The problem of pseudo-STEM programs in higher education: A classification criterion

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Abstract: Most of the indicators for STEM programs in higher education such as the number of programs and students enrolled depend on what is considered as a STEM program. Currently, each country develops its own STEM indicators, without establishing comparable criteria across countries for the selection of the programs considered STEM, which make it difficult for a correct comparison between countries. Despite this, the OECD publishes comparative reports on the state of STEM higher education among its member countries. The OECD develops these reports with data provided by each country; that is, each country decides the mechanisms to produce the data. This paper proposes a selection criterion of STEM programs to generate internationally comparable data. This work obtains the selection criterion through a conceptual and contextual socio-historical review of the STEM movement. This work conducts an exploratory case study in Mexico from 2011 to 2017 to show the discrepancy in STEM higher education indicators when using different selection criteria. The results show that 60% of the programs classified as STEM, do not meet the classification criteria established. Also, that 60% of misclassified programs have
a higher curricular content of administrative or social subjects, but in their name includes words that refer to STEM fields. The authors call these programs as Management-STEM (MSTEM).

**Subjects: Higher Education; International & Comparative Education; Science Education; Technology in Education**

**Keywords:** higher education; STEM education; indicator estimation; selection criterion; comparable STEM indicators

1. **Introduction**

Higher Education in Science, Technology, Engineering, and Mathematics (STEM) is an essential issue for countries that seek to be competitive in the current global knowledge-based economy (OECD, 1996). According to the National Science Foundation (NSF), STEM education provides advanced skills and techniques necessary for a competitive workforce. Besides, this education directly impacts the research, the generation of new technologies, and innovation (National Science Board, 2016). Also, the population receiving STEM education is considered incisive in the development of a country (Bybee, 2010; Gonzalez & Kuenzi, 2012; White, 2014). Having reliable indicators that allow us to measure the progress of STEM higher education is essential to develop policies according to the needs of each nation. Countries such as the United States of America (USA), the United Kingdom (United Kingdom), and China have been generating indicators for almost two decades to determine the state of STEM higher education in terms of quality and quantity (Han & Appelbaum, 2018; Kuenzi, 2008). This type of information allows these countries to make studies and projections on STEM labor demands (Han & Appelbaum, 2018; Han et al., 2015).

Each country currently develops its STEM indicators, but STEM higher education varies according to the needs of each country, which produces different meanings, structures, and appreciations in STEM content (Ritz & Fan, 2015). For example, some countries merge education in science and technology, others integrate engineering fields, while others seek to balance the STEM fields in programs (Moon et al., 2000; Ritz & Fan, 2015). This lack of homogenization on the selection criterion of the STEM programs made it difficult to classify them and to compare between countries. This also affects the comparative reports developed by the OECD, which shows the state of STEM higher education using parameters such as the number of students and the labor supply of their member countries, since the OECD develops these reports base on the data provided by each country, that is, each country decides what data to provide to the OECD and the mechanisms necessary to obtain them.

Examples of this lack of homogenization are the cases of the USA and Mexico. In the USA, several agencies in parallel produce STEM indicators, with their criteria. For example, Carnevale published in 2011 a list under labor criteria, while the NSF published another list with its criteria, which includes university careers in other fields such as educational, learning, social sciences, and psychology (Foundations, 2014). Unlike the USA, in Mexico, there is no official list of programs considered STEM. However, México reports programs on fields of science and technology as STEM, without corroborating that the curriculum content is STEM (INEGI, 2011a; OECD, 2017).

This paper proposes a methodology to homogenize the selection of STEM programs to generate internationally comparable and reliable data. The classification criteria are based on the definitions and socio-historical context of the STEM movement. Furthermore, an exploratory case study is conducted in Mexico to show the discrepancy in STEM higher education indicators using different selection criteria. The NSF establishes the first criterion, and this article establishes the second. With both criterion establishes the number of programs and the number of students. Finally, this work presents the results of the comparison between data obtained.
It is essential to carry out this study in Mexico because, in this country, there is no systematic planning to promote STEM education and to increase the number of students that pursue STEM programs. Also, in Mexico, there is no official report with reliable indicators that show the reality of STEM higher education. Despite this, there are reports of Mexico among the first five countries with more students pursuing STEM careers (fourth of the 34 OECD members with 32% of their student population (OECD, 2017). Also, there are reports of the urgent demand for engineers in industries such as automotive, aerospace, energy, biotechnology, and information technology (FUMEC, 2016). Simultaneously, 31% of employers in these industries report that they have difficulty finding people with the necessary skills for their vacancies (OECD, 2015). These data show the discrepancy in the indicators, and the inconsistency between students pursuing STEM careers, and the needs of the industry.

