

Systematic review: Career expectations and choice action in students' interest in STEM disciplines

Revisión sistemática: Expectativas de carrera y acción de elección en el interés de los estudiantes por disciplinas STEM

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Abstract

The choice of a career is a complex process influenced by various factors, with expectations about the professional future being particularly significant. Historically, it has been found that STEM disciplines are underrepresented compared to others. Additionally, it has been observed that most students who choose these disciplines are male. The objective of this systematic review was to identify empirical studies on students' career expectations and their influence on the decision to pursue careers related to STEM disciplines. This systematic review is limited to studies conducted on high school and undergraduate student populations, published between 2018 and 2024, using databases such as SCOPUS, Dialnet, ERIC, Springer, Core, and DOAJ. Inclusion and exclusion criteria were considered. It was found that few studies address career expectations and their influence on students' decision-making regarding these disciplines.

Keywords: career choice, STEM careers, STEM education, students.

Resumen

La elección de carrera es un proceso complejo influenciado por diversos factores, entre los que destacan las expectativas sobre el futuro profesional. Históricamente se ha encontrado que las disciplinas STEM tienen una subrepresentación en comparación con otras, así mismo se ha notado que del porcentaje de estudiantes que eligen estas disciplinas la mayoría son hombres. El objetivo de esta revisión sistemática fue identificar los estudios empíricos acerca de las expectativas de carrera de los estudiantes y su influencia en la acción de elección carreras asociadas a disciplinas STEM. Esta revisión sistemática se limita a estudios realizados en poblaciones de estudiantes de secundaria y pregrado, publicados entre el año 2018 al 2024, usando bases de datos como SCOPUS, Dialnet, ERIC, Springer, Core y DOAJ. Se consideraron criterios de inclusión y exclusión. Se encontró que son escasos los estudios referentes a las expectativas de carrera y su influencia en la acción de elección de los estudiantes para estas disciplinas.

Palabras clave: elección profesional, carreras STEM, educación STEM, estudiantes

1. Introduction

According to data obtained by the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2022), the percentage of graduates in science, technology, engineering and mathematics (STEM) programs (Science, Technology, Engineering and Mathematics) stands at 24.90% worldwide, where the countries with the highest percentage are Malaysia, Turkmenistan, Tunisia and Trinidad and Tobago with a percentage of 40.23%, 39.57%, 37.88 and 35.35 respectively. However, the low overall rate confirms the conclusions of numerous investigations that have been carried out on the subject (Chong and Quek, 2022; Sahin and Waxman, 2020; Tsakalerou et al., 2024), demonstrating the low proportion of graduates in the STEM disciplines in consideration with other disciplines.

In turn, the Organization for Economic Cooperation and Development [OECD] (2023) in the program for international student assessment (PISA) determined that "in Mexico, 34% of students reached at least Level 2 of proficiency in mathematics, significantly less than on average in OECD countries (OECD average: 69%)" (p.2). Likewise, a considerable decrease was found in the areas of mathematics and a smaller one in the areas of science between the years 2018 to 2022 in 15-year-old students, which according to Landero and Magaña (2023) may be related to the low demand in the choice of STEM careers.

Training in STEM disciplines has gained great relevance and is a point of interest at a global level, because, given the advances in current economic and technological development issues, the need for professionals in these areas is inevitable. However, despite the growing labor demand, the labor force supply is still not comparable to those belonging to other disciplines (Magaña et al., 2023; Sahin and Waxman, 2020; Tsakalerou et al., 2024). Therefore, multiple investigations have been carried out to identify the factors that influence the perceptions and in turn the decisions of students towards STEM disciplines. In particular, the studies carried out on career expectations and the action of choice will be analyzed, which have a great impact on the educational and professional decisions of students. (Chong and Quek, 2022; Jiang et al., 2024).

Currently, there are a large number of studies focused on determining the various factors that influence the choice of STEM careers, such as personal factors (Wong et al., 2022), contextual and agency factors (Blanco, 2009; Cupani and Pérez, 2006; Lent & Brown, 2006; Lent, Hackett, & Brown, 2004., cited in

Carrasco and Valenzuela, 2021). However, it is assumed that there are few empirical references on the influence that career expectations have on students' perceptions of STEM disciplines.

Career expectations play an important role in students' choice, since they consider the results that will be obtained, such as economic income level, social position and some achievement and self-satisfaction factors, which influence the perception of young people and can determine their actions (Abe and Chikoko, 2020; Magaña et al., 2023; Vázquez and Blanco-Blanco, 2019).

Given the importance of STEM disciplines in economic development (UNESCO, 2022), the relevance of understanding the aspects that influence students' career expectations is highlighted, which determine the choice actions, and thus design and structure strategies to address the limitations and increase the rate of graduates in these disciplines.

