OPTIMISING EDUCATION BY THE INTEGRATION OF ARTIFICIAL INTELLIGENCE AND AFFECTIVE COMPUTING: A PERSPECTIVE FOR THE PREVENTION OF EARLY SCHOOL LEAVING

OTTIMIZZARE L'ISTRUZIONE ATTRAVERSO L'INTEGRAZIONE DI INTELLIGENZA ARTIFICIALE E AFFECTIVE COMPUTING: UNA PROSPETTIVA PER LA PREVENZIONE DELLA DISPERSIONE SCOLASTICA

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Double Blind Peer Review

Citazione
Chiusaroli, D., & De Vito, L. (2024). Optimising education by the integration of artificial intelligence and affective computing: a perspective for the prevention of early school leaving. *Giornale Italiano di Educazione alla Salute, Sport e Didattica Inclusiva*, 8(2), Edizioni Universitarie Romane.

Doi:
https://doi.org/10.32043/gsd.v8i2.1171

gsdjournal.it
ISSN: 2532-3296
ISBN 978-88-7730-493-3

ABSTRACT
The international scientific research emphasizes the growing importance of the application of Artificial Intelligence in the field of education. This paper aims to reflect on the possible uses of Artificial Intelligence in predicting the causes of early school leaving. In addition, the integration of the *affective computing* in predictive models based on artificial intelligence, could offer new opportunities to identify, support and motivate students with emotional difficulties.

La ricerca scientifica internazionale sottolinea l'importanza crescente dell'applicazione dell'Intelligenza Artificiale nel campo dell'istruzione. Il presente contributo intende riflettere sui possibili impieghi dell'Intelligenza artificiale nel prevedere i fattori legati alla dispersione scolastica. Inoltre, l'integrazione dell'*affective computing* nei modelli predittivi basati sull'IA potrebbe offrire nuove opportunità per identificare, supportare e motivare gli studenti con difficoltà emotive.

KEYWORDS
Early school leaving, affective computing, artificial intelligence, school discomfort, prevention
Dispersione scolastica, affective computing, Intelligenza Artificiale, disagio scolastico, prevenzione.

Received 05/05/2024
Accepted 17/06/2024
Published 24/06/2024

[1] This paper is the result of a shared work between the two authors. However, to admit a sections attribution of authorship, Chiusaroli wrote introduction, paragraph 1 and conclusions; De Vito wrote paragraph 2.

Introduction

Factors related to early school leaving may arise from personal, family and social conditions characterized by vulnerability, disadvantage and exclusion. These elements, at the same time, are strictly linked to situations such as unemployment, economic and labour instability, material and educational poverty. The combining of one or more of these factors can lead to difficulties in learning, concentration and attention, as well as causing delays in achieving goals related to the level of school attendance, irregular attendance and even premature school giving up. In general, early school leaving can be defined as the absence, the failure or an irregular participation of young school students in education and formative processes. However, this phenomenon manifests itself several causes and effects that can be distant in time and it is difficult to measure their complexity. Dispersion, in fact, can take place at different stages of school journeys and can consist in giving up, early school leaving from the educational system, absenteeism, passive attendance or the accumulation of gaps and delays that can affect student's potential for the cultural and professional growth. Starting from these considerations, this paper aims to reflect on the possible uses of artificial intelligence in predicting the factors contributing to early school leaving. Using advanced algorithms and predictive models, artificial intelligence could analyse wide sets of data related to the socio-economic situation of students, the educational background of their families, the attractive elements of the labour market, their relationship with the school and the educational programmes offered, as well as the individual, emotional and behavioural characteristics of each student. In the present paper, it has been carried out an analysis through several scientific papers related to this matter. This approach provided an overview of the Machine Learning and Deep Learning techniques used to predict early school leaving. In the framework of this contribution was also conducted an enhancement on the topic of affective computing during the detection of school discomfort. Finally, the reflection helped to identify possible gaps in existing literature and it was useful to suggest possible future directions for the research.

