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AN OVERVIEW OF THE CURRENT PROGRESS OF THE HEI'S SUPPORT SYSTEMS FROM THE ENTRANTS' PERSPECTIVES

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Abstract. One of the strategically important processes of the higher education institution activity is the enrollment campaign. In the information and knowledge society, the effectiveness of its implementation depends on many factors, one of which is the use of information technology. Therefore, the purpose of this paper is to examine current researches and determine the existing trends aims to support the decision-making of HEI`s and major from entrants perspective. This literature review uses Scopus and Web of Science databases and Google Scholar web search engine. Major findings include three lines of research that generate contributions on this topic: predicting the success of admission, recommendation of the major or education institution, and investigation of factors influencing the entrant`s choice. The review indicates that the most common is the use of data mining to solve researches tasks. The results of this study allow us to identify key points that are critical at the initial stage of solving decision support issues and to detect the main future directions of research.

Key words: entrants, higher educational institution (HEI), major, decision support, literature review.

Анотація. Одним із стратегічно важливих процесів діяльності вищого навчального закладу є вступна кампанія. В суспільстві інформації та знань ефективність його реалізації залежить від багатьох факторів, одним із яких є використання інформаційних технологій. Тому, метою цієї роботи є вивчення поточних досліджень та визначення їх тенденцій, спрямованих на підтримку прийняття рішень щодо закладу вищої освіти та спеціальності з точки зору абітурієнтів. У цьому літературному огляді використано наукометричні бази даних Scopus та Web of Science, а також пошукову систему Google Scholar. Основні висновки полягають у виділення трьох напрямів досліджень, які створюють внесок у цій темі: прогнозування успішності вступу, рекомендація спеціальності або навчального закладу та дослідження факторів, що впливають на вибір абітурієнта. Огляд свідчить, що найпоширенішим є використання добування та аналізу даних для вирішення завдань дослідженнь. Результати цього дослідження дозволяють визначити ключові моменти, які є критичними на початковому етапі вирішення задач підтримки прийняття рішень, та виявити основні майбутні напрямки досліджень.

Ключові слова: вступники, заклад вищої освіти (ЗВО), спеціальність, підтримка прийняття рішень, огляд літератури.
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Introduction

Information technology (IT) has become an essential part of education institution activity and certainly their competitive advantage. IT has to be an enabler for various efforts of managers to enhance the quality, effectiveness, and accountability of higher education institution (HEI). All implemented technologies must meet the strategic goals such as improving competitive ranking, improving brand image, improving quality of learning and teaching, increasing student satisfaction, increasing revenues, expanding student base, improving quality of service, etc. In addition to its essential role, it is necessary to provide sustainability and continuous improvement processes. Therefore, the implementation of technology requires a detailed analysis of existing modern methods and tools capable of solving current problems facing HEIs

This study examines the application of IT in the scope enrollment campaign to a HEI. Admission into HEI is a complex decision-making task that is more than just passing tests and admission requirements. The way the student chooses the HEI to take admission and alternately the HEI selects, a student to admit has a significant impact on both sides' success [1], [2]. The need to support the decision-making of HEI entrants is currently due to several objective reasons, including:

- increasing the amount of information coming from different educational institutions and generated at the level of government (some criteria for admitting students with many details, including educational institutions; a large number of educational institutions and educational offers); besides, it could also occur data unavailability and its evaluation problems;
- a complication of the tasks facing the entrant (annual change of admission rules and their difference in different institutions);
- the need to take into account a large number of interrelated factors and rapidly changing requirements (factors that affect the popularity of a particular specialty and lead to unpredictable competition for a place among entrants, etc.);
- the desire of applicants to get rid of the uncertainty associated with the inability to assess their chances of admission clearly;
- the importance of the consequences of decisions made (decision could negatively affect both the student and his self-realization - student success, employment, and ranking of the university).