Consequently, the purpose of this systematic literature review is to identify, evaluate, and interpret the existing literature on students' career expectations and choice actions in relation to STEM disciplines, taking into account the variables that may have a greater impact on them, such as social (family, teachers, role models) (González-Pérez et al., 2020; Turner et al., 2019; Zhapa et al., 2023), sociocultural (Chan, 2022; Dewsbury et al., 2019), socioeconomic level (Stahl et al., 2024; Wang et al., 2023), and gender (Kaleva et al., 2019; Verdugo-Castro et al., 2022). To this end, the research question was established; What are the empirical studies published in open access on career expectations and choice actions in the interest of students over 14 years of age in STEM disciplines in the period 2018 – 2024?

2. Methodology

Six databases were used to search for empirical articles: Springer, SCOPUS, DOAJ, ERIC, CORE and Dialnet. To narrow down the results and ensure their relevance, thesauri and Boolean operators were established. Both Spanish and English thesauri were used to broaden the scope of the search. In Spanish, the following thesauri were used: STEM, career expectations and choice action; for English, the following thesauri were established: STEM, career choice and career expectation, supporting these with the Boolean operators AND, OR and NOT.

The most effective searches were those carried out with thesauri and Boolean operators in English, as they provided a greater number of relevant articles.

In order to optimize the search for scientific articles, inclusion and exclusion criteria were established. The inclusion criteria include: the year of publication, between 2018 and 2024 with a range of 7 years of research, empirical articles with open access, focused on STEM disciplines, in English and/or Spanish with a sample of high school students and older (14 years and older). Regarding the exclusion criteria used, the following are found: the year of publication prior to 2018, articles from secondary sources, with restricted access, not focused on STEM disciplines, in languages other than English or Spanish and with a population under 14 years of age.

Figure 1 shows the systematic review process, which began with a total of 20,396 articles found in the 6 search engines, obtained using the thesauri and Boolean operators in English and Spanish indicated above. To reduce the information and select updated research, the publication year filter was applied, considering only articles published from 2018 onwards, with this 11,145 articles were eliminated, leaving 9,251 studies to be considered.

To continue reducing the number of articles, language and open access criteria were applied, with these 3,234 were eliminated, leaving 6,017 publications. Duplicate articles were eliminated in search engines, using the Mendeley reference manager (2024), which identified 4 duplicate articles, leaving 6,013 publications for review.

