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MOVING TOWARDS CULTURE STATISTICS IN ENGINEERING CAREERS

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Abstract

The teaching of Statistics is incorporated, in a generalized form, to practically all engineering careers. In addition to its instrumental nature for most disciplines, it is important to develop statistical reasoning in a society characterized by the availability of information and the need for decision making in environments of uncertainty.

It is essential to reflect on the progress made in this direction and the main obstacles, to ensure that our education in engineering careers fosters the statistical culture in our students so that the contents of other subjects can be used to apply the necessary statistical concepts in every situation. The main objective is not to convert future engineers into "expert statisticians", since the reasonable and efficient application of Statistics for problem solving requires extensive knowledge of this matter and is the responsibility of professional statisticians. Nor is it a question of training them in the calculation and graphic representation, since the computer means solve this problem. The aim is to provide a Statistical Culture based on two interrelated components:

- The ability to interpret and critically evaluate statistical information, arguments supported by data or stochastic phenomena that people may encounter in various contexts, including the media, but not limited to them, and
- the ability to discuss or communicate their opinions regarding such statistical information when relevant.

See the Statistics from their applications in everyday life, give conclusions in the context of the analyzed data, warn about their uses and abuses, prepare our students to analyze and understand it with another look, producing, in addition, a significant learning in them.
The proposal to walk "Towards a Statistical Culture" is based on training teachers who teach to think statistically from the ethical and the conceptual.

Keywords: statistical culture; teaching strategies; significant learning

Resumen

La enseñanza de la Estadística está incorporada, en forma generalizada, a prácticamente todas las carreras de Ingeniería. Además de su carácter instrumental para la mayoría de las disciplinas, es importante el desarrollo del razonamiento estadístico en una sociedad caracterizada por la disponibilidad de información y la necesidad de toma de decisiones en ambientes de incertidumbre.

Es indispensable reflexionar sobre los avances hechos en esta dirección y los principales obstáculos, para lograr que la educación en carreras de Ingeniería fomente la cultura estadística en los alumnos con el fin de que se aprovechen los contenidos de las otras asignaturas para aplicar los conceptos estadísticos necesarios en cada situación.

El objetivo principal no es convertir a los futuros ingenieros en "estadísticos expertos", puesto que la aplicación razonable y eficiente de la Estadística para la resolución de problemas requiere un amplio conocimiento de esta materia y es competencia de los estadísticos profesionales. Tampoco se trata de capacitarlos en el cálculo y la representación gráfica, puesto que los medios informáticos resuelven este problema.

Lo que se pretende es proporcionar una Cultura Estadística basada en dos componentes interrelacionadas:

- *La capacidad para interpretar y evaluar críticamente la información estadística, los argumentos apoyados en datos o los fenómenos estocásticos que las personas pueden encontrar en diversos contextos, incluyendo los medios de comunicación, pero no limitándose a ellos, y*
- *la capacidad para discutir o comunicar sus opiniones respecto a tales informaciones estadísticas cuando sea relevante.*

Ver la Estadística desde sus aplicaciones en la vida cotidiana, dar conclusiones en el contexto de los datos analizados, advertir sobre sus usos y abusos, prepara a nuestros alumnos para analizarla y entenderla con otra mirada, produciendo, además, un aprendizaje significativo en ellos.
La propuesta de caminar "Hacia una Cultura Estadística" se basa en formar docentes que enseñen a pensar estadísticamente desde lo ético y lo conceptual.

***Palabras clave**: cultura estadística; estrategias de enseñanza; aprendizaje significativo*

1. Introduction

Among the main trends in engineering education today is the work with open curricula adapted to social needs with multidisciplinary learning and field experiences. Without forgetting the student-centered learning, with a mediator teacher that promotes the connection of the work done in class with an apprenticeship that brings him closer to professional life.

What can be contributed to these trends, from the field of Statistics, in the training of engineers? Beginning with the basic sciences, we must statistically literate our students in order to train engineers who are statistically cultured citizens.

The expression 'Culture Statistics' arose amongst statistical educators to address the need for statistical knowledge in all areas. In addition, they wanted to highlight the fact that Statistics are considered by many as part of the cultural heritage necessary for an educated citizen.