This work contains four sections. The first section presents the classification criteria of the STEM programs through a historical analysis of the policies and definitions of the STEM movement. The second section describes the methodology for selecting the number of programs and the number of STEM students, according to the NSF criteria and the criteria obtained in this work. The third section shows the analysis of STEM higher education in Mexico, comparing the data obtained for the two established selection criteria. The final section raised the discussion and conclusions on the homogenization of the criteria for selecting STEM programs.

2. Classification criteria for STEM programs

It is necessary to review the political and economic origins that promote STEM programs without neglecting current and future reasons, to define a STEM program (Williams, 2011). Before the promoted STEM fields together, the fields of knowledge that integrate them had a long time in university programs. It was from the Second World War that STEM areas are recognized as fundamental to provide citizens with the knowledge and skills necessary in the economic competitiveness of a country (Bybee, 2013; National Governors Association, 2017). Without a doubt, the relationship between the economic development of a nation and education has been the main engine to promote STEM education (Williams, 2011). Although there are other reasons to promote STEM higher education, most reasons linked to economic development, such is the case in the USA and the UK.

The USA creates a political initiative in 2000 to promote STEM fields in elementary education, to incite the young students the interest of STEM fields, and in the future increase the number of STEM national university students (Bybee, 2010). Because, in the USA, more than half a million university students are foreigners, and a third of graduate students are also foreigners. In addition to the decrease in national STEM talent, it is also among the reasons, the loss of technological leadership, and the dependence of foreign academics to join the workforce (Dugger, 2010). That is why, during the global economic crisis of 2007 and 2009, STEM education was a priority on the United States agenda (Williams, 2011).

The United Kingdom promotes STEM education to meet labor demands reported in the national reports. In the SET for Success report of 2002, there is a shortage in the number of young people studying STEM fields. The report developed by CBI mentions that about 40% of employers find it challenging to recruit people with STEM skills. Some projections suggest, by 2022, an expansion of 300,000 STEM jobs and a replacement of 1.3 million for workers with STEM skills. For these reasons, in 2010, the United Kingdom government implements the National STEM program to provide a coordinated approach to government support to address the problem of STEM skills in schools and universities (Morgan et al., 2016, May).

In the USA and the UK, the reasons for promoting STEM education come from internal indicators analysis. Unlike in Mexico, promoting STEM higher education comes from recommendations made by external organizations and not from own analyzes with built-in internal indicators. International organizations such as the OECD, the IDB, and UNESCO have made recommendations to Mexico for higher education on science and technology, based on the
knowledge economy (OECD, 1996). This economy, promoted by the OECD since 1996, is based on the ability to focus and transform knowledge in a growing economy and recognizes higher education, especially the STEM fields, fundamental to that economy, so it recommends and promotes higher education STEM type (Altbatch & Peterson, 2007). In Mexico, the influence of the knowledge economy has changed the paradigm of higher education. Until 1982, educational policies in higher education were shaped by the exacerbated need to increase access to education and increase the number of students enrolled (Estevez Nenninger et al., 2018). However, after the economic crisis of 1982, the International Monetary Fund (IMF) conditioned rescue packages to profound changes in higher education policy, among other structural changes in the country. After that, the massification paradigm higher education was replaced by quality and efficiency, favoring the creation of STEM programs and the creation of agreements to promote STEM skills in elementary education (Academia de Ingeniería de México, 2012; Estevez Nenninger et al., 2018).

