Student Attrition in Higher Education: A Systematic Mapping of Causes and Retention Strategies

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Abstract. University dropout is a persistent problem that has affected educational institutions for many years. This phenomenon arises from a convergence of unfavorable factors of various kinds, such as: academic, family, economic, social, and institutional, which influence the decision of students to abandon their studies. Furthermore, dropout can be the result of a lack of identification and attention to problematic areas within the university, such as pedagogical deficiencies, lack of flexibility in schedules, and insufficiency in psychological assistance, among other aspects that require strengthening. This problem not only affects students but also higher education institutions. Many studies have been carried out to address this phenomenon through the implementation of different tools where favorable results have been obtained. From this, this study has been carried out aimed at the compilation and analysis of these documents through mapping. Systematic literature, this research was carried out in four (4) digital libraries where 3372 research articles were obtained that were subjected to different filters finally 50 articles were obtained, which answer five (5) research questions that have been raised in the study.

Keywords: Higher education · Student dropout · Retention strategies · University education

1 Introduction

Student dropout has been present throughout history on the university campus due to various factors that influence the lives of students, which drive them to leave the educational system before completing their studies. This phenomenon of student dropout can be caused by certain factors, including economic and family difficulties. A student with economic pressures, such as the need and concern to work to cover his expenses, can affect the student's ability and divert his attention from his career. Family problems also generate a significant impact, among other situations that may arise. The lives of students that give rise to student dropout.

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Those identified as key determinants associated with student dropout include academic performance, institutional habitat, demographic characteristics, economic constraints, motivation, personality, social interaction, financial aid, social commitment, and emotional attachment to the institution [1]. According to research carried out at a university in Romania, student dropout is influenced by academic, family, and individual factors and to fully understand a student's decision to leave the institution, it is essential to address both academic and social aspects [2]. The problem of student dropout in higher education institutions is affected by changes in ways of teaching, the economic situation of students, and limitations in face-to-face interactions [3]. In the analysis carried out by the University of Higher Education of Mumbai, in India, attrition is attributed to factors such as performance on admission tests, goals and commitments, institutional experiences, and non-academic elements such as psychosocial and socialization factors [4]. Dropout is a problem that not only originates from the particular problems of students but also occurs due to the shortcomings that universities may present in different areas, [5], state that "Dropout is a critical indicator of the quality of the educational system since this demonstrates significant failures in the direction, transition, adaptation, and education of students" (p. 1). Educational systems require research that allows us to detect the areas in which there are shortcomings to implement tools that allow us to work with these areas and improve them to be able to face this great challenge of dropout.

As a first step, students who are likely to drop out must be identified to improve retention policies, such as learning and tutoring programs. Therefore, quantifying the risks generated by dropouts can be useful for allocating psychological, administrative, and pedagogical resources more efficiently [6].

The psychological resource has great relevance considering that students tend to be affected emotionally and psychologically by their studies, making it necessary to encourage students by encouraging resilience and motivation considering that this area has a great influence on academic performance, which is an important factor in terms of dropout [7], on the other hand, the pedagogical factor is of utmost importance, which is why the educational system must work for the implementation of these resources that allow students to feel more comfortable and attracted to Their studies [8] state that: "Permanence in studies can still be linked to the quality of the higher education institution. "A university with good quality education tends to have a greater number of students graduating in their careers." (p.3). However, we cannot ignore the strategies that must be implemented in terms of financial resources, scholarships, or schedule flexibility that are required for those students who do not have sufficient financial resources to cover the financial expense that their degree represents [9], state that: "When students receive financial aid, dropout rates are lower" (p.1) [10], state that: "Leaving college without a degree has a negative impact on finances and health mentality of the students." (p.1).

Dropout also influences the increase in economic, social, and academic inequality in society [2, 11, 12], state that: "One of the many arduous challenges for universities will be to design and implement better policies." that provide the means to guarantee educational opportunities for all, as part of the common effort to reduce poverty and combat social inequality." (p.1).

The studies that were investigated have limitations. The study [13], implemented the qualitative methodology that generates certain limitations in the results, it also had

geographical limitations. In this study [14], there was a lack of deeper and broader knowledge, for on the other hand, there was a restriction on the number of institutions in which the study was applied, and there were difficulties in accessing the data required in the research [9, 15]. These limitations generate a knowledge gap which prevents obtaining more information. in research results.

To address this problem, the implementation of software is proposed at the Francisco de Paula Santander Ocaña University. This system will allow continuous monitoring of student's academic performance during their first three semesters of systems engineering. Its main objective is to detect possible dropouts early through alerts to intervene and understand the causes that could be causing this situation, thus allowing the systems department to provide personalized help to each student, looking for solutions to maintain good academic performance and avoid desertion. The implementation of this system is based on the urgent need to address and reduce the persistent student dropout in the university.

