Aberto e Massivo (MOOC) de Combate a Princípios de Incêndio: uma Entrega do Corpo de Bombeiros Militar do ES para a Sociedade | DIAS, D; BATTES-TIN, V. | 2022 | Artigo | Revista EAD em Foco |
| T19 | Formação continuada: a oferta de EaD ao efetivo do corpo de bombeiros militar de Mato Grosso | SANTANA, W. ; ASCENDINO, E. | 2021 | Artigo | Edapeci |
| T20 | O Contexto da Educação a Distância no Corpo de Bombeiros Militar do Distrito Federal | GOMES, U. *ET AL.* | 2016 | Artigo | Revista: EaD & Tecnologias Digitais na Educação |
| T21 | Representações Sociais De Policiais Militares, Sobre Educação A Distância No Âmbito Da Rede Ead/Senasp | SOUSA L. | 2012 | Dissertação | UFC |
| T22 | Gestão da Plataforma EaD CBMES e o Panorama Da Educação a Distância nos Corpos de Bombeiros | DIAS, D; PORTO, B; BATTESTIN, V. | 2023 | Artigo | Revista EAD em Foco |

Table 5 shows that the majority of publications are concentrated in the last decade. The analysis of the studies listed in Table 5 will be presented in the next section, considering the research questions mentioned in Table 1.

## 4. Findings

Of the studies selected, there is a concentration of papers published in the last decade, as can be seen in Figure 1, following a trend in distance education.
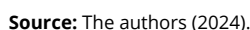
**Figure 1:** Number of studies per year period.



**Source:** The authors (2024).

In addition, a word cloud was built, as can be seen in Figure 2.

**Figure 2:** Word cloud drawn up from the selected studies.



**Source:** The authors (2024).

The visual representation of the frequency of words in the context of the articles complements the analysis and helps in the discussions presented below. To carry out the qualitative analysis, based on the 22 papers selected, the research questions were taken as a reference.

## 4.1. RQ-1: How and in what contexts has distance education been used by fire departments?

From the first research question to be analyzed, it can be seen that in T11, T12 and T13, distance learning was used in a hybrid way, i.e. to develop theory before practical exercises. As seen in T02, back in the twentieth century, in 1989 the Maryland National Fire Academy in the USA carried out a test comparing students who received face-to-face instruction with those who received it via satellite teleconferencing. The University of Charlotte offered an online college course for firefighters (T01) and a community college in Iowa offered a semester-long telecourse as part of its fire science program in 2001 (T16).

T04 presented a project for training firefighters and paramedics in decision-making and dynamic actions. In 2004, the University of Illinois Fire Service Institute (IFSI) implemented what at the time was a new service to make references available on the Internet to support the certification of firefighters in the Firefighter II program (T03), making it the first online certification program for firefighters in America. T11 noted that distance learning for Sweden's firefighters began incipiently in 2008, supported by information and communication technologies (ICTs). T08 discussed the need for continuous training in many professions, including firefighters.

T12 reported that as recently as 2021, Austrian fire schools were in the process of transferring content to online platforms, with the aim of facilitating access to training, especially for volunteer firefighters who have other jobs. T14 and T15 analyzed the creation of specific software so that firefighters in the Czech Republic and Slovakia, respectively, could learn how to fight fires in aircraft.

T17 and T20 analyzed the implementation of distance learning in Brazil's Federal District Military Fire Department (CBMDF), which took place in the second half of 2015. T19 analyzed the relevance of the distance learning courses offered by the Federal Government's National Secretariat for Public Security (EAD/Senasp) in the ongoing training of firefighters in Mato Grosso. T18 showed that Brazil's Espírito Santo

Military Fire Brigade provides content for internal and external audiences, including through MOOCs. T22 complemented the analysis of the CBMES case study and showed the panorama of distance learning in Brazil's fire departments.

## 4.2. RQ-2: What are the main distance learning tools and strategies used by firefighters?

T12, T18, T19, T20 e T22 used moodle as a virtual learning environment (VLE). T11 also used a VLE asynchronously, providing videos, slides and filmed lectures. T12 used didactic content and videos, multiple choice questions, scenarios, calculation exercises and a final exercise. T01 made content available both asynchronously through the WebCT (Web Course Tools) course management system and synchronously through the Centra live conferencing software. T16 used two-way interactive telecourses (audio and visual) from the Iowa Communications Network.

T15 and T04 created their own software, the first for specific aircraft firefighting training and the second being the SIMergency project, which is a collaborative emergency response simulation environment. T03 made content available through a virtual library that centralized information. T02 used satellite teleconferencing to present the same content as the face-to-face class.

## 4.3. RQ-3: What are the benefits and positive points observed in the teaching and learning process resulting from the use of distance education by fire departments?

Bringing up the third research question, in the view of T11, students with distance learning supported by Information and Communication Technology (ICT) took greater responsibility for their studies and reflected more on the course content and their own learning, as well as being better prepared for practical exercises on campus. T12 noted the advantage of reducing students' absence from the workplace.

T01 reports that injured or vacationing firefighters can access training sessions from home if necessary, and that many logistical problems can be alleviated, such as reduced fuel bills and less wear and tear on equipment involved in traveling to a traditional classroom location. T15 points out that very specific knowledge can be covered through distance learning. T13 shows how an integration of PBL (Problem Based Learning) and ICT can affect the implementation of teaching and also contribute to changes in learning processes. T16 showed statistically that distance learning achieved the same results as face-to-face training.

