Alternative methods for teaching Cadastre and Remote Sensing

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Abstract

Cadastre is essential for the sustainable development of modern society. As well, mapping and surveying is one of the most important tasks for surveyors worldwide in order to maintain the Cadastre. This article summarizes a recent study conducted by the authors on overall student assessment of learning Cadastre and Remote Sensing. The goal is to highlight which teaching method has better success rate for students. This paper studies the academic outcomes for a total of 286 students divided into two optional courses of cadastre at higher education for 8 academic years. They are analyzed through three different educational modalities: face-to-face, blended and online for one course, and face-to-face and online for another. In order to deepen the analysis, a model using classification trees (CART) was created. It has been observed that the blended modality is the one that offers worst results in terms of success rate. If we compare exclusively the face-to-face method to the online one, we can conclude that the latter shows better results in all respects, improving the success rate and increasing the percentage of students who obtain highest marks.

Keywords: Online, face-to-face, blended learning, academic outcomes, CART, cadastre, higher education.

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1. Introduction

The form of the cadastre in each state or country is usually a consequence of the jurisdiction's historical development, its laws and custom and, to a large extent, its form of conveyancing and method of introduction of land registration (Williamson 1985). The Cadastre has been traditionally studied from several points of view, e.g. historical (Femenia-Ribera et al. 2014), technical (Abidin et al. 2015), accuracy (Shnaidman et al. 2012), or new trends (De Vries et al., 2015) as 3D Cadastres (Dimopoulou et al., 2013; Spirou-Sioula et al. 2013; Siejka et al. 2014).

On the other hand, the role of the surveyor remains relevant to the modern world (San-Antonio-Gómez et al. 2015), but there are notable changes in how surveyors carry out their work and in the nature of that work (Young et al., 2012). This argues that changes are needed in relation to educational programs (Wang and Wang 2011; Coutts and Strack 2012).

E-learning is emerging as the new paradigm of modern education (Sun et al., 2008). Information technologies are extending opportunities for learners to learn outside institutions, transforming conventional views on education (Collins and Halverson 2010). These transformations require educational systems to adapt, to meet the needs and expectations of learners and stakeholders (Stepanyan et al. 2013). In recent years, the number of students who have been using Geomatics has increased manifold (Srivastava 2013). Over the past decade, initiatives to fund the development of e-learning content for programs for Geomatics have been implemented in various countries. However, many of these e-learning projects quietly disappeared after funding ran out, since they were not built for sustainability (Weibel et al. 2009). The teaching strategies and course structures for teaching GIS to a multidisciplinary audience require pedagogic practice to ensure that there is facilitation of deep learning among students (Srivastava and Tait 2012).

The face-to-face teaching model has been the most widely used since the beginning of the existence of Universities (Prince 2004). Since the popularization of Internet in the nineties, distance learning has experienced a boom in online or virtual education (Barnard et al. 2009). Today, blended learning, also known as semi-distance learning,

coexists with the two models previously mentioned (Osguthorpe and Graham 2003). The face-to-face (FTF) model has been described by some authors as a model of success for a large proportion of the population, based on certain indicators such as the percentage of students finishing their studies or the professional situation reached by the students after a period of time from the completion of their studies (Bartholome 2002).

The online modality is a teaching system for distance learning, supported by the Information and Knowledge Technologies (ICT) that integrates three teaching methods: Asynchronous, Synchronous, and Self-teaching (Goodyear et al. 2001). Other authors define this modality as a means of education that incorporates self-motivation, communication, efficiency and technology (Berman 2006), since, as social interaction is limited, students must stay motivated. In the references, the comparisons between the features of the face-to-face and online models are extensively dealt, highlighting the work of Aragon et al. (2002) and Summers et al. (2005). These authors present the most significant advantages and disadvantages of both models, giving recommendations on the development of a quality and efficient virtual teaching and concluding, in terms of implementation, that "today's problems are not technological, but are derived from knowing what to do, how to do it, and why we do it.". From a student's point of view, comparing Online and Face-to-Face Learning Environments, results revealed that the students in the face-to-face course held slightly more positive perceptions about the instructor and overall course quality although there was no difference between the two course formats in several measures of learning outcomes (Johnson et al. 2000).

The hybrid model, semi-distance or blended learning, is understood by experts as the mode of learning that combines face-to-face teaching with technology for distance teaching (Coates 2003). Garrison and Vaughan (2008) think that blended learning in Higher Education clearly demonstrates how the blended learning approach embraces the traditional values of face-to-face teaching and integrates the best practices of online learning. The blended learning offers a series of adaptations of the traditional method with online education with a double objective: improving the quality of the learning outcomes and the economic advantage for the institution based on personnel replaced by technology (Marsh et al. 2003). 'The key for this methodological change is not to learn more (which in fact is widely demonstrated that it does not occur) but to learn differently. Both online and blended learning are models in which the student has to

develop important skills for their future life in this society' (Bartholome 2004). In any case, it is inevitable that the higher education institutions adopt in a few years blended learning approaches in a significant way (Garrison and Kanuka 2004).