2 Methodology

Systematic mapping is an organized methodology for investigating a specific topic through specific steps of searching, analyzing, and summarizing relevant information from academic articles. By applying this approach to the study of student dropout in university institutions, we seek to identify effective early warning and prevention strategies during the first semesters of study. The objective is to understand what has been researched in this field and how the different studies are related, to determine the usefulness and relevance of the information. This structured process will allow the available information on student dropout to be analyzed objectively and completely, facilitating the identification of effective practices and recommendations to address this problem in the university context.

In this study, the methodology developed by Petersen [5] was used to carry out systematic mapping, which consists of five sequential steps: (i) establish the research questions, (ii) define the search criteria for identifying studies, (iii) establish inclusion and exclusion criteria, (iv) determine the classification scheme, and (v) extract data and map studies.

2.1 Definition of Research Questions

The objective of this systematic study is to identify and analyze effective strategies that help student retention in universities. To achieve this, the following research questions are presented that will guide this analysis:

RQ1: What are the research objectives and contributions of studies on dropout in higher education?

RQ2: What are the most common strategies proposed to address and prevent student dropouts in higher education?

RQ3: In which areas of knowledge is a higher incidence of student dropout observed in higher education?

RQ4: What do the authors think about the impact that student dropouts in higher education generate on society?

RQ5: Are there studies that validate student attrition as a significant challenge in higher education?

2.2 Definition of Search Criteria

The search for primary sources is carried out in two stages. In the first stage, a search string is established that includes the most relevant terms related to the research area. In the second stage, the appropriate electronic databases are chosen to carry out this search.

To build the search chain, main keywords that reflect the central aspects of the study topic were selected, which were extracted from relevant documents. Main keywords were defined such as: "Student dropout", "Retention strategies", "Higher education", "Predictive software", which contain their related terms, see Table 1.

Table 1. Keyword categories and related terms.

Category	Related terms
Higher education	university education
Student dropout	School dropout
Retention strategies	Student persistence strategies

Higher education, Student dropout, Retention strategies, University education

Subsequently, the final search pattern was developed by combining the main keywords with the Boolean operator AND, and those related words were combined with the Boolean operator OR to expand the search, as can be seen below:

(*"Student dropout" OR "School dropout") AND ("Retention strategies" OR "Student persistence strategies") AND ("Higher education" OR "University education") AND ("Predictive software*")

To find relevant information about research on student dropout in universities, online databases known to have important academic studies were chosen. These are the selected databases:

- ACM Digital Library
- IEEE Xplore
- ScienceDirect
- Scopus

In each database, the search engine uses different standards and methods. For this reason, the search string was adjusted to each database to perform an advanced search in titles, keywords of articles, and abstracts, to obtain an initial set of studies and the Number of investigations obtained, see Tables 2 and 3.

Table 2. Search string in databases.

Database	Search String
ScienceDirect	"Student dropout" OR "school dropout" AND "Higher education" AND "Predictive software" AND "Retention strategies" OR "Student persistence strategies"
Scopus	("Student dropout") AND ("Higher education" OR "University education") AND ("Software" OR "Algorithms")
IEEE Xplore Digital Library	"Student dropout" AND "Retention strategies" OR "Student persistence strategies" AND "Higher education" OR "University education"
ACM Digital Library	"Student dropout" + "Retention strategies" + "University education" + "Predictive software"

Table 3. The number of investigations obtained.

Database	Amount
ScienceDirect	647
Scopus	60
IEEE Xplore Digital Library	912
ACM Digital Library	1,573
TOTAL	3,372

2.3 Definition of Inclusion and Exclusion Criteria

Inclusion (I) and exclusion (E) criteria were established, to select which articles to add or eliminate from the analysis:

I1: Articles that have been published in the last nine (9) years (2014 - 2024).

I2: Document types are items only.

I3: Focus areas such as social sciences, psychology, computer science, engineering, and decision sciences.

E1: Articles that are not related to methods or strategies to prevent dropouts in higher education.

E2: Articles focused on educational levels other than higher education.

E3: Articles in which sufficiently detailed methodologies are not applied.

2.4 Determination of the Classification Scheme

To facilitate understanding of the contributions of each article, the studies were categorized according to our research into:

Quantitative research articles: These studies are based on the collection and analysis of numerical data to answer specific research questions. These may include experiments, surveys, or the analysis of statistical data.

Qualitative research articles: These investigations focus on understanding social or human phenomena through methods such as interviews, content analysis, and observations, rather than focusing on statistics or numbers.

2.5 Data Extraction and Study Mapping

The classification and analysis of the articles was carried out according to the categories and steps proposed in Sects. 2.3 and 2.4 to find documents that provide answers to the research questions that were defined in Sect. 2.1.