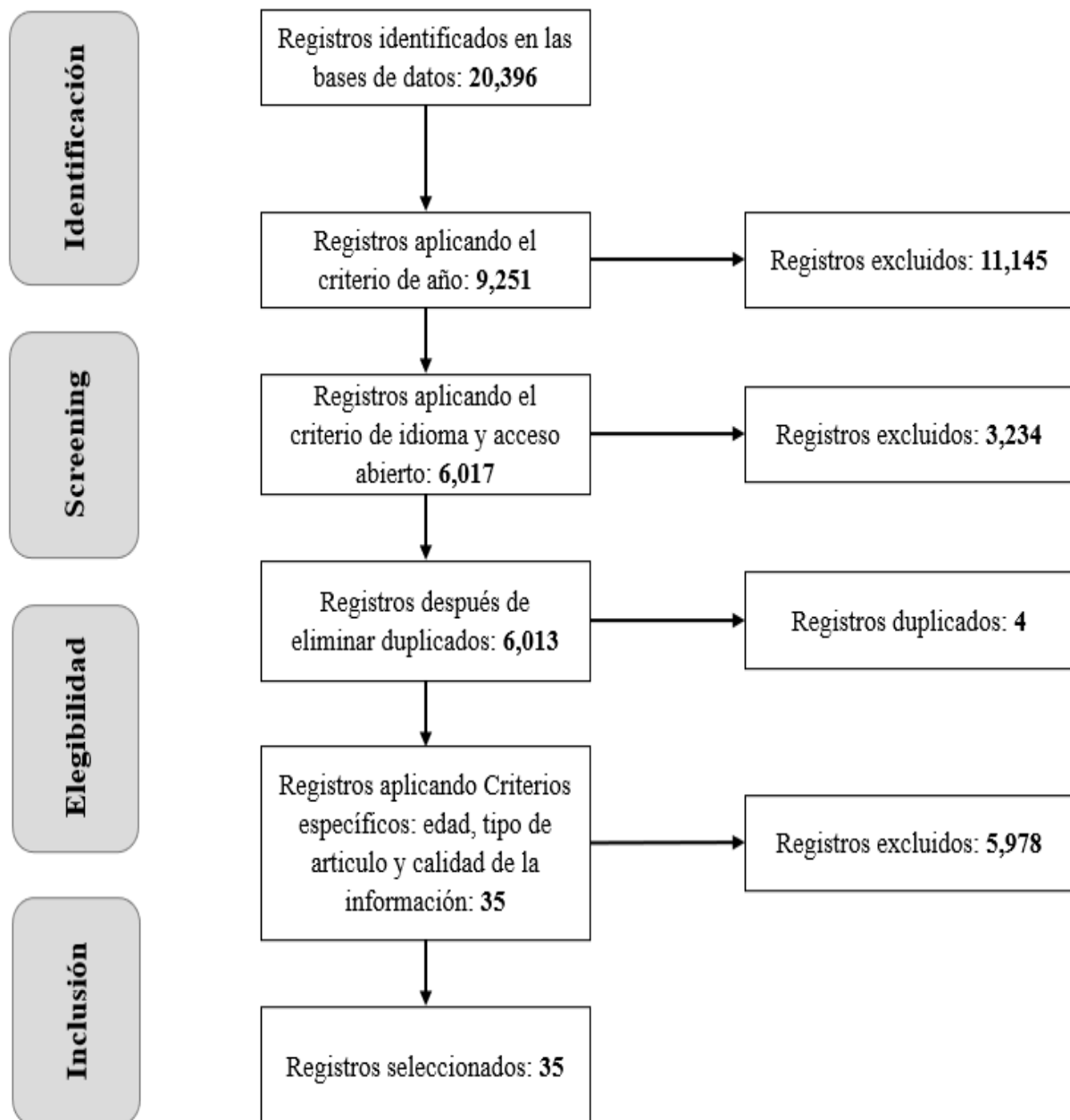


Figura 1. Diagrama de flujo del proceso de la revisión sistemática.

Finally, specific criteria were used to filter the articles to be used in the systematic review, such as the age of the population (over 14 years), the quality of the information and the type of article (empirical). These were identified by reading the full text to determine the usefulness and value of the articles for

the study. At the end, 35 publications were selected which met all the inclusion criteria. Figure 2 shows the search and selection protocol for the systematic review, in which the articles found in each search engine used are presented.