Because of the influence of the factors mentioned above, decisions on admission to a particular major could be made intuitively and be unsuccessful. In addition, since making the right decisions is of utmost importance for entrants and HEIs, there is a need to use methods and techniques that reduce the applicant's risk of making the wrong decision. Such technologies should summarize, analyze information, adapt to changes, and make decisions at the user's request.

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A lot of existing research towards supporting decision-making on a course or program selection is designed for existing students. Today universities have flexible curricula that offer a wide range of elective courses. Therefore, the student often cannot choose the appropriate course for his/her curriculum [3]. In this context, HEI usually employs guidance counselors to help students determine steps to make their educational experience personally relevant and valuable. However, even in those cases, recognizing, planning, and applying approaches for academic success do not always yield a good outcome [4]–[7]. In addition, there is a lot of research on decision-making towards practical major selection, but they aim to support HEIs managers. When used for student enrollment, prediction primarily aids understanding for enrollment trend analysis and could influence future strategy and resource decisions [8]–[10]. However, there is no consolidated overview of the systems and technologies that support decision-making exactly from the entrant's perspective. Therefore, in this study, we aim to describe current trends and specific approaches that support decision-making for HEIs applicants

This paper aims to answer the research question:

1. What are the main concepts of modern research that applies to information systems and technologies of HEIs entrants decision support process.
2. What current methods, techniques, and approaches are used in previous studies to solve the tasks.
3. What are the important factors that are critical at the initial stage of building information systems for the support of HEIs entrants`.

Backgrounds

The enrollment process to HEI varies widely in different countries and sometimes in education institutions. However, in any case, the entrant has to choose an educational institution and major apply to. Each HEI sets its own requirements, deadlines, and restrictions that must be met by applicants.

The government in different countries and the HEIs pay a lot of attention to the admission process itself. In many cases, entrants involve a possibility to use apply to university online. This kind of system includes all stages, including payment. They are easy to use and must be paid for. Katholieke Universiteit Leuven in Belgium (www.kuleuven.be), École Polytechnique Fédérale de Lausanne in Switzerland (www.epfl.ch), University of Groningen in Netherlands (www.rug.nl), University of Oslo in Norway (www.uio.no) have its web portal for applications and admission. Because of the peculiarity of the organization of the educational process of a country, for example, in the UK, there is a Certified Bachelor's Degree Program and Universities and Colleges Admissions Service, UCAS (www.ucas.com).

Guided by various factors, entrants choose the educational institution and major for admission. Given the difficulty, a natural solution is to apply to a large number of universities. However, a large number of applications occurs high investment of time and energy. In some countries, applications are pay. In some, such as Ukraine, the number of applications that can be submitted to HEIs is limited. The University of Edinburgh (www.ed.ac.uk), Oxford (www.ox.ac.uk), Cambridge (www.cam.ac.uk), and London Universities have introduced online consultations conducted to coordinate candidates in the rational choice of course of study or college for entrants. However, the disadvantage is the impact of the human factor. Therefore, there is a necessity to implement an approach that allows applicants to make knowledgeable decisions by assessing their chances of admission.

One of the most effective computer-based information systems are decision support systems (DSS), that by collecting and analyzing large amounts of relevant information in the educational domain focuses on providing appropriate support to improve decision quality. DSS emerged in the early '70s of the last century due to the development of management information systems and are a category of IT that includes any tools that accurately predict the effects of possible decisions. In most cases, this means providing decision-makers with meaningful information that is relevant to a given decision. Due to the current pace of development of IT, DSS is constantly improving in increasing the level of intellectualization and is increasingly used in education. Various modern approaches and methods are used in DSS development today, including expert assessments, neural networks, optimization methods, regression analysis, etc. In addition, DSS can be used to select solutions unstructured and poorly structured tasks, including those with many criteria. This makes it possible to implement DSS at different levels of management of the educational institution, particularly during the enrollment campaign. However, given the wide range of possible approaches to building a system, developers are constantly faced with finding the most effective in each task. As well there is an increasing number of research toward the impact of recommender systems in education domains [11]. Nowadays, the recommender system is more reliable in various areas by applying algorithms concentrating on user-centric and real-time relevance feedback. It provides a solid and accurate result of recommendation [12]. The output of a recommender system is usually a list of prioritized content. In contrast, the production of a decision-making support system attempts to reach a single conclusion with an accurate confidence level.