3 Results

This section presents the results of the systematic mapping of student dropouts in university institutions. The main purpose is to identify and analyze effective strategies to give an overview of student retention during the first semesters. This study was carried out over a period of four months, between February and May 2024.

Figure 1 illustrates the implementation of the steps described in Sects. 2.1, 2.2, and 2.3. In the initial stage of the search in the selected databases, a total of 3,372 articles were distributed as follows:647in ScienceDirect, 60 in Scopus,912in IEEE Xplore Digital Library, and 1,573 in ACM Digital Library.

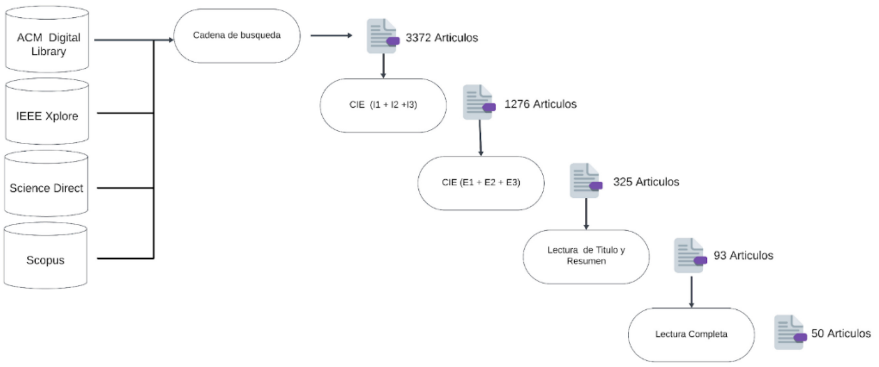


Fig. 1. Overview of the article filtering process.

Subsequently, the inclusion and exclusion criteria (I1,I2,I3,E1,E2,E3) described in Sect. 2.3 were applied. The inclusion criteria considering articles published in the last nine years focused on strategies to prevent dropouts in higher education, and studies in areas of social sciences, psychology, computer science, engineering, and decision sciences. Applying these criteria, 1276 articles were selected. Then, a detailed review of the titles and abstracts was carried out, which reduced the number to 93 articles. Finally,

after carrying out a complete reading and a more rigorous application of the inclusion and exclusion criteria, 50 articles were obtained that are considered adequate to answer our research questions as shown in Fig. 1.

3.1 RQ1 (What Are the Research Objectives and Type of Contributions of Dropout Studies in Higher Education?)

To answer the research question RQ1 (What are the research objectives and type of contributions of dropout studies in higher education?) according to the selected documents, a segmentation of the main research objectives was carried out, remaining as follows:

- Analysis of the causes of dropout rates. It is this study [16], a Correlation Analysis model was used in computer science students, which was used to examine the relationship between school dropout and several factors such as technology use, age, gender, and previous training in computer science to Identify the main causes of dropout.
- Increase student retention. This studio [17], offers a comprehensive perspective on student attrition in the first year of university studies, providing valuable key data to improve student retention and support strategies.
- Early identification of students at risk of dropping out. This studio [18], carries out an analysis with several 677 higher education students, carrying out a survey that allows us to know when the highest peaks in dropout rates occur, resulting in abandonment of studies in the first year of the degree. It was also found that in this study [19], where several predictive models and student segmentation techniques were employed using real data from a French higher education university, the proposed framework allows for effective automatic segmentation of students based on textual data, facilitating more accurate identification of those at risk of desertion. This studio [20], Haga clic o pulse aquí para escribir texto., employed predictive methods that can be adapted to leverage the educational benefits of standards-based grading, improving accuracy in identifying at-risk students
- Identification of dropout risk indicators. In this studio [21], A Cox regression analysis was applied to identify the risk factors associated with dropping out of school, the main result being academic load.
- Classification of reasons for desertion. In this studio [22], A Mixing Structural Equation Model (MSEM) was implemented to classify students who will continue their studies and those who will drop out.
- Early recognition of low-performing students. This studio [23], used a hypermodel that combines Convolutional Neural Networks (CNN) and Long Short Term Memory (LSTM) to predict churn.

Finally, a graph of the keywords found in the research documents carried out which are a representation of the research objectives of this study was obtained, as shown in Fig. 2. On the other hand, addressing the issue of the type of contributions of dropout studies in higher education, contributions such as the following were found:

This studio [24], provides the following contribution,

- Designing performance metrics: Expanding benefit metrics used in business analytics to evaluate predictive models in the context of student attrition.