1. Early school leaving: a widespread and complex phenomenon

A number of factors affecting both the person, his family, and the social context in which the student lives can influence early school leaving. These factors are often linked to situations of vulnerability, disadvantage and social exclusion. When these elements combine, they can cause learning difficulties, problems with concentration and attention, and delays in achieving school goals. Moreover, they

can manifest themselves through irregular presences and, in some situations, lead to the early abandonment of studies. With the terms early school leaving, typical of the sociology of education, we refer to the so complex phenomena that relate to the lack or incomplete or irregular use of educational services by school-aged children and young people (Lo Schiavo, 2006). This definition indicates the relational difficulty between students and school actors and in addition, it recognizes the abandonments before the end of the formative cycle (drop out) as well as the repetitions and irregular school attendance. In general, early school leaving can be defined as the absence, incompleteness or irregular participation of young people of school age in education and training services. However, this phenomenon manifests itself through causes and effects that can be distant in time and difficult to measure in their complexity. The dispersion can take place at different stages of the school career and can consist in abandonment, dropout from the educational system, absenteeism; passive attendance that can affect the prospects of cultural and professional growth of the student (Genzone, 2019).In Italy the Statistical Service of the Ministry of Education monitors the phenomenon every year especially in terms of abandonments.

For example, the last available investigation (2021) shows that the total dropout rate for the 1st grade of secondary school was 0.64% (10,938 pupils), while for the 2nd grade of secondary school this number is 3.79% (98,787 pupils). Therefore, the amount of students that every year leave the Italian school are about 110,000, additionally to those who get lost in the transition from the first to the second school grade. According to the analysis provided by ISTAT (2021), early school leaving is a complex phenomenon. It is surely caused by different factors, including the socio-economic situation of the person, the educational background of the family, the factors of attraction of the labour market, the relationship with the school and with the educational programs offered, the individual specificity and personality distinctions of the person.

According to a Eurostat survey (2020) the school dropout rate, which concerns young people between 18 and 24 years, who have completed at most a first-level secondary education and are not currently engaged in any form of education or training, is 13.1% in Italy, exceeding the European average of 9.9%. Moreover, strong gender inequalities persist, with 15.6% of abandonment for males compared to 10.4% for females, and territorial inequalities, with a progressive increase from North to South Italy and between Italian and foreign students.

Early school leaving is a widespread problem, influenced by multiple factors that interact with each other, determining unique configurations of opportunities and constraints that affect individual learning paths.

Therefore, early school leaving is a complex phenomenon that requires a thorough analysis of the several dimensions that contribute to creating situations of criticality and vulnerability, which may gradually lead students to lose interest in their educational path. It is essential to examine students' experiences and understand how they are affected by the context in which they live. It is necessary, then, to distinguish school discomfort from other types of discomfort, such as social or psychological during adolescence.

School discomfort is not necessarily related to language disorders, psychopathological or cognitive delays. Rather, it manifests itself through dysfunctional behaviours, such as inattention, rejection and disorder, which prejudice a positive participation in studying activities and make it difficult for students to integrate satisfactorily into the classroom. School discomfort, therefore, is also a complex and diversified phenomenon, which often manifests itself before school dropout. According to Mancini and Gabrielli (1998), it is an emotional state, which it is not strictly associated with psychopathological, linguistic or cognitive disorders. It is evidenced through a series of dysfunctional behaviours, such as lack of participation, distraction, tendency to rejection and disorder, difficulty in relating to classmates and lack of critical spirit. These behaviours hinder student's ability and the full participation in school activities and to learning experiences, precluding the optimal use of their cognitive, emotional and relational abilities.

Therefore, the student can reveal a lower school performance, which can be a sign of difficult adaptation to the school context, known as school maladjustment. This phenomenon manifests itself in different forms within each educational system. Students experiencing this type of difficulty find it difficult to meet the multiple demands of the school environment, including homework, individual study, and participation in classroom activities.

Maladjustment presumes many other modes, it is not only limited to academic achievement, but it can also manifest itself through frequent absences. This behaviour can lead to irregular school attendance, compromising the validity of the school year attendance and potentially culminating in failing and the call to repeat the year. This situation can lead to a delay in the school career, which could then turn into a total disaffection with the school, eventually leading to the final abandonment of studies.

