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Article

Rethinking the Teaching of University Statistics: Challenges and Opportunities Learned from the Colombia–UK Dialogue

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Abstract: The aim of this paper is first to examine, through a qualitative analysis of statistics syllabi, the current state of statistical education in a sample of universities in Colombia. The focus is on statistics teaching in degrees for economics and business administration students. The results from the qualitative analysis reflect a preponderance of traditional and didactic teaching methods centered on the teacher, not on the student. The second aim is to present findings from a case study that has developed an innovative pedagogical intervention, called a data fellows program, from the University of Manchester, United Kingdom, which evidences opportunities for how statistics can be taught effectively to non-STEM majors. Further, the data fellows model has also been explored in the context of developing statistical and data skills capacities in Latin America. We reflect on how the lessons from the UK case study could open up opportunities for rethinking the teaching of statistics in Colombia through developing data projects and experiential learning to practice statistics in the real world.

Keywords: statistics education; higher education; learning by doing; pedagogical innovation; data fellows

MSC: 00A35; 62P25; 97K70; 97C70; 97D40

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1. Introduction

The teaching of statistics does not only happen in STEM subjects. In this paper, we explore how statistics is taught in university curricula where the students are not studying a STEM (science, technology, engineering and math) major. As such, we focus on statistics, as a subject in its own right, rather than as a sub-branch of mathematics (the M in STEM), and we consider statistics teaching where it is embedded in non-STEM subjects. We are particularly interested in the application of statistical skills, which are also referred to in this paper more broadly as quantitative skills and are highly relevant to the broader context of STEM education. We contend that statistics education as a scholarly field can benefit from understanding how the social, administrative and economic sciences teach statistics to their undergraduate students. The paper contributes to the knowledge of how statistical skills are, and can be, acquired for non-STEM majors. In a world where data increasingly drive decisions, in the public and private spheres, statistical knowledge is in high demand. As such, the examination of how and where in the curriculum statistics is taught, and especially how students acquire statistical knowledge and skills for the twenty-first century workplace, is important. By examining how non-STEM majors learn how to do statistics, we can contribute to increasing the statistical capacity in society and bring our findings to a wider audience that goes beyond STEM subjects.

This paper examines the current state of the statistical education in Colombia and considers how it could be improved. We frame the research through the introduction of statistics education generally, then focus on the situation in Colombia specifically. The inclusion of a UK case study, which has also been considered for its applicability to statistical capacity building in Latin America, contributes to our research. Our research questions are:

1. What is the current state of statistical education in Colombia higher education non-STEM majors as reflected in statistics curricula?
2. What can be learned from other statistical education initiatives outside of Colombia (considering a UK case study)?
3. How might Colombia improve its statistical education by building on the UK case study?

Using a sample of statistics syllabi from eight Colombian universities (two public, six private), we seek to understand how statistics is taught to economics and business administration students. A grounded theory approach is taken to qualitatively analyze the content extracted from the syllabi, with attention paid to the mix of teacher-centered versus student-centered pedagogical approaches. An exploration of whether the syllabi included any innovative elements or enabled active learning is also undertaken. The latter is especially of interest, as three of the authors have previously worked collaboratively on a project (EmpoderaData) that proposed the use of innovative techniques for learning statistics in real world contexts. In order to explore these approaches in the context of teaching statistics in Colombia to non-STEM majors, we include here a UK-based case study, which presents a strong case for students to be given the opportunity to learn statistics in real-world settings through undertaking data-driven projects conducted in the workplace. This program places 'data fellows' into organizations to practice statistics.

The results from the qualitative analysis of the statistics syllabi and the UK case study, together with the lessons learned from testing the viability of the UK experiential learning approach in Latin America through the EmpoderaData project, are followed with a discussion of the challenges and opportunities. Finally, a conclusion that proposes a major change to statistics education in Colombia is presented.

Understanding how quantitative skills are currently taught through statistics education in non-STEM majors opens up opportunities to create a stronger statistically literate population. This research, thus, contributes to STEM education more broadly.

2. Statistics Education and Why It Matters

2.1. Statistics Education: Where and How Statistics Is Taught across the Curriculum

Statistics is a discipline that involves ways of thinking to deal with uncertainty and to understand the nature of inferential results drawing on sampling theory [1]. Thus, the study of statistics is closely related to the development of random or stochastic thinking that "helps to make decisions in situations of uncertainty, chance, risk or ambiguity due to lack of reliable information, in which it is not possible to predict for sure what is going to happen" [2] (p. 64). It follows that learning statistics will provide students with powerful tools to enable them to critically interpret data and information, and that the knowledge and skills acquired will equip them to better understand real-world problems. Having an appreciation of statistics will help students discuss, discern and make better-informed decisions, taking into account the uncertainty in the data and the limitations of the analysis based on it. Disinformation poses a real threat to democracy, for example, and the development of competent, statistically literate citizens is necessary for their participation in decision making and in civic life [3].

The research on statistics education has increased in recent decades, although to a lesser extent in the countries of the global south. The role of statistical education in training citizens who are required to make societal change, and be capable of good decision-making in the face of crises, is highlighted as an important need [4]. Our approach in this paper focuses on the statistics curriculum in higher education. However, statistical education at all levels of education is expected to "respond to the need of empowering all citizens and professionals in statistical literacy " [5,6] (p. 1). Within schools, for instance, there is a demand for more attention to be devoted to statistics and new calls for statistics to be a crosscutting subject taught in areas of the curriculum, including outside of STEM subjects, in which the use of data is required. Critical statistics teaching that pursues the training of students or citizens for conscious and informed decision making with a positive impact on society has been introduced as an important concept [7–9]. A statistically literate population is desirable, as "an enlightened citizenry that is empowered to study evidence-based facts and that has the capacity to manage, analyze and think critically about data is the best medicine for a world that is guided by fake news or oblivious towards facts" [7] (p. 45).