The fact that each country has different reasons, whether internal or international, to promote STEM education, can influence the meanings, structures and appreciations of STEM content, as well as the methodologies for obtaining STEM parameters (Moon et al., 2000; Ritz & Fan, 2015). The lack of homogenization in the criteria of selection of STEM programs makes it difficult to classify them and their comparison between countries.

David White, in the document: What is STEM education, and why is it important?, defines what a program that is considered STEM should be. He describes: “A STEM student is considered to be one who is enrolled in one of the areas of Science, Technology, Engineering or Mathematics. For example, if a student is specializing in molecular biology, he will enter the STEM workforce as Scientific STEM students may or may not be exposed to the integration of technology, engineering or mathematics, but if they are exposed to each STEM area belonging to their specific field, that is, the integration of all STEM areas into parts The same may or may not occur, but it should be taken into account that they are within a STEM field.” (White, 2014, p. 7). The authors interpret the sentence before as: The programs immerse in one or more fields of Science, Technology, Engineering, and Mathematics are STEM. These programs not necessary have the integration of all STEM areas in equal parts, only need a higher curricular content of STEM fields. This definition facilitates the classification of STEM programs because it allows the selection of all programs within each STEM area.

Rodger W. Bybee, in his document: What is STEM education? He says that each of the STEM fields is directly involved in problem-solving and innovation. Moreover, Bybee said that a student of some STEM field has skills necessary for the knowledge economy (Bybee, 2010). The arguments presented by Bybee support the idea of the independence of the STEM fields.

The STEM document: Science, Technology, Engineering, Mathematics, developed by Carnevale et al., Presents an approach to what a STEM program is according to occupations, and provides a list of commonly occupied STEM subjects. That list includes works focused on computing, mathematics, architecture, engineering, life sciences, and physical sciences (Carnevale et al., 2011). All occupations in the Carnevale list follow the White's definition.

Unlike the definition published by White (2014), the NSF presents a list of programs considered STEM in the document “STEM Fields approved by the NSF” which includes, in addition to the STEM fields, some STEM Education and Learning Research programs, Science Social and Psychology (Foundations, 2014; Gonzalez & Kuenzi, 2012). This list provides a clear example that there are programs classified as STEM that do not follow the definition provided by White.

This work takes the definitions of White-Bybee-Carnevale as a classification criterion for STEM programs. Moreover, this work establishes that: Every program with curricular content is immersed in one or more of the STEM fields, is considered STEM. This work not considered STEM programs, those with curricular content most oriented to other fields and although it contains some STEM subjects.
The above description is the classification criteria proposed to select STEM programs. The following section presents the methodology to obtain the number of STEM programs and students in Mexico with the criteria previously established and with the criteria proposed by the NSF.

3. Methodology to obtain the number of STEM programs and students

The first step was to obtain the STEM programs in Mexico, according to the NSF criteria. There is a list of Mexican programs classified by fields of study in the catalog Mexican Qualification of Programs of Study by fields of academic training (CMPE) (INEGI, 2011b). With the CMPE catalog and the list NSF Approved STEM Fields (Foundations, 2014). The authors did an equivalence of both catalogs, the coincidence was one by one between them, except the Materials Research field, which is in the Engineering field in the CMPE catalog. The list of programs obtained was named STEM-like because all programs in that list are equivalent to the STEM programs approved by NSF.

The second step was to obtain the STEM programs according to the criteria proposed by this work. For this, the authors carried out a curricular review of the STEM-like list, focusing attention on programs whose name referred to non-STEM fields. For example, Computational Systems and Business Administration, another example, the program Specialty of Agricultural Engineering in Agricultural Economics. Both programs are classified as STEM under the NSF criteria because their name refers to STEM fields, but their curricular content has more subjects of administrative fields. The curriculum review analyzed the number of subjects of STEM fields against the number of administrative and social fields. Those programs that have STEM content, but mostly have matters of administrative and social fields, were separated and named Management-STEM (MSTEM) to distinguish them from STEM programs.

After this process, there are three lists of kinds of programs. The STEM-like list, this list contains the programs according to NSF criteria. The STEM list, which contains the programs according to the criterion established in this work. The MSTEM list contains the programs in which curricular load has more administrative or social subjects than STEM subjects.