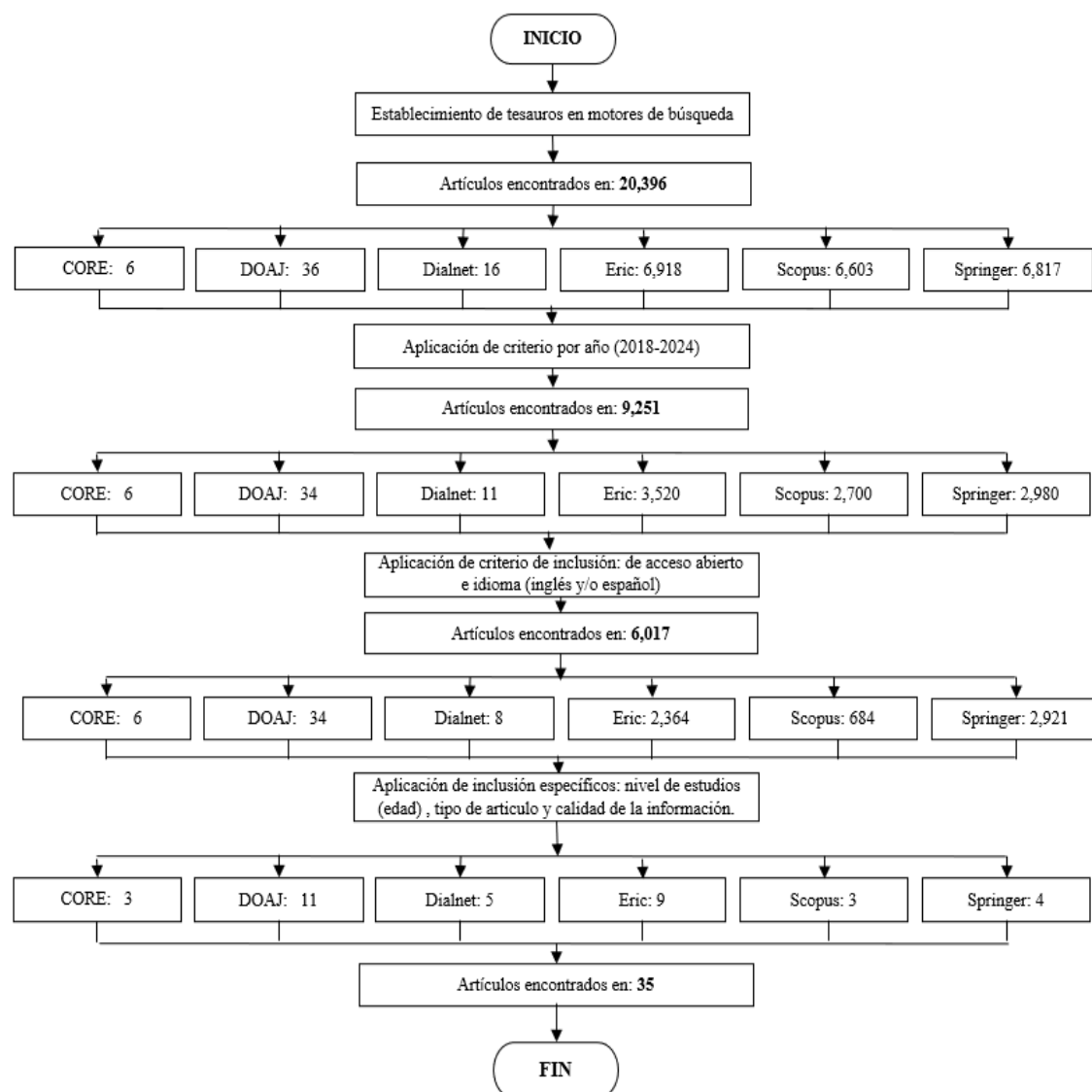


Figure 2. Flowchart of the search and selection protocol of the systematic review.

3. Results

To carry out the systematic review of the literature after considering the inclusion and exclusion criteria previously mentioned, with which of the 20,396 publications found in the search engines using the thesauri and Boolean operators, 20,361 publications were discarded for not meeting the necessary specifications, leaving 35 articles that were selected (0.17%) for a detailed analysis of their content for the research.

Among the six databases used for the information search, it was observed that the search engine with the largest number of publications that met the criteria was DOAJ with 11 publications found (31.4%), followed by ERIC with 9 (25.8%), Dialnet with 5 (14.3%), Springer with 4 (11.5%) and finally Core and SCOPUS with 3 (8.5%) results each, which provided useful information for their analysis.

Similarly, it was found that among the countries of origin of the publications, the country with a clear preponderance of empirical studies focused on investigating the factors that influence career expectations and the choice of students towards STEM disciplines is the United States of America with a percentage of 22.9%, followed by China with 11.4%, Spain with 8.6% and Turkey with 5.8%. The rest of the countries with which we worked only had one article that met all the necessary requirements. Figure 3 graphically presents the number of publications found by country of origin.

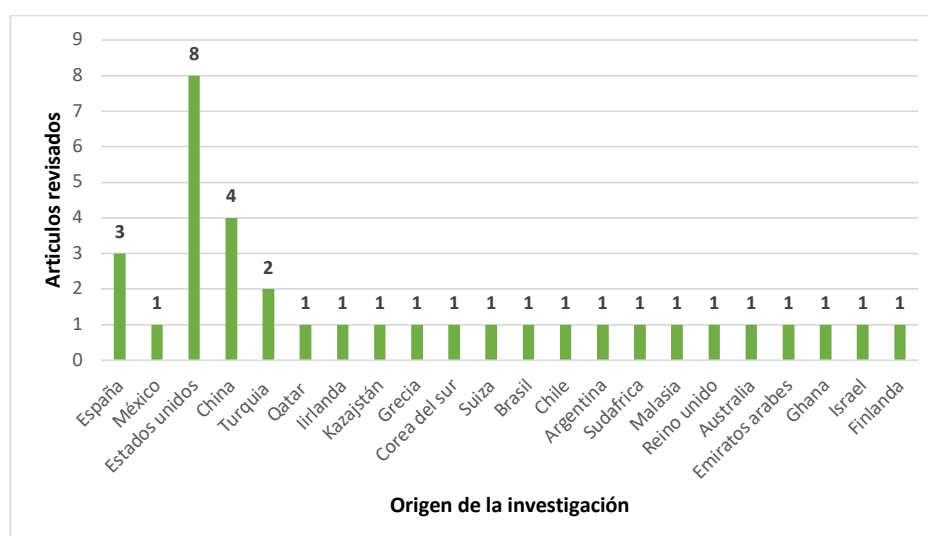


Figure 3. Distribution of scientific articles by country of origin.

Regarding the number of publications per year following the criterion of articles published between 2018 and 2024, it was observed that the year in which there was a greater number of studies was in 2023 with 9 articles, equivalent to 25.8% of the research analyzed for this systematic review, on the other hand, it was found that the years in which there were a lower number of publications according to the established criteria were 2018, 2020 and 2021 with 3 articles of value corresponding to 8.5% each.

In the process of reviewing the data of the studies in detail, the types of approaches used were identified. Of the 35 articles that were selected, 22 of these were quantitative studies equivalent to 62.9% of the articles analyzed, 9 investigations had a qualitative approach corresponding to 25.7% and finally there were 4 publications with a mixed research approach equivalent to 11.4% of the studies collected. Table 1 shows the classification of the articles selected for the systematic review based on the type of approach used in the research.