For many years, Ottaviani (1998,p.1) has promoted 'Culture Statistics', highlighting that, "on an international level, UNESCO has implemented several economical and cultural development policies for every nation, which include not only the basic, but also the numerical literacy. For this reason, statisticians feel the need to diffuse the Statistics field not only as a technique to analyze data, but as a culture, in terms of the ability to understand the logical abstraction that makes the quantitative study of collective phenomena possible".

Beyond the academic, the official statistical agencies have become aware of the need to deliver, in a plausible way, the research they carry out to all citizens and at the same time, to improve the public image of Statistics. In addition to emphasizing the provision of information, the council for governments, professional use and research, official Statistical organizations are interested in providing information to society as a whole.

Thus, the academy and official institutions are concerned with giving a good approach to Statistics. However, the media do not always have theoretical soundness nor interpret statistical information in a correct and ethical way. Cox (1997, p.273) describes this aspect as follows: "the public assessment of the general principles in the interpretation of the evidence is lacking in many aspects of the articles in the press and radio and television programs" .. "The information, sometimes sensationalistic, from the results of small studies, often poorly designed, is especially worrying."

How not to form statistically educated citizens in this situation! It is important that every citizen is sufficiently capable to warn lies or data manipulation in the information that they receive every day via different media.

From the world of Statistics, Gal and Garfield (1995), comment that most Statistics professors would like their students to be statistically educated, by being able to:

- Collect, analyze and interpret data intelligently
- Use statistical thinking and reasoning

- Communicate effectively using the language of Statistics
- Believe in the importance of Statistics to better understand the information in their world
- Consider that, frequently, there are different ways to solve a statistical problem.
- Acknowledge that people can reach different conclusions from the same data, if they have reached different hypothesis and have used different methods of analysis.
- …

From the above, we see it is mandatory for professors who teach a course on Statistics, or for anyone who uses it as a tool, to understand that making calculations or using software to create meaningless graphs which do not offer any conclusions or even worse, offer wrong conclusions because of either a non-ethical manipulation or simply because of ignorance, is simply not enough.

The proposal of taking steps 'Towards Culture Statistics in Engineering careers' is based on training teachers to teach how to think statistically from the ethical and the conceptual.

2. Statistics thought from Statistical literacy

The explosive access to information has given Statistical literacy a leading role at University education and, especially, in the formation of engineers, as it is considered an essential competence for full citizen and professional performance.

Our world, overwhelmed by the huge amount of information, requires citizen training to understand, process and interpret the statistical information that surrounds us. Easy access to this information does not guarantee its accurate interpretation, let alone an adequate processing.

Today's Engineer works in multidisciplinary contexts that require him to develop some skills to have effective participation in managerial, social, economic and even political decisions. In order to do this, they must know how to read, interpret and estimate from real data, in addition to making decisions under uncertain conditions. This level of knowledge leads us to think that being able to critically approach data and using Statistics as a tool to solve both daily and professional issues is necessary. In other words, it is necessary to impose Statistical literacy as part of professionals' training.

Even though the mid-level curricula includes the teaching of Statistics, our experience shows that future engineers, at best, are only able to recognize a handful of formulas that make no sense to them, with poor understanding of the basic principles that underlie data analysis and almost no application of Statistics in their daily lives.

Given this perspective, time should not be wasted. We must begin preparing our Engineering students to be statistically educated citizens, capable of developing data analysis and decision-making with theoretical soundness and ability to sustain their ideas.

How is it done? The results obtained in some investigations, such as those of Jurdak (2006), Ku and Sullivan (2002) or Palm (2008), show that students try harder and obtain better results when they solve contextualized activities, which are interesting to them ... Well, then, let's get to work!

3. A Contextualized Statistics on Engineering issues: Our experience

From the statement of real situations, close to the personal experiences, the feelings and the emotions of the students, in addition to proposing examples that involve engineering situations, it is possible to increase the students' motivation and involvement. Choosing a theme which is close to the interests of future engineers motivates and promotes meaningful learning.

Many authors mention the need to promote active learning environments that involve students through active research and discussion activities (NCTM, 2000; Herrington, Oliver, 2000; Franklin et al., 2005). Activities that allow establishing the relevance and meaning of statistical concepts, based on the study of specific cases or scenarios (Barab, Thomas, Merril, 2001). In order to do this, it is necessary to impregnate the teaching of Statistics on active learning strategies, collaborative projects, use of real data, computational simulations and visualizations, so that students acquire a true conceptual understanding of the concepts.