Teacher training and the study of the processes involved in understanding statistical concepts, as well as the skills and abilities involved in their use, are essential parts of developing a statistically literate population [10,11]. Good teaching will help students to learn statistics well, wherever statistics appears in the curriculum, and whatever educational level this is taught at. Factors affecting the effectiveness of statistics education have been categorized as: (i) the processes or results of statistical education in formal education; (ii) teacher studies on teaching practice; (iii) innovative teaching methods; (iv) the study of a specific topic of great relevance for learning or teaching from the perspective of another discipline, such as mathematics education or psychology, among others [12]. Moving on to examine developments around statistics education in higher education, research outputs in this area are relatively scarce. This is the case despite the fact that statistics occupies an important role in university curricula, both in mathematics departments, some of which have separate statistics departments, as well as in other subjects. Recent publications on teaching statistics [13–16] at the university level can provide some helpful insights on the problems and challenges encountered at this level of education. One of these problems is the difficulty that learning statistics can present for non-STEM majors students who "do not have a solid mathematical foundation and frequently avoid activities that involve numbers" [17] (p. 70), and this often ends in students feeling frustrated and lacking interest in or motivation for learning statistics. The anxiety that learning statistics generates in university students is reflected in several recent articles [13,14,18].

Given the scant literature on statistics education in higher education and in courses that are in non-STEM degree subjects, statistics education in the university context provides an opportunity for further research. An important contribution that will help the statistics education community better understand what is taught in statistics courses is to study what is included in the curriculum, and especially the extent to which this reflects real-world problems. By studying the contents of statistics curricula, and the contexts in which statistics is taught, we can start to reveal what and how university statistics courses are being delivered. Moreover, since "in many university classrooms there are still traditional models of education that focus excessively on the delivery of content ... these models have shown little effectiveness when they are evaluated (in terms of learning)" [17] (p. 78); it is important to reflect on existing learning approaches and pedagogies if we want to propose improvements.

The curriculum is an important starting point for understanding the current state of statistics education (in Colombia), but as we state in the introduction, the findings emerging from a UK program can also help progress our thinking in this area. Therefore, we highlight here the role of statistical education in the social sciences, a subject area that requires critical understanding of statistics to be able to make sense of the world that is increasingly presented in the form of quantitative data.

2.2. Statistics Education: Lessons from a Social Sciences Perspective

We have commented that statistics education is not only delivered through the STEM curriculum; thus, to add to the understanding of how non-STEM degree majors are taught statistics, we turn to lessons learned from the social sciences. In this paper, our qualitative analysis is based on statistics education through an examination of business administration and economics degrees in Colombia. To set the context for the research, this section provides evidence from an initiative that has seen success in training undergraduate students majoring in social science subjects on how to acquire and practice 'quantitative skills' (for a fuller explanation of what we mean by 'quantitative skills', see below). The Q-Step (Quantitative Step Change) program, which ran from 2013 to 2021, was a strategic response to the UK seeking quantitative skills for careers in research and data-led professions. Seventeen universities participated and an external evaluation of the program was published in 2022. The evaluation reported many positive outcomes, including that "participation in Q-Step modules is associated with better employment prospects for students compared to similar students on equivalent courses" [19] (p. 5) and that the centers have "increased engagement with external stakeholders, particularly local employers, through their networks of work placement providers" [19] (p. 38). The evaluation proceeds to highlight the increased capacity across the participating universities to teach quantitative skills, encouraging other higher education providers to follow their lead. It noted that student satisfaction in these courses was high and significant value was placed especially on the work placement activities the centers introduced. The recommendations arising from this evaluation included sharing this good practice more widely across the scholarly community and ensuring that the diversity of backgrounds in the programs of study and work placements is broad. The report concludes with the recommendation that "Q-Step should be presented as a showcase example that encourages other universities to invest in the development of quantitative methods within social science programs and beyond. The evidence from Q-Step suggests that investing in quantitative skills training increases graduate employability, enriches the curricula, increases staff expertise and encourages the recruitment of additional high-quality lecturers" [19] (p. 68). This strong evidence-based recommendation from the Q-Step program evaluation report supports the inclusion of a case study from this social-sciences-led initiative in this paper.

The focus on quantitative skills in the Q-Step program, as introduced above, requires further elaboration in order to clarify its inclusion in, and contribution to, this article on statistics education. In particular, this program was aimed not at STEM university students but at social science undergraduates. Grundy [20], writing about the origins and aims of the Q-Step program, highlights the quantitative skills that social science students are taught. He places the Q-Step program's emphasis on the acquisition of statistical and data skills, with a clear focus on applying the learning to real-world problems. Grundy's coverage of quantitative skills includes understanding how to design surveys and experiments and how to analyze and interpret the data they generate; understanding how to analyze and interpret data from other sources such as social media, administrative data and longitudinal cohort studies; and understanding how to evaluate the quality of data sources, what constitutes good and bad evidence and how it can be used to make decisions. As such, the Q-Step program addressed the need for students to acquire critical statistical and data skills and to have the opportunity to practice them both in the classroom and importantly in the workplace. These quantitative skills put STEM skills in general, and statistics and data skills in particular, firmly in the spotlight for social science majors. Many of the Q-Step centers established work placement programs through which undergraduate students could take their statistical learning and data analysis a step further. Carter [21] presents case studies and vignettes from the University of Manchester Q-Step program (and other universities, including PhD students) evidencing how social science students put their statistical skills into practice through undertaking 'data fellowships'. The 'data fellowships' are based in multiple employment sectors, ranging from local government departments to The World Bank, and show how social science students' quantitative skills can be enhanced in the workplace via experiential learning.

