

ANALYSIS OF A SOCIAL WEBQUEST FOR STATISTICS IN ENGINEERING

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Abstract

A webquest for students of an introductory course in Statistics in Industrial Design Engineering is presented and analyzed. In order to make students work on the most basic concepts (sampling and description of data) and thinking skills, I have designed a webquest [1] where they are critical citizens. The webquest starts with a video from the outstanding series "Against All Odds: Inside Statistics" [2], Program 3, Describing Distributions, which shows how a local government used statistical methods to correct inequality between men's and women's salaries in the USA in the 1980's. Students should investigate the current wage gap, carrying out and analyzing a small survey, and using the official data of the INE (Spanish National Statistics Institute), where one of the variables they should collect and examine is the number of hours devoted to work at home. This webquest is designed to educate students for equality. Students also research a brilliant woman who used statistics to save many lives: Florence Nightingale. The other activities in the webquest also tackle current issues, such as climate change, through ecological footprints, and statistics in daily life, for example in clinical analysis, incorrect use of statistics in the media, or writing a letter to the city council to correct a high water bill based on incorrect water consumption estimates (this activity is based on a true story in which the citizen received a refund). The webquest also has research activities to show the importance of statistics in industrial design, and specifically, in ergonomics. These activities involve the description of relationships: regression line and principal component analysis for the accommodation of pilots in aircraft design [3].

I analyze the data collected from my students about their experience and opinion of the webquest.

Keywords: WebQuest, Education for Equality, Statistics in Engineering, Ethical Values.

1 INTRODUCTION

Firstly, I would like to give some of the reasons why I decided to create a webquest. This webquest is designed for students of Statistics in a degree in Industrial Design. There are a large number of students, with 120 new students starting each year, and in total there are 180 students, who study either in the mornings or afternoons. This subject covers the standard content of an introduction to statistics in engineering: descriptive statistics, sampling, probability and inference. The course is 137 hours, with 60 hours in the classroom or laboratory, and the remainder as independent study.

The statistics subject is compulsory. The subject is run in the second semester of first year. Students may enter this engineering course from any option in high school, including arts, humanities and social sciences, and sciences (technology, and natural and health sciences). The percentage of students who did not study technology in the final years of high school is around 30% to 40%, according to the information provided by students in different years.

In this case, the students may not be very suited to the study of mathematics. Furthermore, a large number of students have the preconceived idea that statistics are not going to be useful in their career, and so they are not very motivated to start with. It is always challenging to teach a subject that many students do not find interesting from the outset, and in particular it is a challenge to teach statistics to non-specialists [4]. Throughout the subject, I try to overcome students' prejudice with problems applied to the field of industrial design and the use of own data [5]. This is reflected in the webquest, where in addition to considering activities applied to industrial design, students will also see how statistics are present in everyday life and interesting social issues. In fact, the webquest is titled "Statistics in Everyday Life". In it I use similar tactics to those described by Phua in [6].

The American Statistical Association (ASA) and the Mathematical Association of America (MAA), which created a committee to study the teaching of introductory Statistics [7], make three fundamental

recommendations [8]: 1) help students to think like statisticians, 2) offer more data and concepts and less theory and formulas, and 3) encourage active learning. In addition, numerous authors argue for learning statistics by doing statistics [9], and using cooperative learning [10,11].

The last reason that I created a webquest has a more social aspect and it was to raise students' awareness and make them reflect on various current issues, such as discrimination for various reasons, care of the environment and climate change, etc. And also to promote critical thinking about students' own results and those of others, including those that appear in the media. And finally, to use teamwork to build various skills, which are fundamental in an engineer, such as decision-making with other group members, dividing the work equally, meeting agreed deadlines, and resolving conflicts that occur in the group. For the last of these, I gave them a Spanish version of the document "Coping with Hitchhikers and Couch Potatoes on Teams" [12], with guidelines for managing conflicts, because they may occur [13]. In addition, I made the webquest a voluntary activity, because it is not included in the official subject program that had to be submitted almost a year before classes started. The webquest can raise the student's grade in the subject (as described in the official program) by 1 point, as long as it is at least 4.5 (on a scale of 0 to 10). At the start, 23 groups were formed, with half of the registered students participating. However only 16 groups delivered a complete webquest at the end of the course.

In section 2, a brief overview of webquests and in particular webquests in statistics is given. In section 3, the webquest that I created is presented. In section 4, I analyze the results of a questionnaire that I gave the students about the webquest, including the students who had done this assignment and those who had not. Finally, in section 5, some conclusions are given.