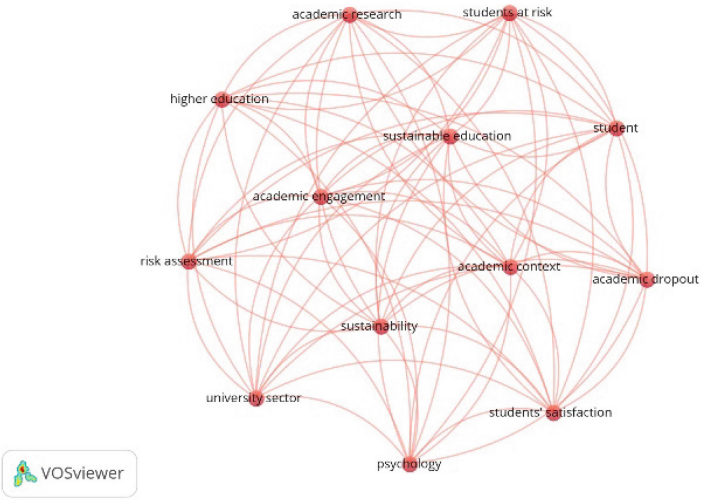


Fig. 2. Overview of the keywords and research objectives.

Other contributions that we found from this study [25] are the following:

- Identification of predictive features
- Incorporation of LMS data: Demonstrate that LMS data has significant predictive power and should be considered alongside demographic and academic data.
- Longitudinal analysis: Visualize how factor importance and prediction performance vary over time.

This studio [26], provides one more contribution to dropouts in higher education:

- Feature selection and construction method: Propose a method based on grammatical evolution for radial basis function (RBF) networks to predict future grades and study duration.

More studies [27–29], provided contributions such as:

- Building predictive models: By extracting important features and building predictive models.
- Early identification of at-risk students: By using machine learning algorithms and available data.
- Applicability in decision making: The results of the study can be used by the university administration to implement rapid assistance programs and design specific interventions aimed at reducing the dropout rate.

3.2 RQ2 (What Are the Most Common Strategies Proposed for Cases of Student Dropout in Higher Education?)

To respond to RQ2 (What are the most common strategies proposed for cases of student dropout in higher education?), the selected documents were reviewed, identifying which

are the most common strategies proposed to address student dropout in education. Superior. These strategy documents were classified into four categories that are considered main:

Predictive and Technological Approaches:

- Several studies propose the use of machine learning techniques to identify students at risk of dropping out, analyzing academic, demographic, and socioeconomic data to detect risk patterns and early warnings [11, 15, 30–32].
- The authors in this article [33], analyze student data to identify what factors cause dropout and thus create predictive models. Factors such as the percentage of credits lost and time between high school and college are used to develop early intervention and prevention strategies, helping colleges provide support to at-risk students and improve retention.
- Other articles describe the creation of software capable of analyzing academic data using the data mining technique, which identifies patterns of poor performance in students, allowing the generation of early alerts to intervene in advance and support them [3, 12].

Interventions and personalized support:

- Some of the selected studies mention that personalized interventions, such as tutoring, counseling, and support programs, help students overcome academic and personal obstacles by providing them with greater opportunities to continue their studies [34, 35].
- In the article [36], they indicate the factors that contribute to student retention, such as teaching approaches, student experiences, and campus life. It uses a multidimensional approach to investigate how these factors influence student persistence. Comparative data is collected with other institutions in the region and specific strategies are proposed to improve retention.
- They also propose offering support groups and programs to improve student's skills and achieve adaptation to university life. Therefore, it not only focuses on improving academic performance but also on strengthening emotional and social aspects that influence the permanence and well-being of students.

Analysis and data collection:

- The article [37, 38], analyzes the reasons for university dropout through various sources, including interviews with students and academic staff, where they use a criterion sampling method to better understand the specific experiences of student dropout.
- This study [38], uses data mining techniques, specifically decision trees, to identify patterns of student dropout at the University of Nariño based on socioeconomic, academic, disciplinary, and institutional data. This approach helps in decision-making to develop retention policies and strategies.

- Several articles highlight the use of data mining techniques to analyze the academic behavior of students, using the Naive-Bayes algorithm to predict dropout and understand the underlying causes. This type of methodology allows us to identify patterns and factors that contribute to dropout, which facilitates the implementation of preventive measures and strategies to address this dropout phenomenon [39].
- On the other hand, article [40] proposes using grouping or clustering techniques to improve precision when predicting dropout. This type of technique allows us to identify underlying patterns by grouping students' data into clusters or groups with similar characteristics. By analyzing personal and academic data, such as demographic background, and academic history among other relevant factors, the study seeks to establish correlations and relationships that give indications of a greater risk of dropping out.

Combined models and methods:

- Documents also mention the combination of predictive models with specific retention strategies. This approach highlights how the uplift model merges several strategies to improve student retention. That is, they not only focus on predicting which students are at risk of dropping out but also work on employing concrete actions to counteract this challenge and promote student success [1].
- On the other hand, some articles combine prediction and student segmentation to address dropout. This approach integrates textual data for a deeper understanding of the causes of dropout and likewise segments students according to their specific needs. This combination allows for more precise intervention, adapting retention strategies to the individual needs of each student [19].