Table 1. Classification of methodological approaches

Approaches	Countries	Indicator	Quotes
Quantitative	Spain	3	(González-Pérez et al., 2020; Vázquez y Blanco-Blanco, 2019; Verdugo-Castro et al., 2022)
	Mexico	1	(Magaña et al., 2023)
	China	4	(Chan, 2022 ; Jiang et al., 2024 ; Sheng et al., 2023 ; Wang et al., 2023)
	USA	5	(Ito, y McPherson, 2018; Sahin y Waxman, 2020; Turner et al., 2019; Verdín et al., 2018; Xu y Lastrapes, 2022)
	Türkiye	2	(Kızılay y Yamak, 2023; Küçük y Çoksan, 2023)
	Qatar	1	(Sellami et al., 2023)
	Ireland	1	(Chatzi y Kourousis, 2024)
	Kazakhstani	1	(Tsakalerou et al., 2024)
	Greece	1	(Mitsopoulou y Pavlatou, 2021)
	South Korea	1	(Hwang, 2024)
	Brazil	1	(Ivarenga y Braga, 2024)
	Swiss	1	(Makarova et al., 2019)

Cualitativo	Chili	1	(Carrasco y Valenzuela, 2021)
	Argentina	1	(García y Fiorenza, 2021)
	Malaysia	1	(Chong y Quek, 2022)
	United Kingdom	1	(Wong et al., 2022)
	South Africa	1	(Abe y Chikoko, 2020)
	USA	3	(Davis y Wilson-Kennedy, 2023; Dewsbury et al., 2019; Lee et al., 2018)
	Australia	1	(Stahl et al., 2024)
Mixto	United Arab Emirates	1	(ElSayary, 2023)
	Ghana	1	(Wrigley-Asante et al., 2022)
	Israel	1	(Budge et al., 2023)
	Finland	1	(Kaleva et al., 2019)

Through the systematic review, it was identified that the population on which the selected articles focused was a population of high school/high school students, which were taken as a single population type as they varied depending on the educational system of each country, but having the same age range. The other type of population found following the criteria of the review were university students.

The majority of the study population were high school students with 19 publications collected corresponding to 54.3%, followed by 16 articles applied to a population of university students equivalent to 45.7% of the studies analyzed.

It was also observed that the predominant language in the studies found was English with 30 articles corresponding to 85.7%, followed by publications in Spanish with 5 articles selected, representing 14.3% of the research used in the systematic review. Table 2 shows the classification of the study population found in the collected articles by academic level and country of origin.

Table 2. Classification of the study population found in the systematic review.

Population	Country	Indicator	Quotes
High School Students	Spain	2	(González-Pérez et al., 2020; Vázquez y Blanco-Blanco, 2019)
	Mexico	1	(Magaña et al., 2023)
	Argentina	1	(García y Fiorenza, 2021)
	China	3	(Jiang et al., 2024; Wang et al., 2023; Chan, 2022)
	USA	4	(Ito, y McPherson, 2018; Lee et al., 2018; Sahin y Waxman, 2020; Turner et al., 2019)
	United Arab Emirates	1	(ElSayary, 2023)
	Qatar	1	(Sellami et al., 2023)
	Israel	1	(Budge et al., 2023)
	Greece	1	(Mitsopoulou y Pavlatou, 2021)
	Finland	1	(Kaleva et al., 2019)
	Swiss	1	(Makarova et al., 2019)
	Türkiye	1	(Kızılay y Yamak, 2023; Küçük y Çoksan, 2023)
University students	Spain	1	(Verdugo-Castro et al., 2022)
	Chili	1	(Carrasco y Valenzuela, 2021)
	Malaysia	1	(Chong y Quek, 2022)
	United Kingdom	1	(Wong et al., 2022)
	South Africa	1	(Abe y chikoko, 2020)
	USA	4	(Davis y Wilson-Kennedy, 2023; Dewsbury et al., 2019; Verdin et al., 2018; Xu y Lastrepes, 2022)
	China	1	(Sheng et al., 2023)
	Ghana	1	(Wrigley-Asante et al., 2022)
	Ireland	1	(Chatzi y Kourousis, 2024)
	Kazakhstani	1	(Tsakalerou et al., 2024)
	Brazil	1	(Alvarenga y Braga, 2024)
	Australia	1	(Stahl et al., 2024)
	South Korea	1	(Hwang, 2024)

Table 2 shows that the United States and China stand out among the literature found with a population of secondary and high school students, with a quantity of 4 (21%) and 3 (15.8%) investigations respectively. For the population of

university students, it was observed that the country with the greatest quantity of studies is again the United States with 4 (25%) articles for this population. Figure 4 shows a graphic representation of the scientific articles found classified by academic level and country of origin.