Section 4.2 presents a case study from one of the UK Q-Step centers, the University of Manchester, to present some of the outcomes and findings of a social-science-led approach to teaching statistics and data analyses. In particular, we examine how this model of skilling-up undergraduates, who have been taught statistics in the classroom and are then immersed in the workplace to develop these skills, is one that educators should consider. Moreover, building on this work through an international project, EmpoderaData, in Latin America, we evidence how it is possible to contribute to the development of data skills capacity for the delivery of the UN's 2030 Sustainable Development Goals. It is our contention that the findings and approaches we present in this article will help statistics educators develop a more statistically literate graduate population and could change how statistics is taught in Colombia.

3. Methods

Based on the authors' aspirations to find actions to strengthen and opportunities to improve statistical education in Colombia, this research concentrates on reviewing the current state of statistical education in higher education institutions in Colombia. This was based on a sample of universities as described below.

Bearing in mind that grounded theory was used, we worked with a final sample of 19 syllabi (primary documents) once theoretical saturation was reached, i.e., when the information gathered in these documents did not contribute anything new to the development of the properties and dimensions of the categories of analysis. The syllabi corresponded to business and economics schools, taking into account the authors' interest in focusing on the teaching of statistics in academic units that did not necessarily have mathematics-dominated curricula. The sample aimed to be as diverse as possible, including public and private universities and universities located in Bogotá, the capital of Colombia, as well as others in different cities.

It is worth noting that a syllabus, according to the instructions of the Colombian Ministry of National Education, must contain at least the following sections: the name of the subject, the number of credits, the hours of mediated study by the teacher and the autonomous work, the central themes, the expected learning results, the justification of the subject or a summary of it, an evaluation methods and a recommended bibliography. We only included syllabi that met this definition.

For the analysis, we used a qualitative approach [22,23] based on grounded theory [24]. We began with the research question 'What is the current state of statistical education in Colombia higher education non-STEM majors as reflected in statistics curricula?'. Figure 1 shows how we undertook the coding starting with our primary data and how we developed a conceptual understanding of our research question through our data. Our sample of statistics curricula—as described above—enabled us to develop and code our dataset for the inductive analysis using Atlas.Ti Software. Our primary data were from the collection of the 19 syllabi from our sample as described above. We allowed the codes to emerge from the data, purposefully avoiding using a predetermined coding scheme, and in this way a descriptive coding system was obtained to initiate the analysis. We then advanced from these descriptive codes to eliciting categories that reflected a deeper and more conceptual understanding of the syllabi. This was achieved by noticing central concepts and relationships between codes, and through a process of iteratively reflecting on and interpreting the collection of codes. The resulting expansion or division of some of them into clearer ones allowed us to advance to this level of conceptual coding. Once this conceptual level was reached, the categories were compared with the primary data and we questioned whether theoretical saturation had been reached, i.e., the level at which the categorical scheme could be understood as an emerging theory with meaning and value. If it was decided that saturation had not been reached, a new iteration was begun, including a new primary document, and this cyclical process continued.

Given the interpretative nature of the research, after theoretical saturation had been reached, a sample size of 19 syllabi from the eight universities in our sample was sufficient and guaranteed the discovery of a model for statistical education in Colombia, from an emerging taxonomy based on grounded theory. The characterization and distribution of these syllabi are shown in Table 1. The hope was to discover a conceptual model that accounts for the state of statistical education in Colombia in business and economics departments.

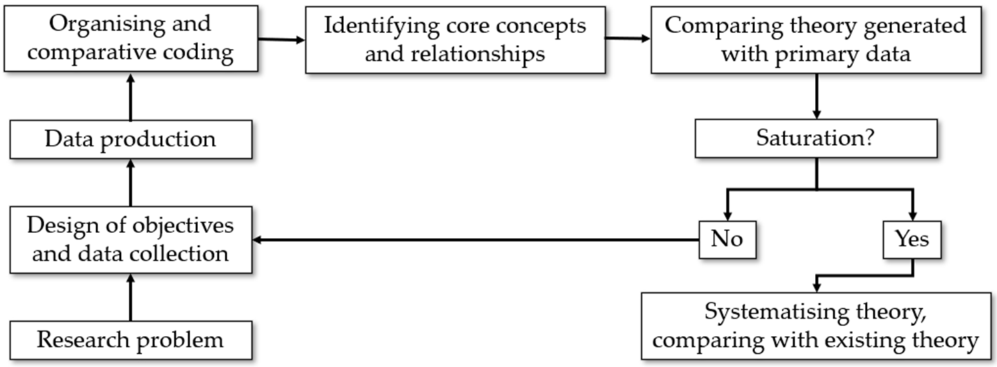

Figure 1. Cyclical scheme of a typical process guided by grounded theory.

Table 1. Distribution of the syllabi.