3.3 RQ3 (in Which Areas of Knowledge is a Higher Incidence of Student Dropout in Higher Education Observed?)

To answer the question RQ3 (In which areas of knowledge is a higher incidence of student dropout in higher education observed?) After carrying out an analysis of the selected documents, it was possible to obtain a complete vision of the areas of knowledge with greater impact by student dropout, revealing the factors that influence this phenomenon. Below are these specific areas of knowledge according to the documents reviewed:

- The article [41], reveals that dropout is significant in engineering programs, among which factors such as the gender of the students stand out because women tend to have higher dropout rates than men, this is due to a lack of female representation, which can leave women feeling isolated due to the absence of supportive female role models and mentors. Additionally, students with lower high school grades are more likely to drop out of the program, as they may not be sufficiently prepared for the academic demands of these programs. Finally, those students who do not consider engineering as their first choice of study tend to have higher dropout rates due to their lack of interest or motivation in the field.
- On the other hand, document [42], points out that students in STEM disciplines (science, technology, engineering, and mathematics) experience high levels of emotional

exhaustion, disillusionment, and reduced work efficiency due to the intense workload, pressure competitiveness, and the feeling of lack of progress in studies, which is closely related to the possibility of students dropping out.

- The authors of [13], indicate that in areas of social sciences and humanities, student dropout is notably high. One of the main reasons is low participation in academic and social activities. Therefore, students who do not feel connected to their academic environment or do not actively participate in university life tend to feel unmotivated and isolated, which leads them to make the decision not to continue with their studies.
- Article [43], indicates that the areas of education and administration, which attract adult students, have high levels of dropout. This is due to the exposure of students to additional responsibilities, such as work and family, reasons why they do not receive sufficient support from institutions, which prevents them from managing these burdens.

3.4 RQ4 (What Do the Authors Think About the Impact that Student Dropout in Higher Education Generates on Society?)

To address question RQ4 (What do the authors think about the impact that student dropout in higher education generates on society?), followed by the analysis of the documents, it was possible to identify perspectives and conclusions given by different authors about the social impact of dropout. Student desertion. Below is a summary of these:

- In [8], they highlight that students drop not only students but also the government, higher education institutions, and indirectly companies. To address this problem, the government has the task of creating policies and allocating resources to support student retention programs. Educational institutions must apply strategies to identify and help students at risk of dropping out of their studies. Additionally, companies can contribute by offering financial support and internship opportunities. This suggests that this phenomenon is a shared responsibility that requires joint participation that can guarantee a promising future for everyone.
- In this article [19], the authors highlight the urgent need to address student dropout and the importance of using advanced techniques, such as machine learning, to identify patterns using sociodemographic characteristics. They also argue that reducing attrition can have significant benefits for society, such as increasing the number of graduate students and improving educational equity.
- In this study [44], the authors state that academic resilience plays an important role in reducing dropout because it promotes student retention and academic success. These authors highlight the importance of strengthening students' ability to overcome academic and personal challenges.

3.5 Definition of Inclusion and Exclusion Criteria

Addressing RQ5 (Are there studies that validate dropout as a significant challenge in higher education?), certain studies were established within the documents investigated that validate how dropout represents a significant challenge for higher education. A classification of the key points provided by the studies was made.

A study [2], indicates the challenge of dropout by demonstrating that academic engagement is a crucial factor that can influence dropout rates. Focusing on these features:

- The association between academic performance and commitment
- Relationship between academic commitment and dropout
- The recent focus on academic participation is to understand the areas of influence of desertion and how to counteract this phenomenon.

The use of robust methodologies such as CRISP-DM with which behavioral patterns in students were sought to identify influential factors in dropout, the approach to better understand the factors that affect performance and therefore dropout, the identification of indicators specifics that can predict dropout through this methodology, are indicators that show the need for a detailed and multifaceted analysis of academic performance to identify and support students at risk of dropout and ultimately the relevance that this topic represents [34].

In a study [12], the development of software that allows predicting the academic performance of students and creating strategies to reduce student dropout rates was proposed. In this research, a qualitative methodology was used with advanced supervised learning techniques, and classifiers such as J48 were used where the classification of the instances was 92.6307%, which highlights the precision and effectiveness of the software to predict academic dropout, these are investigations that demonstrate the importance that desertion represents today.

Research from one study [40], highlights dropout as a serious problem at the university level. This initial statement underlines the magnitude and seriousness of the problem, it also highlights the difficulty with which students manage to graduate, with the graduation rate discrepant with that of students who enroll, which indicates the persistence of dropout, representing a significant concern. For interested universities and entities.