The third step was to build a database. This database had to include all the university programs offered in México, as well as university students, classified by the three lists (STEM-like, STEM, and MSTEM). For this, the authors had access to the country’s higher education statistical yearbooks developed by the National Association of Universities and Institutions of Higher Education (ANUIES).

ANUIIES is a non-governmental association of a plural nature, which, within its multiple functions, develops statistical yearbooks of national universities since 1950 (ANUIIES, 2017). However, only from the year 2011, the information in these yearbooks is available online, and for previous years, there are only print versions, which makes data extraction difficult. For this reason, the present study covers from 2011 to 2017. At the time this work was prepared, the 2018 yearbook was not yet available. The statistical yearbooks of ANUIIES contain information on the number of university programs, university students classified by year, by educational program, by funding (public and private), by geographical distribution, gender, and age. These statistical yearbooks represent the complete information on all programs and the student population of higher education in Mexico. These yearbooks are not separate the information by field of study neither provide an analysis of the data collected.

With the lists of STEM-like, STEM, and MSTEM programs created in the first two steps and the ANUIIES database, the authors constructed their database filtering the information in the ANUIIES database with each of the lists. The result was a new database that contains all programs and university students of the country, classify by STEM-like, STEM, and MSTEM. The following diagram (Figure 1) summarizes the process described above.
Figure 1. Methodology to construct the database that contains the number of students and programs STEM-like, STEM and MSTEM.

Table 1. The number of STEM programs in the CMPE and NSF catalogue offered by fields

| Fields                                      | NSF Approved STEM Fields | STEM-like | STEM | MSTEM |
|--------------------------------------------|--------------------------|-----------|------|-------|
| Chemistry                                  | 10                       | 13        | 13   | 0     |
| Computer and Information Science and Engineering (CISE) | 15                       | 109       | 7    | 102   |
| Engineering                                | 18                       | 683       | 434  | 249   |
| Geosciences                                | 24                       | 19        | 4    | 15    |
| Life Sciences                              | 18                       | 49        | 26   | 23    |
| Materials Research                        | 10                       | Included in Engineering | Included in Engineering | Included in Engineering |
| Mathematical Science                      | 14                       | 17        | 16   | 1     |
| Physics and Astronomy                      | 10                       | 16        | 16   | 0     |
| Psychology                                 | 14                       | 61        | 0    | 61    |
| Social Sciences                            | 20                       | 221       | 0    | 221   |
| STEM Education and Learning Research       | 5                        | 13        | 0    | 13    |
| Total                                      | 152                      | 1201      | 516  | 685   |

Source: Prepared by the authors based on NSF Approved STEM Fields and CMPE catalogue.
4. Results
In the first step of the methodology, this work presents an equivalence between the CMPE catalog and the NSF Approved STEM Fields list, to obtain the list of STEM-like programs. After that, the authors did a curricular review of the STEM-like programs, following the criteria established in this work, to obtain the lists of STEM and MSTEM programs. Those lists have quantitative information on the number of programs that integrate them. Table 1 presents this information for each of the lists, including the NSF, Approved STEM Fields list. This table shows that the NSF Approved STEM Fields list contains 158 programs, while the CMPE catalog contains 1201 STEM-like programs; that is, in Mexico are 1043 more STEM-like programs than the NSF Approved STEM Fields.

Of the 1201 STEM-like programs, 685 are MSTEM, and 516 are STEM. These data show that 57% of STEM-like programs do not meet the criteria established in this work. Observing this information by fields of study, we have that 100% of the programs in the fields of Psychology, Social Sciences, STEM Education, and Learning Research are MSTEM. In the field of Computing and Information Technology and Engineering, 102 of 109 programs are considered MSTEM, which means that 94% of the programs offered in this field are MSTEM. In the field of Geoscience, 15 of 19 programs are considered MSTEM. For the Life Sciences field, 23 of 49 programs are MSTEM; even in the field of Engineering, 249 of 683 are MSTEM, only in the fields Chemistry, Physics, and Astronomy, the 100% of the programs are STEM.

