Abstract: The main objectives of this research are, on the hand, to verify by measuring students´ attitudes and motivations if gender differences occur towards physics, and on the other hand, to check if an instruction of physics affects in the same way to men and women. The sample is constituted by high school students and students in the first year of engineering that have studied necessarily a physics course during the 2013/2014 school year. Analyzing the results of those 772 students it has been concluded that gender differences are significant at high school where the motivation of female students is especially negative after the instruction. Only one in five students is woman at university, where on the contrary differences between genders are not so significant. In both stages, however, instruction affects more positively to men in their image and interest towards physics and its learning.

Key-Words: Physics Education, Attitude, Motivation, Gender, Instruction.

1 Introduction

Due to the fact that attitudes and motivations affect the learning process of students, studies concerning those attitudes and motivations have been developed in Science Education Research [1]. During the last decades and owing to the decrease in students of scientific degrees, Science Education has begun researching this field with greater intensity. Such studies are important because countries that invest in science and technology can expect a promising future that could disappear if undergraduates do not choose scientific studies [2].

Specifically, the aim of this research has been to analyze students’ attitudes and motivations towards physics and its learning at different stages of their formation and depending on their gender, using a pre-post-test methodology. Thus, gender differences can be verified or rejected and it could be understood how instruction affects male and female students.

2 Problem Formulation

Historically, the term attitude has been defined in many ways and it has often been used interchangeably with terms such as interest, value, motivation or opinion. In its simplest form, attitude is a general and enduring positive or negative feeling about some person, object or issue [3].

To the better understanding of this work, it is important to clarify and to differentiate properly the concepts of attitude and motivation. Therefore, an appropriate definition to motivation could be that it as an internal state that arouses, directs and sustains student’s behaviour. As we turn to a discussion of the role of motivation in learning science, it is important to recognize that attitudes influence motivation, which in turn influences learning, and ultimately behaviour [4].

In this paper, all measurements are related to those first two concepts: on the one hand, students' attitudes towards physics are going to be analyzed by measuring their image towards physics. This is because previous researches show that changes in attitudes are strongly influenced by changes in the image toward science [5]. In another work, similarly, alternative teaching that would allow a better image of science was suggested to get higher yields of attitudinal learning [6]. On the other hand, this study will also focus on the motivations of students towards the learning of physics. This is going to be measured by the level of interest of students, taking into consideration that their level of interest is a significant indicator of their intrinsic motivation to learn [7].
2.1 Background and research questions
In previous studies of students’ attitudes towards physics, one relevant factor has historically been the gender with more positive attitudes in male students [8]. This could nowadays occur due to multiple reasons such as the current curriculum (where the visibility of female scientist is low) or because of stereotypes towards students [9]. This last factor appears clearly in researches in which gender differences exist because of the prophecies or labelling that ultimately end up happening [10]. It is noteworthy that there are studies in which it is ensured that differences in attitudes depending on the gender have been declining [11], so in this work it is going to be verified whether the differences between men and women in the Basque Country are still significant or not. It is also known that effective instruction has the potential to improve student attitudes toward science and to increase the motivation to learn [4]. Consequently, it is also going to be measured how much attitudes and motivations evolve throughout the school year in both genders. According to what it has been exposed, the research questions of this study are these ones:

a) Does the gender affect on the attitudes and motivations of students towards physics in the initial situation?

b) Does the instruction affect in the same way in the attitudes and motivations of students towards physics in both genders?

2.2 Methodology
All the measurements have been made by the questionnaire that was designed. Scoring is based on a 4-point Likert scale to compel students to choose between the positive and negative aspect of each statement as in previous works [12]. Answer number 1 indicates a total disagreement to its corresponding statement whereas number 4 indicates complete agreement. Several studies were taken into account to design the statements. The most important one was the Colorado Learning Attitudes about Science Survey (CLASS) [13] because some of their dimensions could be useful for us. Thus, four statements of our questionnaire were taken from CLASS whereas the rest are original to make this study.

The sample is constituted by students that have studied physics in class in the 2013/2014 academic year in the Basque Country (Spain). Data were collected in 8 High Schools (16-18 years) and at the University of the Basque Country, in the Faculty of Science and Technology and in the Polytechnical College with the total amount of 772 students.

Once the data is collected, the next step should be making the factor analysis. This is a statistical method used to describe variability among observed and correlated variables in terms of a potentially lower number of unobserved variables, called factors or dimensions. But first of all, the data must be capable of being factored. To achieve this, Bartlet test of sphericity should be lower than 0.05 (being 0.000 in our case) and the Kaiser-Meyer-Olkin measure of sampling adequacy should be 0.6 or above (which is 0.854 in our sample). The factor analysis provided two dimensions that must overcome the fiability test of Crobach’s alpha. The acceptable values of that coefficient in these cases (0.7 out of 1) confirmed that the dimensions were adequate for the following analyses [14].