Search strategy

We conducted a review of research using Scopus (https://www.scopus.com) and Web of Science (https://www.webofscience.com) online literature database, and Google Scholar web search engine. This study

present the PRISMA scheme, which demonstrates the identification and screening of potentially acceptable studies, and determines the number of studies included in the analysis. The workflow diagram for the systematic identification of scientific literature is shown in Figure 1. Search terms included different combinations of keywords related to "university", "higher educational institutions", "college", "enrolment", "admission", "prediction", "decision-making", "decision support", "decision support systems", "major" joined by operators "OR" and "AND" and different word endings. Search queries were used including the above term for retrieval of primary studies. The search was performed in January 2022. It was targeted to retrieve recent studies from the last five years. The identification process was made using such a database queries and its modification:

- Scopus: TITLE ((hei OR univer* OR colleg*) AND (support OR decision OR prediction OR "decision-making") AND (enroll* OR admiss* OR entrant*)) - 98 results
- WoC - (TI=((hei OR univer* OR colleg*) AND (support OR decision OR prediction OR "decision-making") AND (enroll* OR admiss* OR entrant*))) - 81 results

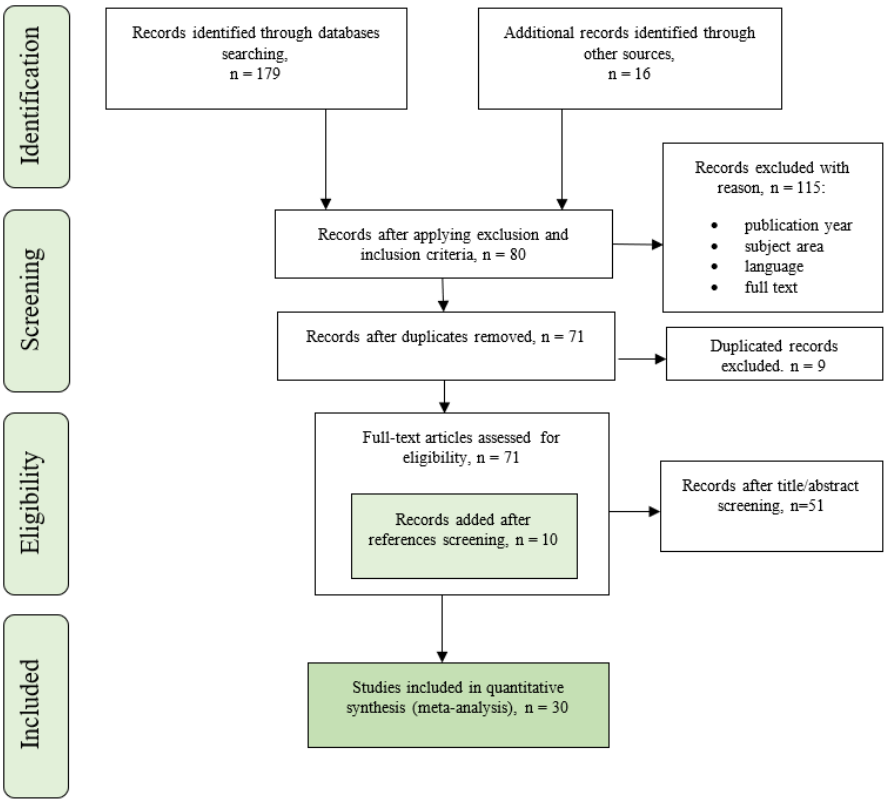

Figure1 – PRISMA workflow for systematic identification of scientific literature

Identified documents was screening in accordance with a set of inclusion and exclusion criteria. Inclusion criteria means that: articles should apply to technologies, systems or methods designed to support HEIs entrants decision making; published in English; published between January 2022 and January 2017; full text available. Exclusion criteria: repeated articles; the study is not available on the web. To apply these criteria in addition to search query we use databases filter tools.