2 WHAT IS A WEBQUEST?

Dodge, the father of the webquest, defined a webquest originally as [1,14]: "an inquiry-oriented activity in which some or all of the information that learners interact with comes from resources on the Internet, optionally supplemented with videoconferencing".

Webquests can be short or long, depending on whether they are designed to be completed in less than 3 sessions or not. In a long webquest, the instructional goal is extending and refining knowledge [15]. They have the following structure: introduction, task, process, resources, evaluation and conclusions. The introduction presents the webquest and the aim is to try to motivate the students. The task contains a description of what should be done and what objective is to be achieved. In the process, we give the steps (clearly specified) to achieve the objective. To move through these steps, the students will need to use the resources. In the evaluation stage, we specify how the webquest will be evaluated. In the last stage, the conclusion, we remind students what they have learned, and encourage them to use it in other contexts. Recently, mini-webquests have been developed, with only an introduction, task and evaluation.

The most common task formats of a webquest [16] are: 1) retelling, 2) compilation, 3) mystery, 4) journalistic, 5) design, 6) creative product, 7) consensus building, 8) persuasion, 9) self-knowledge, 10) analytical, 11) judgment, and 12) scientific tasks.

It is important that a task is interesting and motivating for the students, and that it is a real-life task. A webquest is mostly group work. The aim of a webquest is that students do more than simply copy and paste the information they find. They should carry out a process of investigation and transformation of the information obtained.

There is a guide on how to prepare a quality webquest in [17], which gives the most common errors in each of the sections that make up the structure of a webquest, as well as suggestions for increasing its effectiveness.

2.1 Statistics WebQuests in Spanish

There are ever-increasing numbers of webquests available, as a Google search shows. However, if we restrict the search to webquests in mathematics, and specifically in statistics, there are far fewer, in both Spanish and English. If we also only consider statistics webquests for university students, then there are very few, and if we only consider those in Spanish, there are hardly any. And this is in spite of the fact that statistics is a subject that is often included in many degree courses.

Falcón et al.[18] analyze webquests about statistics and probability in Spanish, but mainly focusing on secondary education. They also describe how to create webquests about statistics and probability.

Huertas and Tenorio present one of the few webquests about statistics at a university level for students of a five-year degree in Business Administration and Management [19]. In this webquest, students must search for official data on the website of the INE and the Andalusian Statistics Institute, and carry out a descriptive study with these data. These same authors also developed another webquest, for high school students (in their 4th year), about women in the history of mathematics [20], which is one of the few webquests in mathematics that raises awareness of gender issues.

The following links are to databases that include webquests about statistics in Spanish, although most of these are not for university students:

- 1) <http://www.estadisticaparatodos.es/webquest/webquest.html>
- 2) http://www.phpwebquest.org/wq25/procesa_index_todas.php
- 3) <http://www.aula21.net/tercera/otrasbibliotecas.htm>
- 4) <http://www.webquestcat.cat/>

3 A SOCIALLY COMMITTED WEBQUEST

3.1 Introducing the WebQuest to the Students

The first time that my students heard the word “webquest” was on the first day of class. One of the homework tasks for the following class was to find out what a webquest is. This homework assignment could be considered a scavenger hunt activity [21]. I ask students to play the role of a detective or a hacker such as Lisbeth Salander, and I ask various questions about the information and resources for the subject [22] that are in the virtual classroom (Moodle platform), and conclude with an activity in which they have to use the IP address to find out who from the United States is looking at the subject resources. When we discuss this task in the next class, I try to make them reflect on two main points: principally, the importance of gathering information on who visits our site, where from, and what they look at, in short, gathering statistics on our website that we can later use to improve it, etc. And secondly, that they should keep in mind that the website is open to everyone, and that whatever they upload to the website (photos, videos, etc.) can be seen by anyone.

The great majority of my students have Internet access at home. In any case, they can use the university's computer classrooms free of charge, as well as laptops, with which they can access the Internet at the university.

3.2 Webquest: Statistics in Everyday Life

In order to make students work on the most basic concepts (sampling and description of data) and thinking skills, I have designed a webquest where they are critical citizens. It is a long webquest, which students can carry out in ten weeks (without considering three weeks of holidays in the second semester) outside the classroom, in a team of 4 students. In Figure 1 we can see the first page of the webquest titled “Statistics in Everyday Life”, with a quote from Florence Nightingale.

WEB QUEST

ESTADÍSTICA en el día a día

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"Statistics ... the most important science in the whole world: for upon it depends the practical application of every other science and of every art; the one science essential to all political and social administration, all education, all organization based upon experience, for it only gives the results of our experience."