Table 2 shows the number of university programs offered in Mexico, classified with the STEM-like, MSTEM, and STEM lists from 2011 to 2017. In 2011, Mexico had 13803 university programs distributed throughout the republic, of which 4546 are STEM-like, 3046 are MSTEM, and 1500 are STEM. These data, in terms of percentage concerning the national offer, 33% of the programs are STEM-like, 22% are MSTEM, and 11% are STEM. In 2017, Mexico increases the number of national university programs to 17833, of which 5258 programs are STEM-like, 3257 are MSTEM, and 2001 are STEM. When obtaining the percentage for the national offer, 29% of the programs are STEM-like, 18% are MSTEM, and 11% are STEM.

In the period from 2011 to 2017, all the programs in Mexico increase the number of them. However, the proportion of the STEM-like and MSTEM programs decreases. As for the STEM programs, their proportion from the total of programs is constant during the period.

| Years | National | STEM-like | MSTEM | STEM |
|-------|----------|-----------|-------|------|
| 2011  | 13803    | 4546      | 3046  | 1500 |
|       |          | 33%       | 22%   | 11%  |
| 2012  | 15060    | 4659      | 2938  | 1721 |
|       |          | 31%       | 20%   | 11%  |
| 2013  | 15942    | 5088      | 3259  | 1829 |
|       |          | 32%       | 20%   | 11%  |
| 2014  | 16361    | 5143      | 3253  | 1890 |
|       |          | 31%       | 20%   | 12%  |
| 2015  | 16892    | 5199      | 3273  | 1926 |
|       |          | 31%       | 19%   | 11%  |
| 2016  | 18780    | 5287      | 3289  | 1998 |
|       |          | 28%       | 18%   | 11%  |
| 2017  | 17833    | 5258      | 3257  | 2001 |
|       |          | 29%       | 18%   | 11%  |

Source: Prepared by the authors.
4.1. The university students
In Mexico, there are four types of university students: 1) students who, for the first time, join a university program are called first-enrolled students; 2) students who attend a university program are called enrolled students; 3) students who have completed all the credits of a university program, but do not yet cover the final requirement to obtain the degree, are called egresados; and 4) students who have obtained the degree are called graduate students. In this article, egresados students are included in the graduate category. The following tables show the number of each type of students split by the STEM-like, MSTEM, and STEM programs.

4.2. First enrolled students
The distribution of the first enrolled students in the university programs reflects which program has the highest demand. Table 3 shows the number of first enrolled students in the country classified according to the STEM-like, MSTEM, and STEM lists. The information indicates, for the year 2011, 822,617 first enrolled students are in a university program, of which 228,777 students are in STEM-like programs, 136,748 students are in an MSTEM program, and 91,529 students are in STEM programs. In terms of percentage, the previous information is, 28% of students prefer STEM-like careers, 17% of students prefer MSTEM, and 11% of students prefer STEM careers. For 2017, 977,742 first-enrolled students are in some university program, of which 296,485 students are in STEM-like careers, 172,285 students are in MSTEM careers, and 124,200 students are in STEM-type careers. When calculating the percentage, 30% of the students prefer STEM-like careers, 18% of the students prefer MSTEM careers, and 13% of the students prefer STEM careers.

In the period from 2011 to 2017, there is an increase in the number of students entering university careers. Regarding the proportion, the students entering STEM-like careers have decreased, while MSTEM students increase by 26%, and the STEM students increase by 36%. The proportion of 18% of MSTEM and 13% of STEM in averages is constant during the period.

For the year 2015, 279,568 first-enrolled students were counted in STEM-like programs, equivalent to 32%. This percentage coincides with that reported by the OECD for the same year (OECD, 2017). However, according to the present study, the real percentage of students enrolled for the first time in a STEM program is 13% for that same year, the remaining 19% are considered MSTEM.