The resulting set allowed us to identify the main studies to which the majority refers. Literature references and related documents based on references (proposed by the system on the documents page) that meet the criteria we also included to results set. To get the set of eligible studies we applied additional inclusion-exclusion criteria. The analysis of full-text studies allowed us to reject works not related to the desired context that were selected.

Data extraction and results

In this work, 30 studies meeting the inclusion criteria were analyzed. Data extraction and its analysis according to current research trends is provided in this section. We group selected studies based on main tasks mentioned by authors of reviewed studies that aimed to support decision making exactly from students' perspective. It should be noted that a significant part of the considered works focused on approaches to assist universities in admissions decision-making or predicting future students' academic performance. Such research plays an essential role in the management and helps the administration reform the marketing models for the institution's overall development.

The main goals identified in studies considered in this paper can be grouped into several concept: predicting the success of admission, recommendation of the major or education institution defining factors influencing the choice of entrant. A few research combine several other goals like defining the number of students ready to join the college, elucidating the predictors that affect the individuals' preparations for university entrance exams, etc. [13].

Major concepts identified: assessment admission chances

This section aims to emphasize and analyze the existing methods for predicting students' admission to a particular university. We will describe some of them in more detail.

S. Sridhar and other authors proposed a stacked ensemble model built to define probabilities to enroll in HEI [14]. The study includes different factors associated with the entrant, particularly their research and industry experience etc. An advantage, in this case, is that the authors assessed several ML algorithms, including other deep learning methods. As the proposed model easily outperforms all other models and provides high accuracy. The authors recommended using the most extensive dataset and Natural Language Processing methods to evaluate the essays and letters as new details regarding the applicants to increase the prediction accuracy.

In another study, researchers deployed the gradient boosting regressor model considering a student's academic successes and university rating. They proposed the probability of admission to that university as an output result [16].

Using different types of artificial intelligence (AI) algorithms, other authors proposed Graduate Admissions Prediction framework [19]. Besides that, a user interface to interact with scholars to see the result was proposed. But from the proposed work users are able to identify chances to get a seat without possibility to get a list of universities in which they can obtain admission.

M. A. Khan, M. Dixit and A. Dixit emphasize the need to save entrants' time and increase their chances of admission to particular graduate programs [20]. They have pitted various ML algorithms against each other to get the best of them. Formed clusters of similar applicants was labeled if they are a correct fit for admission.

Researchers in another study highlighted a task that the entrants do not always clearly understand to which education institution they might get admission to, so they could spend a lot of money and time [21]. Therefore, authors proposed a model that provides the future student with information about their chances to enter the particular university. To make the program available to users, authors developed GUI.

Major concepts identified: recommendation systems

Recommendation system, presented in overviewed study as usual, presents like a subclass of information filtering system, which builds a rating list of objects that the prospective student may prefer. This kind of system is considered an essential tool that can predict and give recommendations, intended to meet users' interests and expectations and solve information overload about HEIs and their majors. User's profile data (set of preferences and interests) and all possible datasets are used to provide recommendation's process results. According to the research objectives (goals) of recent studies, they usually are divided in certain groups such as: choosing programs/majors, selecting courses, long-term academic planning. Therefore, some of the studies we have considered are recommendation systems, several of which we will consider in more detail.