Early researches, related to those risks that are giving rise the phenomenon, are focused on analysing the specificities of early school-leavers, including various demographic and social factors such as socioeconomic status, race and ethnicity, gender and disability status. Living in poverty during primary, middle, and/or high

school years is one of several factors significantly related to early school leaving (Hammond, Linton, Smink, & Drew, 2007).
Young adults between the ages of 16 and 24 living in the highest social classes are seven times more likely to obtain a diploma than those with lower socioeconomic conditions. Although the demographic characteristics associated with early school leaving cannot be changed by school's efforts, such indicators may be considered to identify groups of students who may be at risk of dropping out and who could benefit from services aimed at increasing graduation rates (Hammond et al., 2007). Therefore, a low performance and a low attendance are significantly linked to early school leaving at primary, middle and upper levels (Hammond et al., 2007). However, while initial studies focused on personality characteristics and on those conditions useful to predict what kind of students would have dropped out school (Shannon & Blysma, 2003), research has expanded to examine additional school-based factors that often affect uneasiness and dispersion rates. As Bracci and Grange (2016) observe, the factors of school discomfort prevention are contextual and concern aspects characterizing the relationship with teachers. Be satisfied with the skills possessed by teachers, consider them able to understand student's needs and recognize that they have adequate attention toward students are conditions that reduce the likelihood of being in situations of school discomfort.
Students' experiences at school, therefore, can affect their chances of graduating. Academic performance and interest in school, therefore, are key indicators of possible dropout (Hammond et al., 2007).

1.1 AI and new challenges for education

Various studies, such as those conducted by the OECD in 2023 and by Seldon and Abidoye in 2018, have enthusiastically hosting artificial intelligence (AI) as a solution to major educational problems.
These studies raise several crucial questions about the use of AI in education. In particular, it is necessary to consider the aims of the use of AI, the contexts in which it is used, its operation, the extent of its impact (from the individual student to entire class group, collaboration networks, national and transnational levels) and its operation.
Although boundaries are blurred, the links between AI and education have been divided into four main thematic areas: "Learning with AI", "Using AI to facilitate learning", "Gaining knowledge about AI" and "Preparing for the AI era" (as proposed by Holmes et al. in 2019). The application of AI in education involves the use of AI-based tools in both teaching and learning activities and includes:

- the use of AI to directly support learners through tools such as intelligent mentoring systems, dialogue-based mentoring systems, exploratory learning environments, automated assessment, Chabot and AI to support students with disabilities;
- the use of AI to support administrative systems (such as recruitment, time and management of learning plans);
- using AI directly to support teachers
- the use of AI to directly support learners through tools such as intelligent mentoring systems, dialogue-based mentoring systems, exploratory learning environments, automated assessment, Chabot and AI to support students with disabilities;
- the use of AI to support administrative systems (such as recruitment, time and management of learning plans)
- the use of AI to directly support teachers

Learning AI also increases the knowledge and AI skills of students of all ages (from primary, secondary, to tertiary grade) and of their teachers, including AI techniques (such as learning machine) and AI technologies (such as natural language processing), together with the statistics and coding everything depends on (Miao and Holmes, 2021).

An analysis of the use of AI in high school education (Zawacki-Richter et al., 2019) revealed that almost half (48%) of the examined studies are focused on the use of AI to improve administrative and institutional services. The studies approached mainly three categories of AI applications: the automation of processes related to the admission of students to study paths, the facilitation of communication with students and the efficient programming of resource allocation.

With regard to the issue of early school leaving, it is essential that institutions acquire a detailed knowledge of the numbers and distribution of the student population. In fact, the application of artificial intelligence to predict abandonment is a widespread field of research, especially in MOOCs (Massive Open Online Courses), where dropout rates can exceed 90%. The goal is to understand the factors that influence abandonment, predict and reduce it (Dalipi et al., 2018; Feng et al., 2019; Goel and Goyal, 2020).

The problem of early school leaving has economic, social and educational consequences for the stakeholders of the global education system, ranging from the psychological impact on students to the management challenges faced by institutions.