| Table 3. The number of first enrolled students in Mexico from 2011 to 2017 |
|---------------------------------|--------|--------|--------|--------|--------|
| Years                          | National | STEM-like | MSTEM | STEM | STEM by OCDE |
| 2011                           | 822617  | 228277  | 136748 | 91529 |        |
|                                | 28%     | 17%     | 11%    |       |        |
| 2012                           | -       | -       | -      | -     | -       |
| 2013                           | 841623  | 276168  | 165318 | 110850|        |
|                                | 33%     | 20%     | 13%    |       |        |
| 2014                           | 822617  | 264440  | 158626 | 105814|        |
|                                | 32%     | 19%     | 13%    |       |        |
| 2015                           | 870222  | 279568  | 167945 | 111623| 32%*   |
|                                | 32%     | 19%     | 13%    |       |        |
| 2016                           | -       | 295112  | 173481 | 121631|        |
|                                | 30%     | 18%     | 13%    |       |        |
| 2017                           | 977742  | 296485  | 172285 | 124200|        |

Source: Prepared by the authors. * OCDE (2017)
Table 4. The number of enrolled students in Mexico from 2011 to 2017

| Years | Total | STEM-like | MSTEM | STEM | STEM-like | MSTEM | STEM |
|-------|-------|-----------|-------|------|-----------|-------|------|
| 2011  | 3303128 | 570143    | 284722| 285421 | 344060    | 263171 | 80889 |
|       |        | 17%       | 9%    | 9%    | 10%       | 8%    | 2%   |
| 2012  | -      | -         | -     | -     | -         | -     | -    |
| 2013  | 3174801 | 672232    | 335241| 336991 | 397521    | 301954 | 95567 |
|       |        | 21%       | 11%   | 11%   | 13%       | 10%   | 3%   |
| 2014  | 3303128 | 689881    | 340266| 349615 | 407148    | 306318 | 100830 |
|       |        | 21%       | 10%   | 11%   | 12%       | 9%    | 3%   |
| 2015  | 3427097 | 717485    | 351097| 366388 | 422061    | 314152 | 107909 |
|       |        | 21%       | 10%   | 11%   | 12%       | 9%    | 3%   |
| 2016  | 3807416 | 755025    | 365531| 389494 | 440268    | 323548 | 116720 |
|       |        | 20%       | 10%   | 10%   | 12%       | 8%    | 3%   |
| 2017  | 3822603 | 779623    | 375870| 403753 | 456428    | 332038 | 124390 |
|       |        | 20%       | 10%   | 11%   | 12%       | 9%    | 3%   |

Source: Prepared by the authors.

4.3. Enrolled students

Table 4 shows the number of enrolled students classified according to the STEM-like, MSTEM, and STEM program lists, and also separated by gender. For the year 2011, the number of students enrolled in Mexico is 3303128, of which 27% are enrolled in STEM-like programs, 16% are enrolled in MSTEM programs, and 11% are enrolled in STEM programs. Separated by gender, 27% of students enrolled in STEM-like programs, 17% are men, and 10% are women. Of the 16% of students enrolled in the MSTEM programs, 9% are men, and 8% are women. Of the 11% of STEM programs, 9% are men, and 2% are women. For 2017, 32% of the students enrolled in STEM-like programs, 20% are men and 12% are women; while for 19% of the students enrolled in MSTEM programs, 10% are men and 9% are women; and the 13% of students enrolled in STEM programs, 10% are men, and 3% are women. These data show us that the proportion of women in STEM programs decreases by following the classification criteria established in this study.

The year 2015 is taken to exemplify the distribution of men and women for the STEM and MSTEM programs (randomly selected year, since the proportionality does not change during the analyzed period). For this year, there are 3427097 students enrolled in some university programs, 717485 are men enrolled in STEM-like programs, 351097 are men enrolled in MSTEM programs, and 366388 are men in a STEM program. In percentages of STEM and MSTEM for STEM-like, 51% of men are in MSTEM programs and 49% in STEM programs. The data for women shows that 74% of them are in MSTEM programs and 26% in STEM. These data show that the percentage of women studying STEM programs is lower under the classification criteria established in this study.