One of paper presents a Personalized Career-path Recommender System (PCRS) based on fuzzy intelligence of N-layered architecture. It uses students' academic achievement, personality type, and extra-curricular skills [37]. The main objective of PCRS is to simulate admission expert roles and support future engineering students to make the best decision. The advantage of the system is a scalable design with the possibility to be extended in the future to consider other academic majors of HEI.

The objective of other work is to assess students and, at the same time to help lead the student to the relevant major [31]. Question Answering (QA) technique was used to analyze textual data (questions) and find the correct answer. The proposed framework includes three modules: data mapping module, rules extraction module and QA module. Authors defined two main challenges: data availability and system validation to check if future students' performance goes in line with the system recommendations.

Other authors propose an Intelligent Decision Support System designed using Fuzzy Expert System [32]. A cluster-based preferences technique is performed to obtain the student's favored majors, applying distance measurement. Results showed that 66% were intensely pleased with the system, and 54% were pleased with suggested majors. However, the accuracy and performance of such a system have not been verified enough.

A part of search results includes research that has been done in the field of Educational data mining (EDM). They are based on data generated by various educational systems that are integrated into the educational process. Most of the developed methods and models are intended to investigate the profiles and behaviors of students or entrants and, accordingly, to predict their success. Only a small part of those studies use educational data to contribute to applicants' effective decision making. Unlike most studies, which address the issue of predicting students' achievement at one stage of their study, some study aims to assist students in their decisions throughout their study years. At enrollment, this work predicts a student's GPA in different majors using enrollment data such as high school average, placement test results, and IELTS score [35]. Researchers

emphasize that discovering knowledge from the academic profile of successful graduate applicants and applying it properly for providing or achieving guidelines could be beneficial for the prospective graduate applicants.

Major concepts identified: factors influencing the choice of entrant

Another direction is determining and analyzing affecting factors for the admission to HEI and its results. The central purpose of those research works is to analyze enrollment patterns in HEI and the factors affecting these patterns to enhance the overall performance of the education area [39]–[41]. Authors have discovered knowledge from previous year successful applicants' academic profile with aim to use this data for prospective graduate applicants. Tuition fees, location, institution ranking, institution facilities, employment opportunities, and social media application thus could have a significant relationship with decision-making results. The obtained key factors that are analyzed for various case studies provide a set of trends that influence enrollments. So the results of the influence of external or internal factors on entrant's decision-making can also be used in the development of DSS.

Analysis of researches` methods and techniques

Most of those studies that aim predicting the success of admission or recommendation of the major or education institution bases on data mining. Table 1 presents distribution of studies by task.

Table 1 – Distribution of studies by task

Main Task	Main Research Results
Classification	• predictive model that determine the chances of a student getting accepted by a college [13], university [18]; •classificated value whether a student can be admitted by his or her target university or not [25]; •defined variables that have high impact on entrants decision making [13], [14]; •variables pattern which can predict the future happenings on (re-)entering university [38]; •recommendations in the selection of departments.
Prediction	• prediction of the chances of admit of a student to a particular college or university program [14], [16], [19]–[22], [30]; •college admission score prediction [15]; •best regression models for prediction of graduate admissions [17]; •recognizing and targeting the universities which are best suitable for their profile and prediction of the future applicant's university chance of admission [32]; •prediction the probability of getting fund[12].
Clustering	•cluster similar universities [18], factors affecting the trend of enrollments [34], [39].

The tasks that were set, the researchers explained the ultimate goal, such as: saving entrants` time and money (each application is paid), avoiding their unsuccessful future study performance, avoiding early exclusion and exclusion in general, increasing satisfaction with the chosen field of study, increasing the level of employment. To extrapolate patterns and new knowledge from the data that researchers have collected, different data mining techniques were used (Figure 2).

The considered studies were provided according to the needs of the first-year entrants [13], [21]–[23], [27], [29], re-admission [38], masters level [12], [16], [17], [25], [33], [40], postgraduate students [14], [18]–[20], [28], [32], [36], for students who apply for the admissions of abroad universities [25].