Various governments designed and implemented early warning systems for early school leaving to address efficiently the problem.

An alternative of great importance is the use of Machine Learning and Deep Learning algorithms. These models include early school leaving and provide early warnings allowing for alternative measures targeted at students at risk. Each Machine Learning and Deep Learning model is intrinsically linked to the underlying algorithm, the optimized hyper parameters, the training and test data sets used, as well as the variables and behaviour of the data, the different performance metrics. A systematic review of scientific articles on this topic (Giròn et al. 2023) has provided a series of significant results regarding the use of Machine Learning and Deep Learning techniques for forecasting early school leaving. Have been identified the most promising algorithms and their variants in terms of predictive capability. With the analysis of 23 scientific papers it was highlighted the application of 16 different Machine Learning and Deep Learning algorithms. The most used algorithm in these studies was RandomForest, which accounted for about 21.73% of the total. In addition, RandomForest has shown outstanding performance, achieving impressive precision in abandonment prediction (Giròn et al. 2023).

As Kalegele (2020) notices, using statistical approaches, data inputs can be aggregated into single values ready for machine learning-based calculation of the probability of abandonment. Once the likelihood of dropping out of school is admitted for a particular scenario, the level of risk can be determined and it can be made appropriate intervention decisions.

However, it is important to note that are needed more ESL variables and more investigations using large volumes of data to achieve more robust and generalizable results. The results of the study conducted by Giròn (2023), also highlighted the distribution of articles selected according to their country of origin. Most of the articles (21%) were published in China, while 17.39% originated in the United States. In addition, 8.69% of the selected items came from Korea, India and Spain. Other countries that contributed to the sample were Turkey, Hungary, Germany, Malaysia, Chile, Ecuador, Slovakia and the Netherlands, representing 4.34% of the selected items. These outcomes suggest that early school leaving is a relevant research topic in different parts of the world.

To design an artificial intelligence (AI) system suitable to predict early school leaving, therefore, it is essential to understand the multiple factors contributing to this phenomenon because, as analysed in the previous paragraph, Early school leaving may result from a complex interaction of school, behavioural and socio-economic elements. Identifying these factors and developing a system that can detect them is crucial to implementing targeted preventive strategies.

2. The role of affective computing in detecting school discomfort

As seen above, the prevention of early school leaving is a key global challenge. To address this complex problem, several studies have been conducted to analyse the potential of artificial intelligence in the prevention of the phenomenon. Affective computing is an emerging field of research that aims to enable intelligent systems to recognize, feel, deduce and interpret human emotions. Over the past two decades or so, artificial intelligence researchers have attempted to equip machines with cognitive abilities to recognize, interpret, and express emotions and feelings. In the context of ESL prevention, affective computing can be used to detect and manage the emotional state of students, offering personalized and timely support. Affective computing, used within an intelligent environment (such as a smart classroom), through the use of innovative technologies such as Kinect, eye tracker and webcam, is able to monitor and analyse the behaviour of students, key indicator in school dropout forecasts. (Kadar et al. 2016). Emotions are fundamental to human existence and they deeply affect every aspect of everyday life. They are intrinsic to human nature and play a fundamental role in the overall well-being of the person. Damasio states that the relationship between learning, emotions and bodily is much deeper than many educators perceive.

Emotions are as vast as the diversity of people and their relationship to the environment, including objects, people and other living beings. Concerning with this it is important to consider two aspects. The first one refers to the situation in which a person, exposed to external stimuli, has a physiological flow of activity that will trigger thoughts, emotions and acts in response. And the second one that takes into account the different reaction to threats or friendly situations depending on the feelings or thoughts expressed by the person towards the interlocutors and the context (Ferreira, 2015).

The current research on the affective computing together with the learning assessment can control the affective dimension of the student. In other words, it can detect motivation (Ainley, 2006) or the learning effectiveness (Lynch, 2006).