4.4. Graduate students

Graduate students represent the workforce that produces the country manpower and directly impacts the economy (FUMEC, 2016; OCDE, 2017). Table 5 shows the students classified in the STEM-like, MSTEM, and STEM lists. For the year 2011, the number of graduated students is 816,648, of which 24% are from STEM-like programs, 16% are from MSTEM programs, and 8% are from STEM programs. This data divided by gender shows that in STEM-like programs, 11% are women, and 13% are men, while in MSTEM programs, 7% are men, and 9% are women, and in STEM programs, 6% are men, and 2% are women. This data indicates a lower proportion of women in STEM programs when following the criteria established in this study.
The growth of these students during the period from 2011 to 2017, shows that although the number of students graduated and graduated for all types of careers increases, the proportion of men and women who graduated by any program (STEM-like, MSTEM, and STEM) is constant. This data indicates a proportional growth in graduates and graduates of all programs, regardless of their field of study.

5. Conclusions and discussions
This work builds a classification criterion for STEM programs, based on the definitions of White, Bybee and Carnevelle, of the STEM movement, which states that: All those programs whose curricular content is immersed in one or more STEM fields, is considered STEM type program. The authors analyzed Mexico, as an exploratory case, to demonstrate that, under non-homogeneous classification criteria, the reported parameters that indicate the growth of STEM higher education change dramatically.

In the analysis period from 2011 to 2017, it was found that 60% of the programs that claim to be STEM do not meet the established classification criteria. These programs were reclassified and named Management-STEM (MSTEM) since their curricular content include STEM topics, but mostly it is oriented to administrative or social areas. The authors consider that MSTEM programs are poorly classified in STEM programs because there were no classification criteria like the one presented in this work. Also, MSTEM programs can include in their names some words referring to STEM fields, which, without conducting a curricular content review, can confuse and promote the misclassification of these programs. For example, in Mexico there are programs with the name Industrial Engineering that refers to STEM fields; however, it is a program designed to study the management of manufacturing processes. Even when this program relates to several of the STEM fields, it does not specialize in any of them, and most of the subjects of this program are of administrative fields.

It is essential and necessary to use a classification criterion of STEM programs such as the one presented in this paper since the parameters obtained under different criteria vary drastically. Such is the case of the reports published by the OECD for the year 2015, where Mexico ranked in fourth place of 34 members, with 32% of the first students enrolled in a STEM program. However, when separating into STEM and MSTEM, it was found that there are 13% of STEM students and 19% of MSTEM students. This study coincides with the OECD report, when considering STEM + MSTEM students, this shows that the differentiation between MSTEM and STEM programs is vital given the
importance of STEM careers for the economy of each country. This differentiation also impacts the enrolled and graduate students. It was found for enrolled students, that 14% are in a STEM career, and 19% are in MSTEM. For graduate students, 11% are STEM, and 19% are MSTEM. Separated by gender, 8% of men and 3% of women are STEM. In the case of MSTEM, 10% are men, and 9% are women. By not considering the classification criteria, the numbers show a considerable overestimate of students in STEM careers. This is important because it could lead to an incorrect belief that a country fulfilled its objectives related to STEM higher education when it may be far from reaching them, affecting all the policies and decisions taken by the government on these matters.

This study, in addition to establishing a classification criterion to select STEM programs, reflects the MSTEM phenomenon. That may or may not be present in the same way in countries with a context like Mexico, such as those that belong to Latin America. It also suggests the revision of the STEM programs and their classification as a vital point for any country that seeks to move towards the fourth industrial revolution, the digital economy, and the 4.0 scenarios.

In addition, relevant data on the current state of STEM higher education in Mexico was generated, which is the first step in building the necessary policies around STEM higher education in this country. Besides, these data are the first step to identify the gap between higher education graduate students and the requirements of the STEM industry.

Funding
Two of the authors, Y. Pérez Maldonado and E. De La Cruz Burelo, received financial support from the Consejo Nacional de Ciencia y Tecnología-Fondo Sectorial de Investigación para la Educación through the project A159013 “Evaluación del impacto de las políticas públicas en la productividad científica, tecnológica e innovadora en México”.

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Citation information
Cite this article as: The problem of pseudo-STEM programs in higher education: A classification criterion, Yara Pérez Maldonado, Eduard De La Cruz Burelo & Claudia Marina Vicario Solorzano,Cogent Education (2020), 7: 1833813.

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