The dimensions that are considered in this study are (1) the image that students have towards physics and (2) their interest toward the learning of physics. As it has been mentioned at section 2.1, the students´ image towards physics is an indicator of their attitudes towards physics whereas their interest indicates their level of motivation to learn physics. Bearing in mind those two dimensions, tables 1 and 2 show the statements related to each dimension respectively.

Table 1: statements that correspond to the dimension of image towards physics.

<table>
<thead>
<tr>
<th>Number</th>
<th>Statement</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Physics is useful in everyday life and solving for example problems of the near environment.</td>
</tr>
<tr>
<td>2</td>
<td>It is important to make discussions of current issues and to seek solutions through physics.</td>
</tr>
<tr>
<td>3</td>
<td>Physics is part of our culture and consequently we all should know about it.</td>
</tr>
<tr>
<td>4</td>
<td>I think that physics is an appropriate resource to understand nature.</td>
</tr>
<tr>
<td>5</td>
<td>The history of civilization is connected to the knowledge and development of physics.</td>
</tr>
</tbody>
</table>

Table 2: statements that correspond to the dimension of interest toward the learning of physics.

<table>
<thead>
<tr>
<th>Number</th>
<th>Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Reading about class issues (whether in books, articles...) helps me understand the concepts.</td>
</tr>
<tr>
<td></td>
<td>I do not feel calm until I understand the</td>
</tr>
</tbody>
</table>
fundamental physics of devices that I often use.

I like physics problems and especially finding solutions until I achieve a result that convinces me.

I like especially the physics problems that require a lot of maths.

I study physics because I think it will be useful after my studies at school / college.

I am aware of scientific informative news (through radio, television, social networks...) that institutions related to physics (ESA, CERN, NASA, Elhuyar...) provide.

The concepts of intrinsic motivation and extrinsic motivation could be important in the dimension of students’ interest to learn. Previous studies specified that intrinsic motivation refers to the fact of doing an activity for itself, and the pleasure and the satisfaction derived from participation. On the other hand, extrinsic motivation pertains to a wide variety of behaviours which are engaged in as a means to an end not for their own sake [15]. Although students’ interest is in general more related to intrinsic motivation (which is measured by the statements 7 and 11 of our questionnaire), some statements also have a more extrinsic character (statements 6 and 10).

Once dimensions are specified, comparisons between different groups are carried out depending on the variables described in the theoretical framework. The Kolmogorov-Smirnov test let us know if the distribution of the sample that is being considered in each case is normal or not. Secondly, we look for statistically significant differences by Student’s t-test (if the distribution of the sample is normal) or the Mann-Whitney U test (if the distribution is not normal). The p-value is the parameter that indicates the probability to achieve significant results when comparing two groups and it is calculated through both statistical tests. In each comparison, it is verified that statistically significant differences occur when the p-value is lower than 0.05 (which means that there is a maximum error of 5%).

The results are shown using bar charts that specify the average score of the students’ interest and image towards physics. Moreover, in each chart bar it is specified the standard error of the mean through error bars, which is the standard deviation of the theoretical distribution of sample means, that it is a way of measuring the sampling error [14].

3 Results and discussion

This study is focused on high school and 1st year engineering students’ image and interest towards physics and its learning. Furthermore, the results obtained from each stage will be analyzed taking into account the gender in order to answer the research questions.

3.1 High School

Regarding high school students firstly, the results of the statements related to students’ image towards physics have been grouped in the average of the figure 1.

![Fig. 1: averages of the image students have towards physics at high school.](image)

The averages obtained in high school are close to the central value of 2.50 points, being men’s averages higher in both the pre-test and the post-test. Only women's image towards physics at the end of the instruction can be considered negative, with an average of 2.43 points on a 1 to 4 Likert scale.

Using the statistical tests that have been previously described, we find that the significant statistical differences between men and women happen in both the initial situation (p < 0.005) and after the instruction (p < 0.001) at this stage. In the initial situation, the differences in gender comes especially from a greater perception in the case of men (0.20 points higher) who think that physics are part of the culture and consequently everyone should know about it (statement number 3). After the instruction, however, the greatest difference between men and women lies on their perception about the connection between physics and the real world. The clearest example is that the importance they attach to discuss current issues and to seek solutions through physics is especially different (with a difference of 0.39 points in this statement number 2).

The same perception has decreased in 0.24 points from the initial situation in female students and that
is why, female students’ image towards physics is significantly worse after the instruction (p < 0.005). Consequently, the differences between men and women have been increased at the end of the school year as it has been observed with the p-values previously cited.

Regarding the statements related to students’ interest toward the learning of physics, the results obtained at this stage are gathered in figure 2.