A study [45], that validates dropout as a significant challenge in South Korean education where it is considered that it is not being sufficiently addressed, recognizes the high impact, addresses this problem from various aspects of the student, uses methodologies such as the use of non-linear panel data models providing results that highlight certain key and influential factors.

As the last reference of the studies that provide an answer to this question, we find a study that focuses on online students, where it is determined that school dropout (SDP) is a significant phenomenon that has an impact on both students, teachers, and institutions, It is an impact that validates the importance of addressing this problem not only from the student perspective but also from the university and teachers, this study provides an approach to the evolution of analytical exams using learning techniques efficiently and accurately to address this challenge, detecting those students at risk of dropping out [46].

4 Conclusions

Academic dropout in higher education is a critical phenomenon that affects students, educational institutions, and society in general. This refers to the interruption of students' studies before completing their training, which leads to the loss of educational and

personal development opportunities, while for institutions it represents inefficiency and additional costs. On the other hand, at a social level, human talent is reduced, which affects economic and social progress.

The systematic mapping in this study (Sect. 2) has allowed a clear understanding of student dropout, where it reveals strategies to obtain early warnings and prevention during the first semesters of study. Through a meticulous methodology, it was possible to identify and analyze relevant studies, providing a vision of the outstanding practices and approaches to face this challenge. We began the analysis with 3372 articles which, after carrying out a careful inspection, discarded those articles that did not meet the defined exclusion and inclusion criteria. Therefore, the remaining 50 articles produced the relevant evidence to answer the research questions presented in Sect. 2.1-RQ1: What are the research objectives and contributions of studies on dropout in higher education? RQ2: What are the most common strategies proposed to address and prevent student dropouts in higher education? RQ3: In which areas of knowledge is a higher incidence of student dropout observed in higher education? RQ4: What do the authors think about the impact that student dropouts in higher education generate on society? RQ5: Are there studies that validate student attrition as a significant challenge in higher education?

According to the results presented in Sect. 3, the main objectives of research on academic dropout in higher education focus on identifying the causes of this phenomenon and proposing useful solutions. Furthermore, the research contains a diversity of areas of knowledge, which indicates the breadth of the impact that this phenomenon causes. Some studies focus especially on strategies to prevent dropout, while others combine multiple approaches, such as personalized tutoring, mentoring programs, and the use of educational technologies. There is also research that validates the efficiency of these strategies both individually and in combination. This review highlights the importance of the contributions, which establish a solid foundation for future studies and make it clear that intervening in academic dropout is important to improve performance and impact in educational institutions. With this analysis, we provide educational communities with an overview of current research and highlight the need to continue exploring new strategies to counteract attrition, thereby creating opportunities for future research.

References

1. Baranyi, M., Nagy, M., Molontay, R.: Interpretable deep learning for university dropout prediction. In: Proceedings of the 21st Annual Conference on Information Technology Education [Internet], pp. 13–9. ACM, New York, NY, USA (2020). https://doi.org/10.1145/3368308.3415382
2. Bedregal-Alpaca, N., Tupacyupanqui-Jaén, D., Cornejo-Aparicio, V.: Analysis of the academic performance of Systems Engineering students, possibilities of dropping out and proposals for their retention. Ingeniare Chilean engineering magazine [Internet] **28**(4), 668–83 (2020). http://www.scielo.cl/scielo.php?script=sci_arttext&pid=S0718-33052020000400668&lng=en&nrm=iso&tlng=en
3. Berka, P., Marek, L.: Bachelor's degree student dropouts: Who tends to stay and who tends to leave? Stud. Educ. Eval. **70**, 100999 (2021)
4. Bonaldo, L., Pereira, L.N.: Dropout: Demographic Profile of Brazilian University Students. Procedia - Social and Behavioral Sciences [Internet] **228**, 138–43 (2016). https://linkinghub.elsevier.com/retrieve/pii/S1877042816309466