The researchers used data sets that contained:

- past enrollment dada: for example, past data of college-wise allotment based [13], data present on Edulix (https://www.edulix.com) [14], [18], [29];
- previous year entrants dataset from similarly graduate programs [12], [17], [20], [21], [30], [39];
- survey results: [22], [34], [38], [41];
- students data: the dataset of graduated students' [16], academic data of successful students who have already got an opportunity to study [28], [29], the academic background information of previous undergraduate students and the application results of their target universities [25], some personal and academic information of a particular student [36];
- universities advisers [25];
- current user data [19], [27], [29], [31], [33].

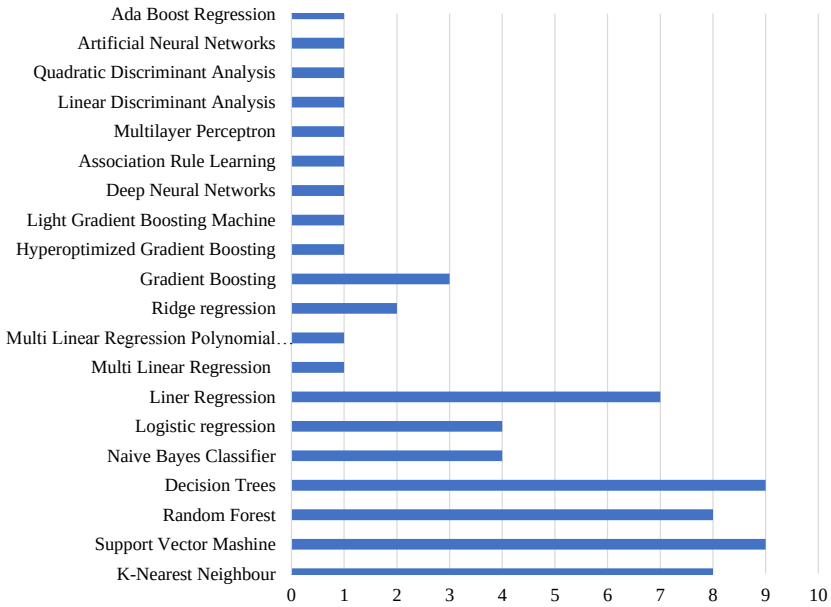

Figure 2 – Distribution of studies by methods

Discussion and future research

Current research highlights that choosing HEI and specific majors is a complex and challenging process with long-term consequences. Future students usually choose HEI and majors considering the advices of their tutors, family and their entrance exam results [38]. Some online resources support these matters, but they could be not precise enough and do not examine all the affecting results data. Furthermore, some existing experts offices could make entrants spend much time and money, without a guarantee of giving fully true information. As a result, many students spend months and years of preparation focusing on things that, unfortunately, will not improve their chances of getting into the desired institution [20]. Due to unconscious choice, the chosen program is often not as expected, which causes low motivation during the study process [19], [38]. To make a appropriate decision, a student needs an expert opinion, time, and effort. So the need to create a system that would help entrants make effective choices is obvious.

In this study, we define three main research concept in order to support HEIs entrants, such as predicting the success of admission, recommendation of the major or education institution and investigation factors influencing the choice of entrant.

Because of high competition in applying to HEI and the payment of every application, entrants in most cases choose a few of HEI only. Therefore, it could be helpful to entrants to use a prediction system to determine their possibilities of becoming a student of particular HEI based on their educational achievements. This prediction system could help entrants reduce the list of possible HEI or majors and determine their chances of getting into the desired HEI. Therefore, researches in overviewed studies emphasize the usefulness of university admission prediction systems to determine their chances of acceptance to a specific HEI. From the latest studies, it is obvious that using historical, current, and continuance data relationships from an educational context is really useful in terms of providing prediction in the HEIs admission process. Most papers evaluate these models to select the best effective model with the highest accuracy rate and the least error.