Florence Nightingale (1820-1910)

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Figure 1. The first page of the webquest.

In the introduction, I explain that we will be working on the basic concepts, which must be very clear, for the rest of the topics of the course, and that we will discover how statistics (even the most basic ones) can help us with everyday problems in real life, and also in industrial design (ergonomics, emotional design, etc.). In addition, students need a basic knowledge of statistics to be critical citizens and to be able to effectively participate in public argumentation based on figures and data, which is inherent to life in a democracy.

The task can be seen in Figure 2. The students form groups of four in order to carry out a series of activities using the resources indicated. They will do group assignments and deliver them through the virtual classroom by uploading files, in accordance with the requirements of each activity. In addition, at the end of the webquest, the students will do an individual activity and fill out a questionnaire about group work. Below we describe each activity.

3.2.1 Activity 1: Teamwork

This activity involves forming groups. Students should form a group so that all members have similar objectives (with the same level of enthusiasm for work, even though the other students may not be their best friends). They have to name their team and choose a spokesperson, who will be responsible for communicating with the lecturer and uploading the team's tasks to the virtual classroom on the dates indicated. Moreover, as this is a project, the students must prepare an initial project plan, (allocating the tasks between team members, and the dates on which the material will be read, etc., with enough time before the delivery dates). This first task has a deadline of two weeks. This enabled me to see if the students had allocated the tasks fairly or not, and to suggest corrections to their plan.

TAREA



Utilizando el material de clase que tienes en el **aulavirtual** de la asignatura y los **enlaces y recursos** que te indico, debes realizar las tareas, siguiendo las indicaciones que se incluyen en la webquest. Lo primero es que formes un grupo con 4 compañeros (excepcionalmente podéis formar un grupo de 5 o de 3 personas) para trabajar en equipo y llevar a cabo las siguientes tareas:

- **¿Hay diferencias de salario entre hombres y mujeres?**
- **¿Soy capaz de reconocer abusos y malos usos de la Estadística en los medios de comunicación?**
- **Who is who? Un poco de historia.**
- **¿Es correcta la factura? ¿Debo reclamar?**
- **Diseño de la cabina de un avión.**
- **Mi huella ecológica: ¿cuál es mi contribución al cambio climático?**



Las tareas realizadas conformarán un trabajo colectivo que habrá que ir **entregando** a través del aulavirtual. Además, al final, **individualmente** se realizará una actividad y se rellenará un cuestionario sobre el trabajo en equipo.

INICIO	INTRODUCCIÓN	PROCESO	RECURSOS	EVALUACIÓN	CONCLUSIÓN	FIN
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Figure 2. Task module for the webquest

Some of the groups made very original presentations. For example, one group presented in the style of the movie Ocean's Eleven, and another in that of a television presentation of a soccer team playing in the Champions League.

3.2.2 Activity 2: Do men and women receive different salaries?

Unfortunately in engineering, there are usually not very many female students. However, in industrial design engineering, things are more balanced with about 50% female students. This activity has a large component of education for equality. An excellent collection of resources on education for equality can be found in [23].

The activity starts with a video from the outstanding series "Against All Odds: Inside Statistics" [2], Program 3, Describing Distributions, which shows how a local government used statistical methods to correct inequality between men's and women's salaries in the USA in the 1980's. Students should investigate the current wage gap, carrying out and analyzing a small survey, and using the official data of the INE (Spanish National Statistics Institute, <http://www.ine.es>), where one of the variables they should collect and examine is the number of hours devoted to work at home. Data collected in this survey must be delivered by the end of week five. As the students obviously do not have the same resources as INE to enable them to carry out this survey, one of the questions asks them to indicate how they would go about it if they had these resources.

In addition to the survey, they must find out about Lilly Ledbetter, and about the Lilly Ledbetter Fair Pay Act in the USA. For research on the European Union, I give the students a link to the European Parliament, where this issue was dealt with, and they must also find out why International Equal Pay Day is proposed to be celebrated on 22 February.

With the analysis of their data and the investigations carried out, they must write up their conclusions.