University	Type	Location	Program	Syllabi
U. de los Andes	Private	Bogotá	Business Administration and Economics	3
Escuela Colombiana de Ingeniería	Private	Bogotá	Business Administration	1
Konrad Lorenz	Private	Bogotá	Business Administration	2
U. de la Sabana	Private	Bogotá	Business Administration and Economics	2
U. del Rosario	Private	Bogotá	Business Administration and Economics	3
U. del Valle	Public	Cali	Business Administration and Economics	4
U. Autónoma de Occidente	Private	Cali	Business Administration and Economics	2
U. de Antioquia	Public	Medellín	Business Administration andEconomics	2

Specifically, the descriptive coding system [25] was initially made up of 65 codes (see the "codes" column in Appendix A) showing an emerging taxonomy from a purely descriptive perspective. After incorporating decisions towards a conceptual convergence, 11 groups of codes (see Figure 2 and also column the "group codes" in Appendix A) were organized, which ended in a categorical scheme of three nodes (Figure 3). The evolution of the coding system from the descriptive segment to the conceptual segment is organized in Appendix A.

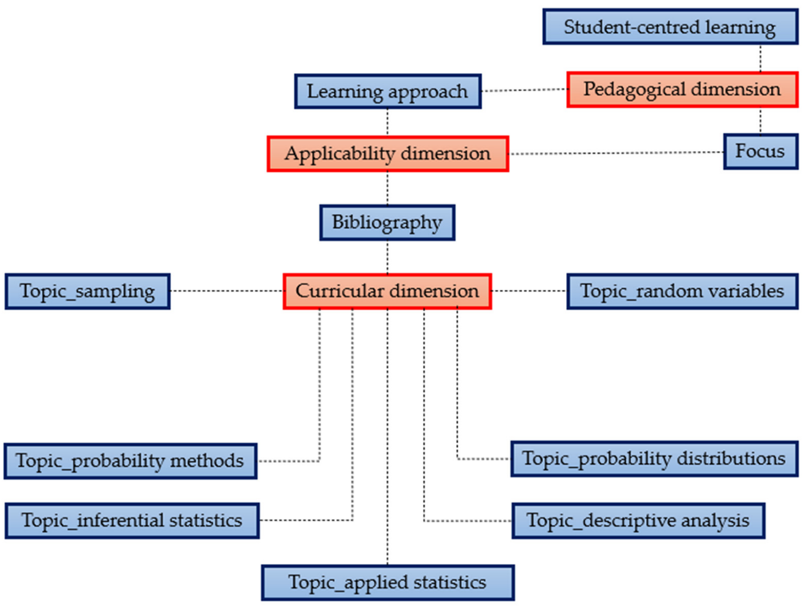

Figure 2. Relationship between the three dimensions of the analysis and the 11 code groups. The red nodes represent the three dimensions (emergent categories) and all other nodes represent groups of codes. This scheme comes from a first coding system of 65 codes, which is shown in Appendix A.

	Applied focus	Disciplinary focus	Technological focus	Theoretical focus	Traditional Learning approach	Project (Student-centered learning)	Learning strategies (Student-centered learning)	Theoretical evaluation (Student-centered learning)
Applied focus	0	22	11	36	12	9	5	0
Disciplinary focus	22	0	3	18	2	4	0	0
Technological focus	11	3	0	6	22	8	21	2
Theoretical focus	36	18	6	0	3	1	0	0
Traditional Learning approach	12	2	22	3	0	3	46	79
Project (Student-centered learning)	9	4	8	1	3	0	1	0
Learning strategies (Student-centered learning)	5	0	21	0	46	1	0	11
Theoretical evaluation (Student-centered learning)	0	0	2	0	79	0	11	0

Figure 3. Co-occurrence matrix. Cell ij of this matrix shows the co-occurrence of code i and code j, i.e., the number of times these two codes are linked to the same citation.

4. Results and Findings from the UK Case Study

4.1. Results from the Qualitative Analysis of Statistics Syllabi in Colombia

The final results from the qualitative analysis show that in Colombia, statistical education in higher education non-STEM majors can be conceptually reduced in three dimensions—the curricular, the pedagogical and the applicability (application of statistics) dimensions. We found that each is intrinsically connected to the other; what these courses teach, how they teach and their learning goals are captured in these three dimensions within the syllabi. We found that the applicability of statistics education, although evident—and our stated focus in this study—is still emerging. The learning strategies where students have some freedom to undertake their own research and become novice users of statistics in their professional lives are most often controlled by their professors and students are seldom allowed to leave the sandbox examples they are given.

This categorization emerged after carefully examining the nineteen syllabi. We created a coding system of 65 codes. In Section 4.1.1, we describe how we arrived at the final three-dimensional model of statistical education based on our data (i.e., the curricular, the pedagogical and the applicability dimensions) by outlining the most relevant codes that emerged from the analysis and how they interact with each other.

4.1.1. The Dots: Main Characteristics of Colombian Statistical Education

We chose the most relevant codes—with the higher absolute frequencies—to describe the results with the information closest to the syllabi. The codes were (1) applied focus, (2) disciplinary focus, (3) technological focus, (4) theoretical focus, (5) traditional learning approach, (6) project, (7) learning strategies and (8) theoretical evaluation. These eight codes convey how statistics courses are taught, how they fit into the focus, the learning approach and the student-centered learning groups from the *pedagogical dimension* of the course (Figure 2). The first four categorize how the syllabi approach the topics and how they frame the learning goals of the course; the fifth includes all references to lecture-like classes, in which students are assumed to have a passive role; the final three show how students are assessed via a research project, class assignments and exams.

The applied focus (code 1) drives the courses towards problem-solving strategies. Through the learning strategies, evaluations and approach to certain topics, students are taught how to use statistics in real-life situations, albeit frequently controlled by the professors. This can open students' curiosity to explore new ways in which they can use statistics in their professional lives further on.