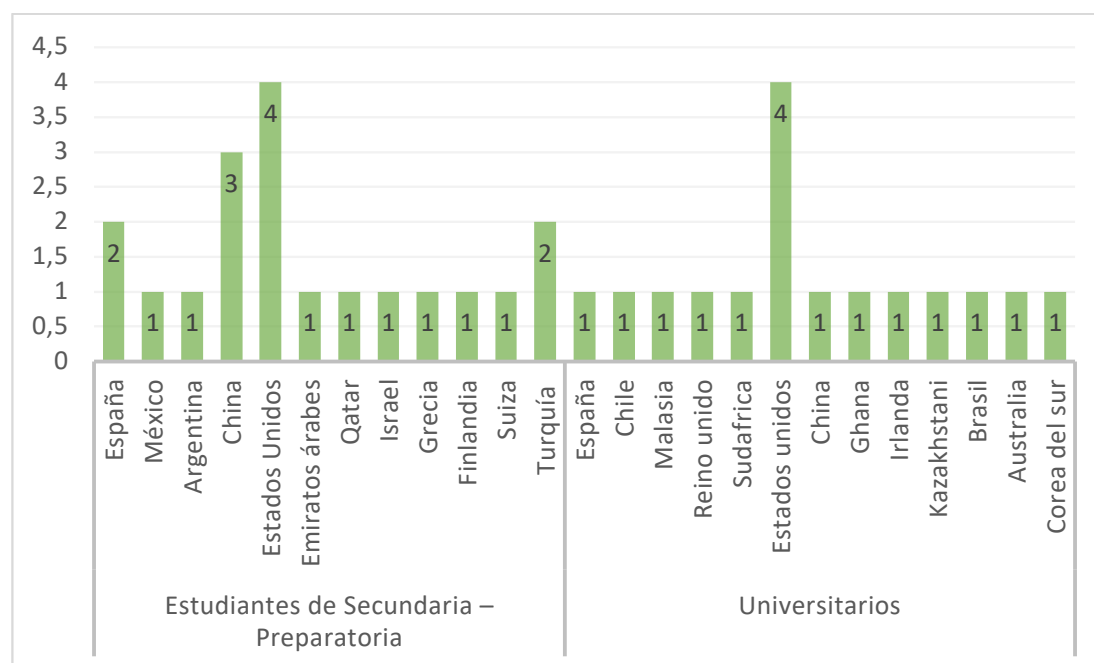


Figure 4. Distribution of scientific articles by academic level and country of origin.

Likewise, during the systematic review, secondary variables were identified that are associated with career expectations and the choice of students when considering STEM disciplines. It was found that although the populations used in the studies are different, the variables with the highest frequency are the same. The secondary variables that were found to be most represented in the systematic review process were gender with 26 results in total, followed by self-efficacy. The variable with the lowest frequency was the perception of STEM fields with six results found, which represents a research opportunity. Table 3 shows the classification of the secondary variables collected during the systematic review segmented by the population of the studies.

Table 3. Classification of secondary variables found in the systematic review

Population	Secondary variables	Indicator	Quotes
Estudiantes de Secundaria – Preparatoria (High school)	Apoyo familiar	3	(Küçük y Çoksan, 2023; Turner et al., 2019; Wang et al., 2023)
	Autoeficacia	11	(ElSayary, 2023; González-Pérez et al., 2020; Ito, y McPherson, 2018; Jiang et al., 2024; Kaleva et al., 2019; Kızılay y Yamak, 2023; Mitsopoulou y Pavlatou, 2021; Sellami et al., 2023; Turner et al., 2019; Vázquez y Blanco-Blanco, 2019; Wang et al., 2023)
	Factor económico	6	(Chan, 2022; Küçük y Çoksan, 2023; Mitsopoulou y Pavlatou, 2021; Sahin y Waxman, 2020; Turner et al., 2019 ;Wang et al., 2023)
	Sentido de pertenencia	3	(Budge et al., 2023 ; Chan, 2022; Ito, y McPherson, 2018)
	Experiencias STEM	6	(González-Pérez et al., 2020; Jiang et al., 2024; Lee et al., 2018; Mitsopoulou y Pavlatou, 2021; Sahin y Waxman, 2020; Sellami et al., 2023)
	Género	15	(Budge et al., 2023; Chan, 2022; ElSayary, 2023; García y Fiorenza, 2021; González-Pérez et al., 2020; Jiang et al., 2024; Kaleva et al., 2019; Kızılay y Yamak, 2023; Küçük y Çoksan, 2023; Magaña et al., 2023; Makarova et al., 2019; Mitsopoulou y Pavlatou, 2021; Sellami et al., 2023; Vázquez y Blanco-Blanco, 2019; Wang et al., 2023)
	Interés	8	(Chan, 2022; Kaleva et al., 2019; Kızılay y Yamak, 2023; Magaña et al., 2023; Sellami et al., 2023; Turner et al., 2019; Vázquez y Blanco-Blanco, 2019; Wang et al., 2023)
	Percepciones de los campos STEM	3	(Ito, y McPherson, 2018; Lee et al., 2018; Makarova et al., 2019)
	Modelos de rol	4	(Chan, 2022; García y Fiorenza, 2021; González-Pérez et al., 2020; Wang et al., 2023)