The first topic of the video series presents the mean, median, and five number summary. The second topic of the video series deals with the problem of food composition, which is fundamental to good nutrition, presenting boxplots. To reinforce the idea of the random variable and at the same time highlight the importance of a balanced diet over junk food, a section of the second activity of the

webquest is dedicated to a nutrient that is often mentioned in advertisements: fiber. In addition to searching for information on fiber, the students must also find out how much fiber is in (100 g) servings of 5 foods of vegetable origin (foods of animal origin do not have fiber) in different information sources, seeing that they are not the same (and in some cases they vary quite a lot) and questioning the reasons for this. I also ask them to reflect on the lack of information about the number of samples used to estimate the amount of fiber (which in some sources is only one!), and the lack of a measure of dispersion in the great majority of databases on food.

The last topic of the video presents a musical analysis of urine data, and the standard deviation. Based on this story, I give them a urine analysis in English (so they are also working in a foreign language) of Jane Doe (an unknown woman), to find out what the reference range is, and how it is calculated, and answer various interpretive questions. In this way they can also see how statistics appear in medicine too.

3.2.3 Activity 3: Am I capable of recognizing abuse and misuse of statistics in the media?

Unfortunately many journalists have never taken a course in statistics, and in spite of this, they do not hesitate to report on figures, which are sometimes dealt with carelessly, leaving citizens vulnerable to media hype, political demagoguery and commercial fraud. The students must read the section (1.3) on abuses of statistics in the book by Triola [24], and look for examples of the improper use of statistics (it is enough to pay a little attention while reading, listening or watching the news or advertisements, because these problematic uses are more common than one would like to think). The students must incorporate these examples into the project, identifying the source (and date) where the example was found, and explaining why there is a misuse of statistics and suggesting what or how the information should have been presented so as not to mislead.

3.2.4 Activity 4: Who is who? A little bit of history

This webquest is designed to educate for equality [25] and students should also research a brilliant woman who managed to save a lot of lives using statistics: Florence Nightingale. On the website of the Royal Spanish Mathematical Society there is a section dedicated to women and mathematics, which well worth reading [26]. In this activity, students also have to carry out an activity on linear regression, using it in an ergonomics problem to estimate the mean and average deviation of the length of the forearm of adult men in the Autonomous Community of Valencia (the region of Spain where our university is located) during the second half of the 19th century, when Florence Nightingale, and Sir Francis Galton (who introduced the concept of the regression line) were alive.

3.2.5 Activity 5: Is the bill correct? Should I make a claim?

This activity is based on a real case that occurred in Valencia, in which the citizen was able to use statistics to obtain a refund. The students must study the water bills for a family to detect the incorrect estimates for water consumption made by the utility company, which led to higher bills for the family. Based on the tables constructed and the investigations on rates that change according to two-monthly consumption, they must write a letter of complaint to the municipal council and the utility company to request a refund of the amount they were overcharged.

3.2.6 Activity 6: Design of an aircraft cockpit

This is a research activity to show the importance of statistics in industrial design, in particular in ergonomics. In this activity, students must use principal component analysis, an advanced statistical technique that has not been explained in the classroom, for the accommodation of pilots in aircraft design [3]. With this problem students can see that combining percentiles of different variables, as is all too usual in ergonomics, is not appropriate if one wants to cover a certain percentage of the population.

3.2.7 Activity 7: My ecological footprint: what is my contribution to climate change?

This activity must be carried out by all members of the group and delivered individually through their virtual classroom user account. If one group member does not do the assignment, then the work of the rest of the group will not be assessed, so if any group member is not working, the others will have no choice but to inform me about this point. I could also use a strategy such as this one [13], where they must carry out an extended version of the project and it will be assessed differently depending on whether all the group members do it correctly or not.

In this activity, the students must find out what an ecological footprint is, and what their footprint is. They must estimate the weight of their waste weekly for several weeks, divided into different

categories: paper and cardboard, glass, organic, packaging, oils and other. They must use graphs and numbers to describe these data. Using the web page <http://www.vidasostenible.org/CIUDADANOS/A1.ASP> they can make another estimate and comment on the recommendations made.

The last part of this activity is to answer a small questionnaire on how their group worked.

3.2.8 Resources, Assessment and Conclusion

In many of these activities, the students are given links to use, but not in all of them. I decided not to give them all the links because they are university students, so they must start to do their own web searches, rejecting pages that are not useful in achieving their goal.

In their assessment, the whole group receives the same grade based on the detailed criteria that appear in the webquest, although here I only include the main criteria: on-time delivery, completeness, correctness of statistical content, appropriate and accurate use of language without spelling mistakes, originality, presentation, team work, reading comprehension, and good use of the Internet.

The conclusion is presented in section 5.

3.3 Evaluating the WebQuest

Any webquest may be evaluated, as explained in [27], on different aspects: overall aesthetics, introduction, task, process, resources, and evaluation. While designing the webquest, I have tried to achieve the maximum scores in each category, but obviously this is based on my opinion. I am not the best person to judge my own work.