The disciplinary focus (code 2) involves topics, methods and approximations to the students' major. In some syllabi, unsurprisingly the main motivation of the course converges on how statistics can be used in business administration and economics, such as business risk and performance indicators, stock market fluctuations and project management. This allows students to get closer to their major, with clear explanations of the use of statistics.

The technological focus (code 3) is, in essence, the use of statistical software. In these courses, they mostly use R, Stata and SPSS. This provides a more hands-on model of education, in which students are encouraged to transfer their theoretical knowledge to statistical software, which ultimately they will most likely use in their career.

The theoretical focus (code 4) delves into the study of statistics on an abstract level, covering how mathematical formulas work and how to use them. The core of these syllabi is the mathematical component rather than real-life examples and data. This approach, while important, on its own drifts students further away from their potential interest in mathematics and might deepen their frustration towards learning statistics.

The traditional learning approach (code 5) arises from the courses that follow the conventional professor–student roles. Basically, the professor teaches the topics from a textbook chapter, which is previously read by the students, who usually solve some exercises in class or are left some homework. This approach encapsulates students into boxes, whereby their only job is to learn, have questions and be able to solve textbook problems. This also limits the students' creativity and curiosity and the possibility to learn-by-doing.

The project (code 6), learning strategies (code 7) and theoretical evaluations (code 8) are how the professors evaluate the students. Although most of these revolve around problem-solving strategies, the problems are in controlled environments in which the statistics and data are perfectly clear and the concepts can be easily applied—far from what students will have to deal with in their professional lives. The connections among these eight codes let us draw conclusions on how statistics is taught in Colombia.

4.1.2. Connecting the Dots: How Different Course Focuses and Learning Approaches Interact with Each Other

Grounded in the conceptual coding system and aligned with the most frequent codes, using Atlas.Ti, we built a co-occurrence matrix (Figure 3) that shows how the eight most relevant codes are interrelated. A co-occurrence matrix (or adjacency matrix) shows how many times two nodes (codes in this case) occur in the same part of a syllabus.

The closest relations within the codes are between the theoretical evaluation and traditional learning approach, with 79 co-occurrences. All of the syllabi describe evaluations as written exams in which students have to solve problems, such as the ones studied in class; some are during the class, while others are assigned as homework (these were also classified with learning strategies, with 11 co-occurrences). Also related to the traditional learning approach (with 46 co-occurrences), the learning strategies are those exercises and class assignments – usually extracted from the textbooks – that professors use to show a controlled and safe application of statistical theory. In some of these, the students are expected to use statistical software programs to solve the problems, often regarding topics close to their majors, showing the relations to the technological focus (the technological focus and learning strategies have 21 co-occurrences. Additionally, the disciplinary focus and the technological focus are closely related, with 22 co-occurrences).

Regarding the relations among the focuses, the syllabi show that often the applied (the applied focus shares 9 co-occurrences with project, 22 with disciplinary focus and 11 with technological focus), technological (the technological focus has 8 co-occurrences with project, 11 with applied focus and 3 co-occurrences with disciplinary focus) and disciplinary (the disciplinary focus shares co-occurrences with project, 22 with applied focus and 3 with disciplinary focus) focuses are joined together by a project—a student-centered learning strategy that encourages the students to choose a problem related to their major (disciplinary) to use the mathematical formulas learned in class (applied) using statistics software (technological), as shown on Figure 2. Leaving aside the innovative potential these projects have, in some universities students are expected to choose a problem from a curated list created by the professor and to stay within the bounds of what was taught during the term. This makes some projects also part of the traditional learning approach, with 3 co-occurrences between project and traditional learning approach.

The applied focus appears in two ways: mixed with a theoretical focus (36 co-occurrences) or with a disciplinary focus (22 co-occurrences, see Figure 3). In the theoretical focus, the applicability of statistics is limited to the use of formulas to solve problems that are usually decided and controlled by the professors. This is also related to the disciplinary focus (which is also tightly connected to the theoretical focus, with 18 co-occurrences, as shown in Figure 3), as some of these problems are related to economics or business administration. In this way, the applied focus joins how they teach statistics, what they teach and what the goals of the course are.

4.1.3. Three-Dimensional Model of Statistical Education

As stated in Section 4.1, the final results from the data we collected and analyzed show three dimensions of how statistics is taught in Colombia (as shown in Figure 3 and mentioned in the methodology): (A) the curricular dimension of the courses, (C) the pedagogical dimension of the courses and (B) the applicability, which is the bridge that joins both (A) and (C).

The curricular dimension (Figure 4A) includes the topics and bibliographies studied in the courses. Although we do not elaborate here on what is taught in statistical courses, we categorize the topics and bibliographies for the syllabi. The topics cover both probability and statistics, from random variables to the design of statistical models. The bibliographies focus mostly on statistical theory; they are used as guides for the course and exercise workbooks.

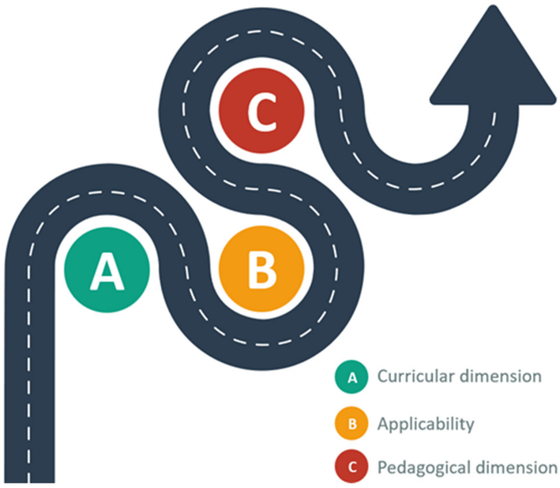

Figure 4. Main categories of statistic education in Colombia.