Universitarios	Apoyo familiar	4	(Dewsbury et al., 2019; Verdín et al., 2018; Verdugo-Castro et al., 2022; Wrigley-Asante et al., 2022)
	Autoeficacia	5	(Abe y chikoko, 2020; Carrasco y Valenzuela, 2021; Hwang, 2024; Sheng et al., 2023; Verdín et al., 2018)
	Factor económico	9	(Abe y chikoko, 2020; Carrasco y Valenzuela, 2021; Chong y Quek, 2022; Davis y Wilson-Kennedy, 2023; Verdín et al., 2018; Verdugo-Castro et al., 2022; Stahl et al., 2024; Wong et al., 2022; Wrigley-Asante et al., 2022)
	Sentido de pertenencia	4	(Davis y Wilson-Kennedy, 2023; Stahl et al., 2024; Wong et al., 2022; Xu y Lastrepes, 2022;)
	Experiencias STEM	6	(Carrasco y Valenzuela, 2021; Chong y Quek, 2022; Davis y Wilson-Kennedy, 2023; Tsakalerou et al., 2024; Verdín et al., 2018; Wong et al., 2022;)
	Género	10	(Abe y chikoko, 2020; Alvarenga y Braga, 2024; Carrasco y Valenzuela, 2021; Chatzi y Kourousis, 2024; Hwang, 2024; Tsakalerou et al., 2024; Verdín et al., 2018; Verdugo-Castro et al., 2022; Wrigley-Asante et al., 2022; Xu y Lastrepes, 2022)
	Interés	3	(Hwang, 2024; Davis y Wilson-Kennedy, 2023; Sheng et al., 2023)
	Percepciones de los campos STEM	3	(Carrasco y Valenzuela, 2021; Sheng et al., 2023; Tsakalerou et al., 2024)
	Modelos de rol	4	(Dewsbury et al., 2019; Stahl et al., 2024; Tsakalerou et al., 2024; Wrigley-Asante et al., 2022)

The data presented in Table 3 show that there is no significant difference between the variables analyzed in the studies applied to high school and university students by academic level. Despite this, it is observed that in both populations there is little research evidence about some of the proposed variables, such as the perception of STEM fields and the sense of belonging. Figure 5 shows a graphic representation of the classification of articles by research variable, taking the study population as a reference.

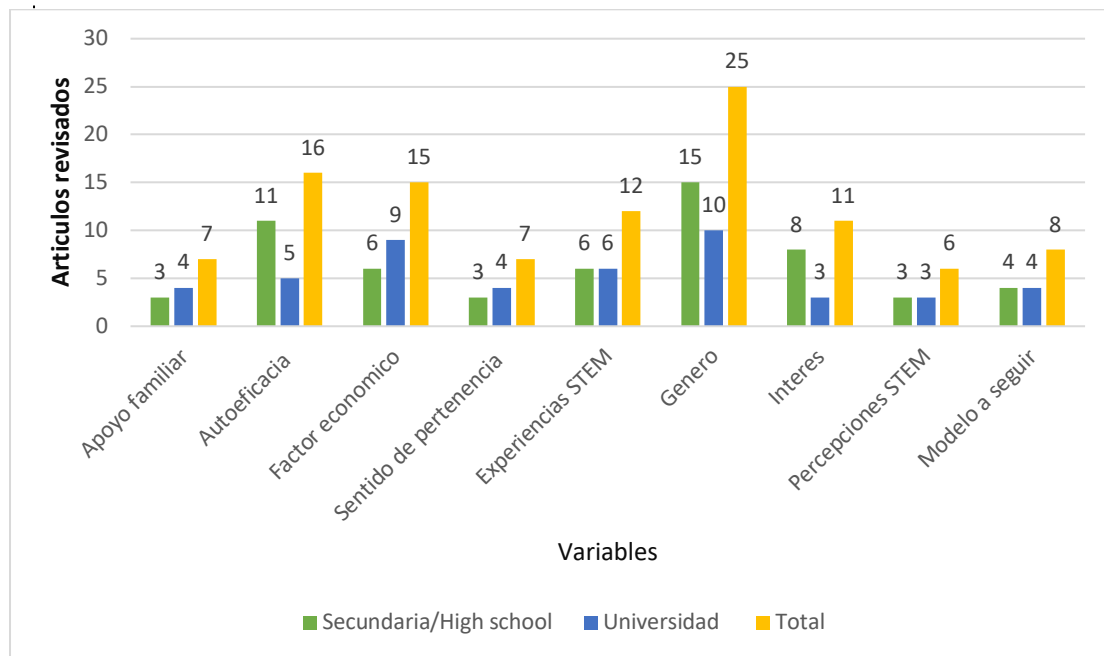


Figure 5. Classification of articles by variables identified according to their population.