![Figure 2: Averages of student’s interest toward the learning of physics at high school.](image)

The averages in this case, range from the negative 2.15 points of women in the post-test to the slightly negative results of men in the pre-test with 2.49 points. Statistically significant differences were also confirmed between men and women in their interest to learn physics (p < 0.005 in the pre-test and p < 0.001 in the post-test). The gender difference is even greater at the end of the instruction due to the significant decline that has occurred in the case of women during the school year (p < 0.01), which comes largely from the decline in 0.28 points in the statement number 10, which specifies that students study physics because they believe it will be useful after finishing high school.

Analyzing the results statement by statement, it is noticeable that the gender difference in both the initial situation and the end of the instruction comes mainly from statement number 7. This statement which measures intrinsic motivation, asserts that students do not stay calm until they understand the fundamental physics of devices they normally use. Although men’s perception is higher, it is also far from the central value of 2.50 points, with values between 2.01 and 2.11 points. Moreover, the worst valued statement is in all cases the other one which is also related to intrinsic motivation with values between 1.44 and 1.78 points on a 1 to 4 Likert scale. This statement number 11 asserts that students are aware of scientific informative news (through radio, television, social networks…) that institutions related to physics (ESA, CERN, NASA, Elhuyar…) provide, what is denied by students’ answers.

### 3.2 Engineering

Concerning to engineering students of the first year, the results related to their image towards physics is shown by the figure 3.

![Figure 3: Averages of the image students have towards physics at college.](image)

Student’s image of physics is positive at this stage for men and women in both the initial situation and after the instruction. All averages are between the 2.92 points of male students at the pre-test and the 3.17 points of male students in the post-test. Statistical tests show that differences between genders are not significant in these cases with p > 0.5 in the pre-test and p > 0.1 in the post-test. For both genders the statement number 4 that points out that physics is an appropriate resource to understand nature, is the most valued statement with punctuations above 3.03 points in both the initial situation and after the instruction.

The unique significant difference in this case is the increase of men’s image towards physics during the school year with p < 0.001. This increase comes especially from students’ perception that physics is useful in everyday life and solving for example problems of the near environment (with an increase in 0.45 points in this statement number 1).

As far as the statements related to the interest of students to learn physics is concerned, the results of this stage are grouped in figure 4.

![Figure 4: Averages of student’s interest toward the learning of physics at college.](image)
The interest of students to learn physics is close to the central value of 2.50 points in all cases. In the initial situation, the values are slightly negative (2.49 points) in both genders in which the statements measuring intrinsic motivation are the most valued with punctuations close to 3.0 points.

After the instruction, female students’ interest toward the learning of physics decrease to 2.45 points whereas men’s interest is increased up to 2.60 points. It has to be mentioned that none of these changes during the school year is statistically significant, but the difference between genders after instruction is statistically significant (p < 0.05). In this case, the statement number 11 which measures intrinsic motivation is the one that makes the difference with a discrepancy of 0.68 points between genders.

4 Conclusion
There are different tendencies at high school and at university in the initial situation. On the one hand, gender differences are significant in high school students in their interest towards physics as well as in their image towards physics, with better results for men. Nevertheless, on the other hand, gender differences do not occur in the initial situation with similar averages in both genders at college. Therefore, the way in which the instruction affects the students of each stage may be especially important to understand these facts.

At high school male students maintain their image and interest towards physics from the initial situation constant until the end of the instruction. In the case of female students, however, significant decreases occur in both cases during the instruction. Similarly, in the engineering course obvious changes do not occur in female students, whereas male students are more favoured again because of instruction. Consequently, in all stages the differences depending on gender have been increased in image and interest towards physics from the initial situation, a fact that post-test results reaffirm.

It is noteworthy that one of the worst results after instruction lies on high school female students. In previous works in which negative results were also obtained by female students, it was determined that although these valuations and negative conceptions do not necessarily lead to a certain behaviour, such as abandonment of scientific studies, it is likely to affect in their decisions and choices [16]. After the instruction female students do not believe that physics is going to be useful after their studies at high school as much as they believed in the initial situation so even their extrinsic motivation to learn has decreased. Taking that into consideration, it has been observed that the sample of this study at university is constituted by one in five female students, strengthening those conclusions.

In any case, high school students’ image of physics is relatively positive comparing it to the interest they show, which decreases due to instruction in both genders. The relation of motivation with students’ learning and ultimately with their behaviour that is described in the problem formulation, indicates that the lack of interest of high school students would result in few scientific and technological university students.

Finally, engineering students’ results indicate that their image towards physics is positive in both genders, whereas interest is just close to the central value. Consequently and bearing in mind that instruction does not affect in the same way to each gender, the next step should focus on increasing the motivation of students in order to encourage the learning of physics.

References:
[6] Ebenezer, J. V., and Zoller, U., Grade 10 students' perceptions of and attitudes toward science teaching and school science, Journal of