The pedagogical dimension (Figure 4C) encompasses the methodology and central axis of the class. The methodology is the main line of work in the syllabi, dictating how the topics are taught and afterwards how they are evaluated. The central axis of the class reflects who the main character of the course is: whether the lectures revolve around the professor, or whether they embrace the students as the true protagonists. As we discussed above, this is the center of attention of this research.

The bridge that connects both the curricular and pedagogical dimensions is the possibility to apply the knowledge acquired in class. This is the applicability (Figure 4B). We found that certain topics, such as statistical models, are usually taught using examples applied to real life problems, some of them regarding the disciplines (majors). These, however, are often controlled and delimited by the professors, not letting the students learn statistics in a real-world environment but in a textbook-safe way.

4.2. UK Case Study: Developing Statistical and Data Skills in Higher Education

Our second research question is 'what can be learned from other statistical education initiatives outside of Colombia (considering a UK case study)?'

The focus of this section is to consider recent developments in teaching statistics to non-STEM majors to help educators reflect on how statistics teaching could be improved wherever it is delivered in the curriculum. This is important, as in order for statistical educators to be able to tackle some of the challenges that have been elicited in the previous section, we need to consider alternative approaches and ways of developing statistically literate citizens [26]. In the UK, the acronym given by the British Academy to those who graduate from social science, arts or humanities degrees is SHAPE (social science, humanities and arts for people and the economy), with 'the Right Skills' report [27] highlighting the importance of quantitative skills developed by SHAPE graduates for the labor market. International bodies concerned with developing and evaluating statistical education have increasingly been paying attention to the development of data skills. Watson and Smith [4], who are particularly concerned about the increasing need to educate students to evaluate data and information critically since the COVID-19 pandemic, note that "the Practice of Statistics' should be ... recommended ... wherever data-based questions are relevant in context and informal inferences can be made." [4] (p. 177). In a recent focus on research outputs examining the teaching of statistics and data analyses in the social sciences, scholars have taken different approaches, including drawing attention to the importance of making students part of the dataset [28], reflecting on the embedding of the real world context of teaching statistics to social science students [29] and using a project-based approach with datasets of interest to the students [30]. International bodies concerned with the development of statistical literacy, including the International Association for Statistical Education (IASE), need to take note of these approaches to developing statistical reasoning and data skills, including applied learning, beyond STEM-only subjects. It is the combination of the context of the research and subject expertise that social science students excel at, as well as their understanding of the complexity of modelling social systems and behaviors.

Adopting the precept that students' curiosity will drive them to learn to use tools and methods, including statistical techniques and software, to investigate interesting social research questions was the premise for the development of the Q-Step Center at the University of Manchester and the Data Fellows program. A data fellow is the term given to a University of Manchester undergraduate student who has satisfied eligibility criteria (at the degree program level and having taken the required prerequisite statistics courses), has applied through a competitive process to undertake an 8-week-long data-driven research project with an external organization and subsequently has been successfully embedded in the host's workplace to conduct the project. To date, 330 data fellows have been placed in around 60 host organizations. Some of these data fellows now work in social research and statistical careers. Posters produced by each year's cohort, dating back to 2014, can be found online (https://www.humanities.manchester.ac.uk/q-step/student-stories/; accessed on 14 September 2022) [31].

The interaction between teaching statistics and data analysis and the resulting analytical and research skills that can be applied in the workplace provides compelling evidence for the success of this data fellows program [21,32]. Some data fellows have their heads turned. Some return to university to undertake a quantitative research dissertation in their final year. Examples of former students who have done so, and gone on to win research dissertation prizes, include those who wrote theses involving sophisticated statistical analyses and data-driven research. The following dissertation titles reflect three former data fellows who graduated with sociology or politics degrees: 'The Pattern of Relative Material Deprivation in the United Kingdom in 2011 using an Updated Version of the Carstairs and Morris Deprivation Index'; 'Why Can't iSleep? A Sociological Perspective on the Impact of Screen Time on Adolescents' Sleep Duration'; and 'Who are the 'Left Behind'? The Status Stratification of UKIP Support'. Another former data fellow, a criminology graduate, analyzed the Scottish Crime and Justice Survey data to explore victim reporting of partner abuse to the police using bivariate and logistic regression analyses of the factors involved. For this dissertation, she scooped up a prestigious national prize [31]. Three of these former data fellows are now working in careers in regional or national government, two as lead data analysts, one as a government statistician and the fourth is studying for a PhD. We include these as examples here not to claim that they are representative, but to show how social science degrees, coupled with experiential learning opportunities, can produce highly trained graduates who can and do enter professions and advanced study that require a high level of statistical training. As these examples show, graduates who move into data or statistical professions do not need to have studied a STEM degree. Indeed, non-STEM majors from the social sciences can and do learn statistics to a level that can help them find roles in data and statistical careers.