5. Burgos, C., Campanario, M.L., de la Peña, D., Lara, J.A., Lizcano, D., Martínez, M.A.: Data mining for modeling students' performance: a tutoring action plan to prevent academic dropout. Comput. Electr. Eng. **66**, 541–556 (2018)
6. Chindoy Chasoy, B.Y., Diaz Pedroza, K.Y., Rosado Gómez, A.A.: Development of software to predict academic performance using data mining techniques and tools. Journal of Physics: Conference Series [Internet] **1708**(1), 012037 (2020). https://doi.org/10.1088/1742-6596/1708/1/012037
7. Christou, V., Tsoulos, I., Loupas, V., Tzallas, A.T., Gogos, C., Karvelis, P.S., et al.: Performance and early drop prediction for higher education students using machine learning. Expert Syst. Appl. **225**, 120079 (2023)
8. da Cruz, R.C., Juliano, R.C., Monteiro Souza, F.C., Correa Souza, A.C.: A score approach to identify the risk of students dropout: an experiment with Information Systems Course. In: Proceedings of the XIX Brazilian Symposium on Information Systems [Internet], pp. 120–7. ACM, New York, NY, USA (2023). https://doi.org/10.1145/3592813.3592896
9. Elmehdi, H.M., Zawam Dalah, E., Bukhatir, A., Ibrahem, A.M.: Retention at the University of Sharjah: Factors and Strategies. In: 2020 Advances in Science and Engineering Technology International Conferences (ASET), pp. 1–6. IEEE (2020)
10. Feng, G., Fan, M.: Research on learning behavior patterns from the perspective of educational data mining: Evaluation, prediction and visualization. Expert Syst. Appl. **237**, 121555 (2024)
11. Fior, C.A., et al.: IMPACT OF SELF-EFFICACY AND ACADEMIC PERFORMANCE IN THE DROPOUT OF HIGHER EDUCATION STUDENTS. School and Educational Psychology [Internet] 26 (2022). http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1413-85572022000100322&tlng=en
12. Gupta, K., Gupta, K., Dwivedi, P., Chaudhry, M.: Binary Classification of Students' Dropout Behavior in Universities using Machine Learning Algorithms. In: 2024 11th International Conference on Computing for Sustainable Global Development (INDIACom), pp. 709–14 IEEE (2024)
13. Guzmán-Castillo, S., et al.: Implementation of a Predictive Information System for University Dropout Prevention. In: Procedia Computer Science (2022)
14. Hegde, V., Prageeth, P.P.: Higher education student dropout prediction and analysis through educational data mining. In: 2018 2nd International Conference on Inventive Systems and Control (ICISC) [Internet], pp. 694–9. IEEE (2018). https://ieeexplore.ieee.org/document/8398887/
15. Kayanda, A.M., Machuve, D.: A web-based data visualization tool regarding school dropouts and user assessment. Engineering, Technology & Applied Science Research [Internet] **10**(4), 5967–73 (2020). http://etasr.com/index.php/ETASR/article/view/3411
16. Kemper, L., Vorhoff, G., Wigger, B.U.: Predicting student dropout: A machine learning approach. European Journal of Higher Education [Internet] **10**(1), 28–47 (2020). https://doi.org/10.1080/21568235.2020.1718520
17. Kim, D., Kim, S.: Sustainable education: analyzing the determinants of university student dropout by nonlinear panel data models. Sustainability. **10**(4), 954 (2018)
18. Krüger, J.G.C., Britto, A. de S., Barddal, J.P.: An explainable machine learning approach for student dropout prediction. Expert Systems with Applications, 233 (2023)
19. Kuzilek, J., Zdrahal, Z., Fuglik, V.: Student success prediction using student exam behavior. Futur. Gener. Comput. Syst. **125**, 661–671 (2021)
20. Lam-On, N., Boongoen, T.: Using cluster ensemble to improve classification of student dropout in Thai university. In: 2014 Joint 7th International Conference on Soft Computing and Intelligent Systems, SCIS 2014 and 15th International Symposium on Advanced Intelligent Systems, ISIS 2014 (2014)