As Kadar et al. (2016) note, personalised support based on artificial intelligence systems is provided in a non-intrusive manner during the learning activity. For example, while the student is talking, the system may suggest slowing down by turning on a light or playing a sound. In this way, the support is integrated smoothly into the learning activity without interrupting the natural flow of the educational process. This feature requires to enrich the system with the ability to detect changes in the affective state of students (for example by physiological sensors), as well as to interact with the user through the preferred sensory channel (for

example, sight, hearing, touch, smell) Gutiérrez et al. 2016). Calvo and colleagues (2010) consider, in this meaning, six main perspectives: emotions as expressions, emotions as bodily incarnations, cognitive approaches to emotions, emotions as social constructs, affective neuroscience, the basic interest and the psychological construct of emotion. All these trends are important for the analysis and characterization of emotional states and affect Affective Computing (AC) systems. AC systems can create different scenarios that help and improve educational conditions. A system for identifying emotions can detect signs of frustration during the learning process or lack of understanding while studying concepts and definitions. This means that technologies based on these perspectives can be used to track emotional trends in groups, detect emotional interactions, and detect patterns and states of anxiety or depression. By identifying these conditions from the outset, educational staff can intervene by providing individual psychological support to students. Such early intervention can help prevent future problems that could interfere with the learning process of students and even with their life in general (Kadar et al., 2016).

A study conducted by Kadar and colleagues (2016) identifies as a possible technological solution to avoid early school leaving of students and increase their performance, developing a framework based on the principles of the Internet of Things (iot) integrating different devices such as biomedical sensors and eye-trackers to gather information. The goal is to use information gathered from different sources to support teachers in identifying and managing the emotional state of students during classroom lessons. The scenario proposed by the authors consists in assessing the emotional state of the student for the emotional management and prevention of the abandonment of higher education institutions. In this context were identified four situations to study, as illustrated: gait and posture analysis; eye tracking detection; automatic facial emotion detection; emotional recording based on data integration; The gait and posture analysis situation study is performed when the student enters or leaves the classroom. To implement the study of this situation it was used a 3D motion capture device, consisting of an RGB camera and a depth sensor in order to track the key points of the student's skeleton. A change in the student's regular gait is also expected to indicate a change in his or her emotional state. The eye-tracking situation, on the other hand, is performed when students are sitting at a desk. The eye tracker, in this occasion, was used to track both head and eye movements. This analysis allows recognizing the affective states of the student, both to measure the level of involvement of the student during the learning tasks. In addition, in the situation of data integration-based emotional map study, data from previous situations is

collected and processed in real time to create an emotional map to detect potential problem situations, such as disengagement, attention disturbance, learning difficulties, emotional stress and, consequently, the risk of school dropout and discomfort.

Conclusions

The analysis conducted through the systematic review of scientific works has provided a series of significant results regarding the use of Machine Learning and Deep Learning techniques for the prediction of early school leaving. The analysis carried out in this paper underlines the importance of understanding and addressing the problem of early school leaving through the use of advanced technologies such as Artificial Intelligence (AI) and affective computing. Early school leaving is a complex and multifactorial phenomenon, influenced by a series of personal, family, social and contextual variables. AI offers a wide range of possibilities in education, from collecting and analysing students' socio-economic data to forecasting early school leaving. Predictive models based on advanced algorithms allow early detection of students at risk and implement targeted interventions to prevent dropout. However, it is important to note that the integration of these models with affective computing approaches can represent a further step in the optimization of prevention strategies. The affective computing is a promising prospect for the detection of school discomfort, as it allows you to monitor the emotional state of students during learning activities. By integrating biomedical sensors and eye-trackers, you can detect signs of stress, disengagement or frustration and provide personalized support to address such situations in a promptly manner. However, it is worth noting that, now, the integration between predictive models of artificial intelligence and affective computing techniques needs to be still investigated. The integration of these two approaches could allow a deeper understanding of the emotional processes of students, the factors influencing their participation, their academic success and the possible risks of abandonment. In conclusion, an effective combination of predictive approaches and emotional monitoring could significantly improve the prevention of early school leaving. Therefore, we suggest the requirement for further research and a better and effective integration of these two perspectives in the prevention of early school leaving.

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