The EmpoderaData Project: Adapting the Data Fellows Model to Latin America

Our third research question was 'How might Colombia improve its statistical education by building on the UK case study?' The success of the University of Manchester data fellows program has already led to interest from other countries in developing the model in international contexts. The EmpoderaData research project was a transnational partnership between the University of Manchester (UK), Universidad del Rosario (Colombia), Fundação Getulio Vargas (Brazil) and Data-Pop Alliance (US and France) to explore the transferability of the data fellowship program to Colombia, Mexico and Brazil. The project used a mixed-methods, three-stage approach to explore this issue with stakeholders who were involved in data or statistical literacy advocacy (including university teachers) or policy-making in the three countries. First, a workshop was held in São Paulo (May 2019) with 30 key stakeholders from the three countries. The workshop was followed by in-depth semi-structured individual interviews, held remotely in June–July 2019, with 18 stakeholders (some of whom were at the first workshop). The final stage involved a workshop at the University of Manchester (October 2019) to present and discuss the preliminary findings with potential partners or advisors who had emerged from the first two stages of the project.

The results from the project illustrated a need for basic data skills training in the three countries. In particular, in Colombia and Brazil, there was a very keen interest in adopting the data fellows model to build the statistical and data literacy capacity to help deliver the SDGs. Furthermore, a key recommendation from the research was the notion of a hybrid model that would bring together data fellows with complementary backgrounds (such as social scientists and STEM students) to work collaboratively on SDG-related challenges [33,34]. This finding—that hybrid teams are required to conduct rigorous statistical analyses informed by strong subject expertise—is at the heart of what we propose in this paper. The notion of teams with mixed skills and backgrounds is not new, but developing teams in civic and business society that can tackle complex data-driven problems is evidenced by our work. Thinking about the talent pipelines leading into such teams is an important area of investigation if we are to be able to deliver on the SDGs country-by-country. As a result of phase 1 of the EmpoderaData project, two parallel in-country projects emerged in Colombia (led by the Universidad del Rosario in Bogotá) and Brazil (led by the FGV Business School in São Paolo). This second phase notes "the results from the EmpoderaData project give a very clear narrative that a data fellowship model can be flexibly adapted to different disciplines or subjects (traditional social science, business studies and mathematics), within different country contexts and with different curriculum designs" [34] (p. 1019).

5. Discussion: Challenges and Opportunities in Colombia

Much has been said about the project-based approach [35–37] and its importance for science teaching and meaningful learning. The advantages of endowing concepts with meaning through contextualized learning are that this also places the learning subjects (the students) as the main actors in such a way that they remain active and motivated and become builders of methodologies and solutions that allow them to learn. However, as has been shown in our research, methodologies like these are not used in the educational reality of Colombia, particularly in relation to project-based learning and learning by doing; there is still much work to be done and much to transform.

The research exercise carried out by this group of researchers shows how, although there is a declaration of applicability when teaching statistics, in reality most of the learning continues to be centered on the teacher; learning based on experience does not have important representation. Although an aspiration has emerged to focus the learning on the student, applicability and autonomous work, this is summed up, in many cases, in the use of already structured formulas and procedures; where critical and significant thinking does not have much prominence.

It is essential to remember that statistics is the science of data and that data are not numbers, but rather numbers in context, where "contextual knowledge is indispensable" [10] (p. 339). It is also important to remember that students' experiences are important, i.e., that they will be using statistics to interpret their nearby reality and solve their problems.

Moving towards a student-centered model in Colombia is a great challenge because of the amount of transformation that would be needed around teaching existing practices. For example, it is necessary: (i) to review the curricula in order to be able to guarantee the time required for this model; (ii) to include this type of model in teacher training, since the professor no longer reproduces but rather generates relevant questions for the development of the students and produces dynamics that favor doubt, debate and the construction of knowledge; (iii) to propose new didactics of statistics; and (iv) to rethink the dynamics in which universities bring students closer to the situated use of their learning.

Now, we highlight the need for and relevance of field practices, as they are powerful activities that allow the student to establish and stimulate a dialogue between the learning that emerges within the class and the reality of its use in the context of a specific practice, thereby developing important competencies and skills for their profession. Learning by doing is a method with which students can discover and correct errors that emerge from their practices in the reality of the situation they are dealing with [38,39]. In addition, they strengthen an essential skill—to know in which scenario they should use a piece of knowledge and what knowledge to use [40,41]. This "ability to apply mathematical knowledge is often much more difficult than is supposed, because it requires not only technical knowledge (such as preparing a graph or calculating an average), but also strategic knowledge (knowing when to use a concept or given graph)" [42] (p. 9).

The results from the current teaching of statistics in Colombia and the data fellows program used in the UK suggest that changing the way statistics is taught in Colombia would be beneficial for non-STEM majors and for social science students in particular. The UK Q-Step program arose from the call for social science professionals with strong quantitative skills. In Colombia, the context is not that different. The research prior to EmpoderaData enlightens how data-literate professionals are needed for jobs in private industry, public policy making and the government.

As this shift in teaching statistics for social sciences would respond to these positions in the job market, graduates would be perfectly suitable for these vacancies. Furthermore, students would learn to learn and learn by doing, both of which would expand their curiosity and encourage them to challenge how they approach their dissertations and other research projects. By building on the students' curiosity, linked to a strong basis of statistical skills, the UK model has been successful in driving students to do their dissertations on social sciences using quantitative data-driven research. We find no evidence that this would be any different with Colombian business or economics students.

6. Conclusions

Statistics education is key for social science students in a data-driven world. Scholars highlight the bridge that statistics provides to join different disciplines together, to train students to draw conclusions from data in order to make informed decisions and to encourage students to upskill their critical thinking and statistical skills. We explored how selected universities in Colombia and the UK teach statistics. We focused on students in non-STEM degrees, recognizing that studying statistics might cause students some concern. Our contributions apply to two different scenarios: a traditional approach to teaching from Colombia and a hands-on approach from the UK.