So I have also collected students' opinions through an anonymous questionnaire.

4 ANALYSIS OF THE RESULTS OF THE QUESTIONNAIRE ABOUT THE WEBQUEST

To evaluate the webquest, an anonymous questionnaire was handed out to the students at the end of the course on the day they did the examination. As it was anonymous, they were free to express their opinions. In addition, the students who did not participate in the webquest could also answer the questionnaire, in order to give their reasons. The questionnaire was designed to provide information about the strengths and weaknesses of the webquest, and the students' opinions of it.

The majority of students (approximately 50%) who did not participate in the webquest said the reason was that they had too much work in other subjects. The distribution of the other answers can be seen in Figure 3.

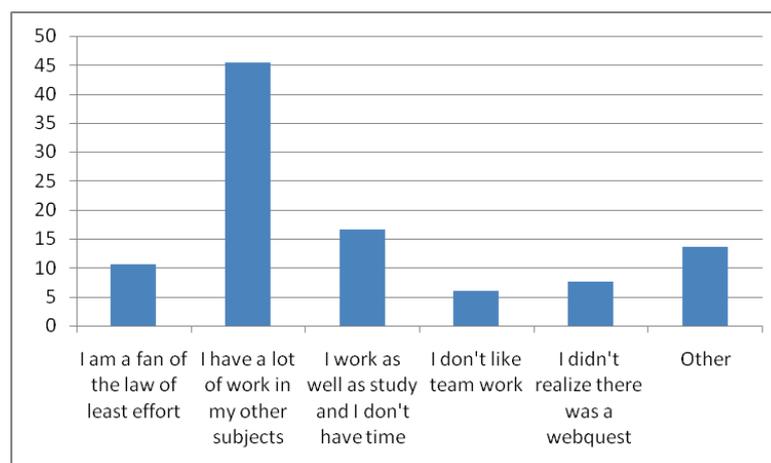


Fig 3. Reasons for not participating in the webquest (percentages).

In response to the question on whether they would use statistics in the future, 75% of those who didn't do the webquest answered yes, whereas 91% of those who did it answered yes.

Of those who did the webquest, 91% said they had learned from it, and 68% said they had fun working on it. The majority of the students who did not have fun were those that said they had difficulties in

carrying out the webquest, with group work (note that in the end there were 10 people expelled by the different groups for being hitchhikers or couch potatoes), or else they had difficulties with the statistics because they hadn't attended the classes. Note that of the 14 students who did not enjoy the webquest, 12 were repeating students. The average level of satisfaction with the webquest was 7 points on a scale of 0 to 10.

What attracted students' attention or made them think the most was mainly seeing so many applications of statistics in real life and in current issues, the importance of caring for the environment, and the issue of salary discrimination between men and women. Finally, in response to the question on what they liked the most, there were a wide range of answers, including references to practically every activity. Many agreed that it was the group work or being able to apply statistics to current issues.

Students were provided with feedback about their errors. According to the criteria in section 3.2.8, only 2 (the group work problems concentrated on these groups) of 16 groups failed the webquest. The 14 remaining groups made an appropriate work, 6 groups obtained an excellent.

5 CONCLUSIONS

This section presents the conclusions that are included in the webquest itself. The webquest has helped my students to not only learn about statistics but also to reflect on a variety of current problems, such as discrimination for various reasons, caring for the environment, and climate change, etc. (this is taken from their answers to the questionnaire). It has helped to develop their critical skills when thinking about their own results, and those of others, including those appearing in the media. Finally, the majority has been able to enjoy the advantages of working as a group, and for the rest, the small-scale negative experience will be helpful when they need to manage other conflict situations of greater magnitude.

The webquest can be adapted for use or at least serve as an inspiration to other lecturers. Although it is designed for university students in their first year of engineering, it could be adapted for introductory statistics courses in other qualifications, and even for secondary school by reducing the level and number of activities. For example, in activity 2 about salaries, students also gather information on education level: this provides students with the opportunity to reflect on what could happen to them without a good education, which might be useful given the large numbers of students abandoning the Spanish school system.

It requires a great effort to find and use examples and problems that get students interested, and even more so when our degree does not coincide with the qualification in which we are teaching, but it is worthwhile. With empathy (putting ourselves in our students' shoes), and trying to connect with them, we can improve this situation greatly, or at least this is how it appears to me from the evaluations on my teaching that I have carried out with students over the years.

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