In order to reach a greater scope in the recruitment of students in STEM disciplines, it is necessary to consider all the variables that can have a positive and negative impact on the choice action of these, this systematic review focused on career expectations, which have a fundamental role in the selection of a discipline, when considering the reaction that will be obtained from said action, within these expectations are the economic ones (Financial stability), social (Contributions to society) and self-satisfaction (Interest) (Abe and Chikoko, 2020).

Discusión

Through the analysis of the existing literature regarding career expectations and how these influence students' career choice action, it was possible to identify contextual factors such as socioeconomic level (Mitsopoulou and Pavlatou, 2021; Stahl et al., 2024), family (Wang et al., 2023; Wrigley-Asante et al., 2022) and gender stereotypes (Chatzi and Kourousis, 2024; Kaleva et al., 2019) towards STEM disciplines have a great impact on students' career

expectations and decision-making in the choice action, in accordance with what has been stated by various authors (Carrasco and Valenzuela, 2021; Verdugo-Castro et al., 2022; Wang et al., 2023).

Likewise, it was found that with regard to STEM disciplines there is a great gender barrier (Alvarenga and Braga, 2024; Chatzi and Kourousis, 2024; Wang et al., 2023), this being the predominant variable in the literature found, which has a great impact on career expectations by limiting students in their decision-making. Gender stereotypes are mostly present in conservative countries, in which there is a gender gap when perceiving some of the STEM disciplines as masculine, although various authors consider that this gap has decreased over time (Küçük and Çoksan, 2023; Sahin and Waxman, 2020), it is still predominant in the countries of the Asian continent (Chan, 2022; Elsaray, 2023; Tsakalerou et al., 2024; Wang et al., 2023).

Through this study, it was found that despite having a wide variety of literature regarding the factors that influence students' choices in STEM disciplines, it was identified that there is a shortage of research focused on career expectations and their level of influence on them, mainly in the knowledge of STEM fields. Likewise, it was found with the publications analyzed that there is little research on these variables in the Mexican context, which represents a significant study gap, providing an opportunity to delve deeper into the study of this variable and others associated with this problem.

Regarding the population, no significant difference was detected in the number of articles collected by level of education. However, it is important to highlight that for these variables it is important to consider the upper secondary level (secondary and high school), because the selection of a career has not yet occurred and the strategies to promote these disciplines may have a greater impact.

In this review, it was possible to identify the main variables that have an impact on career expectations and consequently in the choice of students towards STEM disciplines. Among these variables, gender was already highlighted, but at a personal level, factors such as self-efficacy, economic level, STEM experiences and the development of interest come into play, which influence both positively and negatively the decision-making and the permanence of students in STEM fields (Chan, 2022; Ito and McPherson, 2018; Mitsopoulou and Pavlatou, 2021).

Although the study is limited to recent empirical literature with the established inclusion criteria, it does allow us to visualize research opportunities that contribute to contextualizing the problem, not only in Mexico, but in various countries in Asia, Europe, and Latin America, thereby contributing to efficient solution proposals to the underrepresentation of professionals in these disciplines in the labor field.

4. Conclusions

In conclusion, it was found that there is a wide variety of studies referring to the factors that influence students' choices in STEM disciplines, however, it was identified that there is a shortage in the literature focused on career expectations, and their level of influence on choice actions by the students covered by the study.

Similarly, it was identified that the countries with a clear preponderance of empirical studies focused on investigating career expectations and the choice of students towards STEM disciplines are the United States of America, followed by China and Spain, which in turn denotes a lack of research in Latin American countries, in which there is only one article referring to the research topic, as is the case of Mexico. These results highlight the importance of promoting in-depth research on this topic, which allows generating evidence in accordance with the diverse contexts and realities experienced in various countries.

In turn, it was identified that the year in which there was greater interest in addressing the research topic and therefore the number of publications was higher was in 2023 with nine publications found, followed by 2022 with six publications, which reflects that the interest and importance of researching career expectations and the action of choosing students towards STEM disciplines has increased in recent years.

On the other hand, it was observed that there are multiple variables that influence career expectations and guide students' academic decision-making regarding the choice of STEM disciplines. There is a wide variety of research carried out that addresses this problem from different perspectives, but there is little evidence on studies referring to career expectations and how these influence students' choice action. On the other hand, the study allows

identifying variables of great relevance to the problem such as perceptions of STEM fields and role models, which have been little studied in relation to career expectations and choice actions, so it is suggested to consider them as future lines of research.

5. Authors' contribution

Y.A.G.D: Data collection, analysis of results, final discussion of the article

DEMM: Direction, discussion and final revision of the article

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