21. Llauró, A., Fonseca, D., Romero, S., Aláez, M., Lucas, J.T., Felipe, M.M.: Identification and comparison of the main variables affecting early university dropout rates according to knowledge area and institution. Heliyon. **9**(6), e17435 (2023)
22. Maldonado, S., Miranda, J., Olaya, D., Vásquez, J., Verbeke, W.: Redefining profit metrics for boosting student retention in higher education. Decis. Support Syst. **143**, 113493 (2021)
23. Marbouti, F., Diefes-Dux, H.A., Madhavan, K.: Models for early prediction of at-risk students in a course using standards-based grading. Computers and Education, 103 (2016)
24. Martins, M.v., Baptista, L., Machado, J., Realinho, V.: Multi-Class Phased Prediction of Academic Performance and Dropout in Higher Education. Applied Sciences **13**(8), 4702 (2023)
25. Matz, S.C., Bukow, C.S., Peters, H., Deacons, C., Stachl, C.: Using machine learning to predict student retention from socio-demographic characteristics and app-based engagement metrics. Scientific Reports **13**(1) (2023)
26. Moreira da Silva, D.E., Solteiro Pires, E.J., Reis, A., de Moura Oliveira, P.B., Barroso, J.: Forecasting Students Dropout: A UTAD University Study. Future Internet **14**(3) (2022)
27. Mubarak, A.A., Cao, H., Hezam, I.M.: Deep analytical model for student dropout prediction in massive open online courses. Comput. Electr. Eng. **93**, 107271 (2021)
28. Nurmalitasari, A.L.Z., Faizuddin Mohd Noor, M.: Factors Influencing Dropout Students in Higher Education. Education Research International 2023 (2023)
29. Olaya, D., Vásquez, J., Maldonado, S., Miranda, J., Verbeke, W.: Uplift Modeling for preventing student dropout in higher education. Decision Support Systems 134 (2020)
30. Paura, L., Arhipova, I.: Cause Analysis of Students' Dropout Rate in Higher Education Study Program. Procedia - Social and Behavioral Sciences 109 (2014)
31. Pecuchova, J., Drlik, M.: Predicting students at risk of early dropping out from course using ensemble classification methods. Procedia Computer Science **225**, 3223–3232 (2023)
32. Phan, M., de Caigny, A., Coussement, K.: A decision support framework to incorporate textual data for early student dropout prediction in higher education. Decision Support Systems 168 (2023)
33. Prenkaj, B., Stilo, G., Madeddu, L.: Challenges and Solutions to the Student Dropout Prediction Problem in Online Courses. In: Proceedings of the 29th ACM International Conference on Information & Knowledge Management, pp. 3513–4. ACM, New York, NY, USA (2020)
34. Rodrigues, H., et al.: Artificial Intelligence Algorithms to Predict College Students' Dropout: A Systematic Mapping Study. In: Proceedings of the 16th International Conference on Agents and Artificial Intelligence. SCITEPRESS - Science and Technology Publications, pp. 344–51 (2024)
35. Yes, M.J.: Student Academic and Social Engagement in the Life of the Academy—A Lever for Retention and Persistence in Higher Education. Education Sciences **13**(3) (2023)
36. Srairi, S.: An analysis of factors affecting student dropout: the case of tunisian universities. Int. J. Educ. Reform. **31**(2), 168–186 (2022)
37. Tenjo-García, J.S., Figueroa-García, J.C.: Analysis of student dropout in industrial engineering students using computational intelligence techniques. In: 2024 IEEE World Engineering Education Conference (EDUNINE), pp. 1–6. IEEE (2024)
38. Timaran Pereira, R., Caicedo Zambrano, J.: Application of decision trees for detection of student dropout profiles. In: 2017 16th IEEE International Conference on Machine Learning and Applications (ICMLA), pp. 528–31. IEEE (2017)
39. Tiukhova, E., Vemuri, P., Flores, N.L., Islind, A.S., Óskarsdóttir, M., Poelmans, S., et al.: Explainable learning analytics: assessing the stability of student success prediction models by means of explainable AI. Decis. Support Syst. **182**, 114229 (2024)
40. Truta, C., Parv, L., Topala, I.: Academic engagement and intention to drop out: Levers for sustainability in higher education. Sustainability (Switzerland) **10**(12) (2018)

41. Turhan, D., Scheunemann, A., Schnettler, T., Bäulke, L., Thies, D.O., Dresel, M., et al.: Temporal development of student burnout symptoms: Sociodemographic differences and linkage to university dropout intentions. Contemp. Educ. Psychol. **73**, 102185 (2023)
42. Vaarma, M., Li, H.: Predicting student dropouts with machine learning: an empirical study in Finnish higher education. Technol. Soc. **76**, 102474 (2024)
43. Vega, H., Sanez, E., de La Cruz, P., Moquillaza, S., Pretell, J.: Intelligent System to Predict University Students Dropout. International journal of online and biomedical engineering **18**(7) (2022)
44. Venegas-Muggli, J.I.: Higher education dropout of non-traditional mature freshmen: the role of sociodemographic characteristics. Studies in Continuing Education **42**(3) (2020)
45. Viloria, A., et al.: Integration of data technology for analyzing university dropout. In: Procedia Computer Science (2019)
46. Viloria, A., Pineda Lezama, O.B.: Mixture structural equation models for classifying university student dropout in Latin America. Procedia Computer Science. **160**, 629–634 (2019)
47. Wild, S., Schulze, H.L.: Student dropout and retention: An event history analysis among students in cooperative higher education. Int. J. Educ. Res. **104**, 101687 (2020)
48. Xenos, M., Pierrakeas, C., Pintelas, P.: A survey on student dropout rates and dropout causes concerning the students in the Course of Informatics of the Hellenic Open University. Comput. Educ. **39**(4), 361–377 (2002)
49. Yilmaz, T., Sarpkaya, R.: A case study on university dropout: perspectives from educational faculty students and academicians. Res. Educ. Administr. Leaders. **7**(3), 519–559 (2022)
50. Zumárraga-Espinosa, M.: Academic resilience, performance and intention to drop out in university students from Quito. Latin American Journal of Social Sciences, Children and Youth. **21**(3), 1–34 (2023)
51. Petersen, K., Feldt, R., Mujtaba, S., Mattsson, M.: Systematic mapping studies in software engineering. from Proceedings of the 12th international conference on Evaluation and Assessment in Software Engineering, Italy (2008)