T07 says that implementing a distance program can be a catalyst for changes and improvements in training practices, leaving a lasting impact. T19 pointed out that continuing training through distance learning makes it possible to reduce public spending compared to face-to-face courses, and there is acceptance on the part of military firefighters. T17 noted that it was possible to infer that the majority of students approved of the use of distance learning in the Corps' career courses. T18 pointed out that in addition to training their own personnel, fire departments can be responsible for making more educational content available to the general population, helping to protect and prevent society. T22 points out that MOOCs and hybrid courses have shown positive results and can disseminate content in a democratic way to fire stations.

## 4.4. RQ-4: What are the challenges, limitations and negative points that firefighters face when implementing distance education?

The fourth question looks for barriers and negative aspects observed by the authors. In T11, it was observed that interaction and collective collaboration occurred in a lesser degree among students who had

theoretical distance learning when they went to practical group instruction. In addition, it was observed that there is still resistance on the part of some firefighters to the use of distance learning practices, where the culture of an older emergency instructor having to pass on his classroom experiences to the student is still prevalent.

T06 recalled that the student drop-out rate in distance learning is twice as high as in face-to-face learning and that resistance to distance learning can largely be attributed to structural and personal factors. With regard to instructors and institutions, T06 points out that training deficiencies for instructors and deficiencies relating to pedagogical and organizational readiness, in combination with a conservative educational structure, result in a reluctance among team leaders and instructors to experiment and develop new pedagogical approaches.

T03 reported that it was difficult to obtain substantial initial funding because the benefits seemed indirect and not yet proven. T07 noted that during implementation personal obstacles were overcome. However, during the dissemination phase, where other instructors were involved, conflicts and dilemmas arose, resulting in changes that were closer to instructor-centered and campus-centered approaches (The dissemination phase seems to be a critical point, so that orientations thought up in the implementation are not influenced by previously established conceptions).

T19 said that military personnel have no incentive to take the courses and don't feel motivated. T17 said that it is necessary to rethink the necessary structure and the availability of the military personnel for the course at the same time as their routine activities. T20 stressed that distance learning is little used in the CBMDF, missing out on a great opportunity for training due to its accessibility and connectivity. T18 highlighted the challenge for fire departments to make training available to the population, as they don't always have teams dedicated to producing distance learning content. As reported by T22, most institutions still need to establish a legal framework for distance learning, as well as standardize the production of content.

## 4.5. "QP-5: What research methodologies have been used in the implementation and analysis of distance education?"

Analyzing the methodology used in the studies, T11 used interviews with students and teachers from both classroom and distance learning methods. T12 created a moodle course to apply the theoretical part of the subject and requested validation from firefighters. T16 analyzed three classes of the same course, two groups, face-to-face and remote, chosen at random, and a group of distance learning volunteers. A statistical analysis of the pre- and post-test results was carried out. T06 analyzed interviews with instructors and teachers, as well as conducting observations of field exercises. T10 also focused on interviews with students from both teaching models and practical exercises.

T05 points out, after a five-year longitudinal study, that the implementation of a distance education program must be linked to a historical theoretical framework and include data collection over time, as was done in his work. T02 administered multiple-choice tests to the two groups of students to see if there was a significant difference in the results between those who took the class in person and those who took it via teleconference.

T19 used exploratory research, collection of statistical data from Senasp and the application of questionnaires to verify the perception of firefighters. T20 applied an effectiveness questionnaire to the students in the pilot project in 2015. T18 carried out a satisfaction survey with course participants in the virtual classroom. T18 and T22 carried out satisfaction surveys with participants in the moodle course itself. Expanding his analysis, T22 submitted a survey to representatives of all the fire departments in Brazil, with the aim of obtaining a national overview of distance learning.

## **5**. Discussions and Conclusion

From the analysis it was possible to conclude that the theme of the use of distance education by fire departments needs to be explored further, given the low number of published works found within the established criteria. In addition, the incipient nature can be observed, since the few implementations have taken place in recent years. Fire departments, which are essentially traditional institutions, are gradually updating the way they train, first by adding technological simulation tools, games and virtual reality, in person, and recently by increasing strategies focused on remote teaching.

It was noted that distance learning for firefighters plays a role in shortening distances and reducing costs. Furthermore, it offers opportunities for new training and complementary teaching. The trend towards hybrid training was evident, with the theoretical content available remotely to the student via VLEs, thus placing the lead role in learning the content on the student, and the practical content being developed in person later in a group. This format tends to streamline practice and reduce face-to-face days.

Some highlights are presented below:

• Firefighter training is traditional and any kind of change in the pedagogical process must be planned in the long term and gradually.

• Institutions are looking to distance learning to reduce costs, shorten distances between students and professionals who have the knowledge, provide training at alternative times and provide ongoing training.

• In distance learning, students are more independent in their search for knowledge, but are less interactive in face-to-face practical classes.

• There is resistance from teachers who are used to the traditional classroom model.

• Many teachers who move to the online model try to replicate the same lessons they teach in person, i.e. they do not try to train themselves in how to use technology to transmit knowledge remotely.

• The drop-out rate for online classes is higher than for face-to-face classes.

• The hybrid method, with online theory and face-to-face practice, appears to be the most suitable for the realities analyzed.

Within the selected research parameters, a small number of papers were found, showing an avenue for further research. There were no studies involving distance learning for firefighters and science teaching, and few studies presenting MOOCs in the context of firefighters, showing that these are potential lines of research to be developed as future work.

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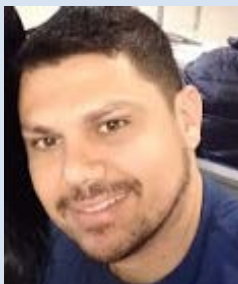
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