This scenarios must be didactically organized so that mediation accompanies and guides the reflection and inquiry of students, with clear guidelines that define individual, group, and collaborative activities so that students can bring their own perspective of the problem into play, contrast their ideas with those from their classmates, and make them evolve towards more complex visions of reality.

The work with this type of proposals implies the interaction between the individual work of the student and the cooperative one, oriented towards the comprehensive learning of concepts, search procedures, information collection, representations, graphs and the improvement in the students' analysis, argumentation, formulation of conjectures and creativity capacities and, the adequate organization of the information for their communication (Lipson, Kokonis, 2005).

For this reason, the objective of our proposal is to develop the learning in real contexts (characteristic of the student or the engineering), with which students are challenged so that they can see these concepts from their purest conception, reality.

If we are working on the exploratory data analysis field for example, we would follow these steps:

1. A challenge is posed on a current problem linked to the students' specialty.
2. The integration of the concepts learned is promoted (Descriptive measures, Graphs, Interactions, Comparisons of data sets, etc.).
3. The combination of theory and practice is encouraged so that, through collaborative work, the problem under study can be solved.
4. A decision is made with critical thinking and deep ethical attitude.

5. Students are encouraged to transform knowledge into practical results, even to solve some Engineering social problems.
6. Students are requested to contextualize the results to demonstrate their usefulness.
7. The critical and conscientious use of some software is motivated, choosing the best option, but instead staying in the cold numbers, encouraging them to think of the results as decision elements.
8. The submission of a technical report is requested, which respects the statistical basis and applies it in the context of the problem under study.
9. Not complying with this technical report, which serves as an incentive to learn to communicate in writing, we request a report written as a "press release", available to any user, that summarizes the process performed and shows the conclusions of simple way.
10. Finally, in addition to requesting that the students present their results orally in a limited time, creativity is encouraged by demanding an original and attractive title.

Is it too much to ask? This experience hasn't ceased to surprise us and confirms that, if Statistics are seen in the field, when tasks in daily and professional life are contextualized it marks students, helping to highlight the usefulness of Statistics to unfold smoothly in life, helping them realize, consciously or unconsciously, how frequently they use it in real life.

By presenting a guide of practical applications, with real data on the specialties of the engineering where Statistics are being taught, we have concluded that statistical knowledge cannot be understood if it is not presented together with its practical use, and that it cannot be applied solely to abstract problems that do not exist in real life. This implies that concepts and statistical techniques must be contextualized.

It is about presenting more global scenarios or situations that allow the development of the different phases of a statistical study, based on the presentation of a problematic situation (which may even exceed the subject of the subject), starting by deciding an adequate sample size, selecting a sampling technique, a way to collect, organize and present the data, choosing a way to perform the analysis (for example, a Deep Exploratory Data Analysis) and thus, continue describing the best ways to give conclusions about the problem posed, in an ethical and responsible framework.

4. Conclusions

What has been achieved with this proposal? Preparing our students to learn the statistical concepts from their first university steps, to grow with them and become familiar in such a way that when they hear or read the statistical information, that day by day appears on the television screens, on the Internet, In magazines and newspapers, they are able to understand it, criticize it, and infer and analyze it correctly. Furthermore, and this is not something to be sneezed at, we have avoided the sufferment of many young professionals as they realize they don't have the previous concepts, essential to face the labor demands.

How is this achieved? Posing situations of Engineering, from:

- The use of real data collected by the students themselves, involved in topics of their specialty.
- Underline the conceptual understanding instead of the simple knowledge of procedures.
- Contextualize the results obtained, without losing sight of the importance of taking the appropriate actions to achieve the objectives.
- Use appropriate technology to facilitate conceptual understanding and data analysis.
- Encourage a respectful use of data to give respectful and ethical conclusions.

In short, it is hoped to give students the opportunity to become citizens who are immersed in a statistical culture that will allow them to develop successfully and honestly in an increasingly competitive environment in terms of knowledge, and increasingly distant from ethics in making of decisions.

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