A large part of the studies proposes a solution to implement the most accurate method to recommend major considering entrants' preference, skills, and abilities. Also, because of the appearance of flexible curriculum policies, many HEI proposes a broader list of courses and majors. So entrants have to make the best use of available information to make more informed decisions. This contributed to the emergence of a particular research direction investigating information systems called Academic Advising System (AAS). This kind of software solution could provide support and motivation to the student's study plan building process, and assisting in the achievement of their educational goal. This, in turn, could increase the effectiveness of the HEI managers' strategy and, accordingly education process in general. Mostly these are recommendation systems. However, AAS requires dealing with a significant decision space, many factors influencing the choice, and many constraints (e.g., course prerequisites, maximum credit hour load, course priorities, etc.). However, AAS requires a significant decision range, many factors influencing the choice, and many restrictions (e.g., course prerequisites, maximum credit hour load, course priorities, etc.).

However, existing studies have some disadvantages:

- insufficiently dedicated to the Graphical User Interface, there are only in a few studies [19], [21], [27], [28], [33];

- in most cases there is no comparison with other machine learning methods;
- insufficient factors are taken into account that may affect the outcome of the system;
- some uncontrollable factors such as significant political and economic changes are not put into our consideration. Family financial conditions and parental education levels will affect student admissions, but it could be impossible to obtain these data in some cases. Therefore, most studies ignore them;
- all works concern a specific country, HEI and even the level of education. DSS is in essence such that it can be very specific, focused only on a certain type of problem. Hence, in each of the studies we see a focus on a specific country, institution, and the direction and level of education.

The results of the analysis of existing research show that the implementation of methods and techniques of machine learning give high accuracy results when used to support applicants. The obtained results are quite accurate and allow the implemented research methods in the construction of the system, which assess the chances of entry and recommend the most appropriate areas for users. However, in addition, there may be other tasks included in the system. We assume that the effectiveness of support for entrants can be increased by combining in one system the functionality of predicting the success of entry and the offer of an alternative of specialty for the user.

We assume that future research should be directed towards data collection and preprocessing. Discovering the hidden knowledge from those students' academic records and applying it properly for decision-making will be very much helpful. Other data sources can be past enrollment data, survey results, user profile data (set of preferences and interests). In addition, it is necessary to explore a variety of independent traits that will affect the outcome of prediction and recommendation. Since the limited number of indicators considered in the calculations has a negative impact on the results, there is a need for further research of the target audience, taking into account the behavior of the modern generation; determining the interests of the university, trends, and current state of the market for educational services, the economy of the country as a whole.

Searching for a set of the most effective data methods and models to solve the problem of forecasting the success of the application by the applicant. It is needed to use different methods, individually and in combination, which could show a sufficiently high accuracy to assess the applicant's chances of admission to the most appropriate HEI. Given the objectives and results showing the developed methods, it is important to determine the most effective in every specific task.

Conclusion

We conducted a systematic literature review and identified relevant research concepts that aim to support entrants' choice of HEI or major for obtaining an educational level. We found that current researches consider enrollment at different levels - the first year, re-enrollment, and master's level. The considered researches concerned different HEI, majors and even countries. Nevertheless, all the studies summaries that the presence of a decision support system will positively affect both the life trajectory of the future student and the activities of the HEI.

The majority of studies used the ML methods and techniques to solve decision-support research dilemmas through technology. This study allows us to assume that the more effective solution could be the implementation of system that provide predicting the success of entry and the offer of an alternative choice of specialty for the user. The results of this study allow us to identify key points that are critical at the initial stage of building IT solution to solve this task.

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ОГЛЯД СУЧАСНОГО СТАНУ СИСТЕМ ПІДТРИМКИ АБІТУРІЄНТІВ ЗАКЛАДІВ ВИЩОЇ ОСВІТИ

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