Our first research question was to explore 'What is the current state of statistical education in Colombia higher education non-STEM majors as reflected in statistics curricula?' This paper shows that from an analysis of the syllabi included in our sample, the way in which Colombian universities teach statistics has two main dimensions—the curricular and the pedagogical. Both are joined by applicability; some topics and teaching strategies are driven by how statistics is used in real-life scenarios. These scenarios, however, are frequently decided and controlled by the professors, which adds to the traditional approach to statistics that these courses have. Although there are some innovative examples, most topics are covered in a traditional way; students must prepare for the lecture, do some exercises in class, take theoretical exams and in some cases do a group project for applicability. Our research was based on a small sample of statistics and probability courses' syllabi for economics and business administration students. Whilst we do not claim this to be a representative sample, it nevertheless offers a new insight into Colombian statistics education.

Our second research question was 'What can be learned from other statistical education initiatives outside of Colombia (considering a UK case study)?' The inclusion of the UK case study showed how the University of Manchester has addressed the quantitative data skills deficit among social science students. This model involved students acquiring critical data skills in the classroom and then putting those skills into practice via paid employment (through data fellowships) during the course of the undergraduate degree. The Q-Step program from which the data fellowship model arose has been highly commended because of the impact on the future careers and studies of the students who participated, and has demonstrated that social science degrees, coupled with experiential learning opportunities, can produce graduates who are highly statistically literate. The transferability of the data fellowship model to Colombia, Mexico and Brazil was explored via the EmpoderaData project and the results produced a very clear narrative that the model can be flexibly adapted to different disciplines or subjects (traditional social science, business studies and mathematics) in different country contexts and with different curriculum designs. The results also suggested that hybrid teams within civic and business society, with mixed skills and backgrounds, are needed to tackle complex data-driven societal challenges, illustrating the importance of real-world statistical literacy education for both STEM and social science students.

Thirdly, we sought to address through our research the question of 'How might Colombia improve its statistical education by building on the UK case study?' The Q-Step program in the United Kingdom was designed to create a step-change in teaching quantitative skills to university undergraduates in the social sciences. If statistical education in Colombia is to be reformed in a similar way then universities could start by creating experiential learning opportunities to extend the classroom learning into real-world contexts. This could be achieved in two ways. First, more real-world examples are needed in statistical curricula, and these could transform students' engagement with statistics. This would be a relatively low-cost solution but could radically reshape what is taught. Second, a program like the data fellows initiative could be initiated and evaluated to test the extent to which this improves the student experience (and career outcomes) in learning statistics using real-world projects in the workplace. This immersion-in-the-workplace approach would be more costly but the advantages of creating meaningful links with industry for participating universities could be enormously beneficial. The framing of this work using the UN's Sustainable Development Goals would be a further aim to provide a global meaningful approach to statistics education.

This paper has addressed a highly topical issue, namely that of the approach to teaching statistics through university curricula. The inclusion of a UK case study, which embraces learning by doing (through the embedding of students in the workplace to practice their statistical and data analysis skills learned in the classroom), opens up the opportunity for a radical rethink of how statistics could be taught in Colombia. This also provides an opportunity for future research to be conducted in which students reflect on their learning and instructors redesign curricula to embrace these hands-on learning experiences. A systematic analysis of new methods of teaching and learning statistics in Colombia would offer much for understanding how statistics curricula in Latin America could be redesigned with a focus on twenty-first century skills for the workplace.

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Appendix A

Table A1 shows the descriptive coding system (composed of 65 codes) (see column "Codes"); a next step in the understanding of the data is shown in the column "group codes", which represents the way in which, from the researchers' interpretation, certain codes could be grouped into more conceptual and dense associations. Finally, the column "dimensions" shows the three final categories (pedagogical, curricular and applicability) that will allow us to account for the state of statistical education in Colombia.

Table A1. Relationship between dimensions, code groups and codes from the analysis conducted in this research.

Dimensions	Group Codes	Codes
Pedagogical and Applicability dimensions	Focus	Applied focus
Pedagogical and Applicability dimensions	Learning approach	Innovative
Pedagogical dimension	Focus	Disciplinary focus Technological focus Theoretical focus
	Learning approach	Prerequisites Service Traditional
	Student-centered learning	Independent learning Learning strategies Project Research Teamwork Theoretical evaluation Unorthodox evaluation
Curricular and Applicability dimensions	Bibliography	Applied bibliography

Table A1. *Cont.*

Dimensions	Group Codes	Codes
Curricular dimension	Applied statistics	Graphs Indexes
	Bibliography	Tech bibliography
	Descriptive analysis	Central tendency Covariance Descriptive analysis Dispersion Introduction—statistics Mathematical concepts
	Inferential statistics	Chi-square test Confidence interval Estimation Experiment design Goodness of fit test Hypothesis testing Inferential statistics Regression and correlation Statistical models Types of errors
	Probability Distributions	Bernoulli Binomial Central limit theorem Cumulative Exponential Gamma Geometric Hypergeometric Introduction—Probability Logistic Moment-generating function Multivariate Distribution Normal Poisson Probability Distribution Random variable functions Uniform
	Probability methods	Bayes theorem Counting Rao-Blackwell theorem
	Random variables	Bivariate models Discrete and continuous variables Multivariate models Random variables Univariate models
	Sampling	Conditional probability Probability laws Sampling Stochastic convergence

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