The use of distance learning technologies, and more specially, online distance learning, has enhanced the changes now occurring in the delivery of education (Palloff and Pratt, 2002). From an institutional point of view, the process of incorporating the online teaching method at universities has been materialized mainly with the creation of Virtual Campus (Bande and Canay, 2001). Recent studies in our virtual learning environment, such as the Andalusian Virtual Campus (CVA) which the University of Almeria belongs to, along with the rest of Andalusian universities (Spain), indicate that students consider these experiences positive as they facilitate interaction between both their teachers and other students (virtual tutoring, e-mail, chat, forums, etc.). Virtual teaching platforms also allow them to work regardless the class schedule, access the information from anywhere (high volume of information put into the network whenever available) (Guasch et al. 2010). Other works on this same experience (Barroso and Cabero 2010) stand out that, from the student's point of view, one of the advantages of this type of training is that it allows their approach to ICTs and given the importance they will have on the student's future, they consider this aspect a great value. Within this same experience, the CVA, from the point of view of teachers and when making the comparison between online and face-to-face teaching, they believe that the online method "requires a greater investment of time to create quality educational materials and to keep them constantly updated, which implies the need to be continuously updated in the technology world in general and in the possibilities of the particular platform, together with the constant attention required to meet the needs and demands of the students" (Cabero and Romero 2010). Further studies indicate that the access to virtual campus courses occur by 18 % more with best students, those entering university with a mark higher than 9 in the entrance examination to university, compared to those with a 5, i.e. the minimum mark (Bande and Canay 2001).

For academic results in the CVA, the work of Garcia and Galindo (2009) shows on a course for the academic year 2007-08 with 76 students, where the success rate (first and second call) is 66.7 % of students enrolled, of whom 32.2 % got pass rate, 45.8 % good rate and 6.8 % excellent rate. Educators report course drop out and failure rates among

distance learners that are significantly higher than those for traditional, campus-based students (Nash, 2005; Wojciechowski and Palmer, 2005). Generally speaking, there is 80 % failure in the management of distance learning courses and over 60 % students' abandonment (Cabero 2006). Research on network-based learning have shown no significant differences in performance between students who have followed a traditional methodology (face-to-face) and those who have followed technology-based learning (online or blended learning) (Cabero and Romero 2010). On the other hand, there are studies that directly link the quality of virtual teaching to academic outcomes (Smith et al., 2000). Within this framework, we set the objective of comparing the three learning models described in accordance with the learners' academic results obtained over nine academic years in two courses taught by the same professor but varying the teaching model throughout the years.

2. MATERIALS AND METHODS.

2.1 Courses under study.

The courses of spatial sciences used for this study were, first Cadastre and second Remote Sensing, both optional courses of the Academic Plan 2000 for all the degrees of Technical Agricultural Engineering (ITA) at the University of Almería (BOE, 2000). Furthermore, these courses could be chosen as elective for any degree followed at the University of Almería.

The representativeness of the course Cadastre within the Spanish universities has been studied (Manzano and Salmerón, 2006), and it has been observed that courses related to Cadastre are present in 70 % of state universities and in 30 % of private universities in Spain, noting that 90 % of the degrees offering them are engineering studies. Although specific data are not available, the Remote Sensing course is also usual for engineering studies and for degrees in Geography and Environmental Sciences.

The courses under study were taught by the same professor during the whole period of the curriculum, what we might call the "life cycle" studied: 8 academic years from 2002-03 to 2009-10, thus the same endpoints are considered.

The virtual part of the courses was created on Web-CT, the most supported tool worldwide, with over 3500 users (mostly universities), used by 15 million students, over half a million teachers, and translated into 15 different languages to be used in 72 countries (Mondejar et al. 2006). In the course Cadastre, the first 3 academic years were face-to-face, the following 3 years blended (60 %), and the last 2 years online. With regard to Remote Sensing, the first 4 academic years were face-to-face and the following 4 years were online.

The online method implies that students can pass the subject without attending a single day to class. They have all the materials available on the website, on-line documentation and activities and the assessment mark is obtained through the activities performed during the teaching period, unlike the blended model, by which some of the activities are shown and defended in class.

Figure 1. Home page of the course Cadastre in Web-CT.

2.2 .- Research subjects.

Students who have completed the courses have an age difference of one to three years, so this variable has not been taken into account. The data analyzed correspond to the results of the first registration of each student. Students repeating the course have been

excluded. Table 1 summarizes the distribution of students for the course Cadastre, while Table 2 shows data for Remote Sensing.

Table 1. Distribution by degrees and gender of the students studied for Cadastre.

Degree	**XY**	**XX**	**Total**
ITA Mechanization and Rural Constructions	38	14	52
ITA Agricultural and Food Industries	8	5	13
ITA Horticulture and Gardening	35	13	48
ITA Farming Operations	22	4	26
Agronomic Engineering	5	3	8
Others	1	3	4
Total	109	42	151

Table 2. Distribution by degrees and gender of the students studied for Remote Sensing.

Degree	**XY**	**XX**	**Total**
ITA Mechanization and Rural Constructions	29	3	32
ITA Agricultural and Food Industries	0	6	6
ITA Horticulture and Gardening	30	13	43
ITA Farming Operations	13	3	16
Agronomic Engineering	28	8	36
Others	3	0	3
Total	103	33	136

It is observed that there are more male students enrolled in these courses, but this is widespread in engineering degrees and we can consider this as a representative data for courses under study.

3. RESULTS.

The academic results of the students have been grouped into the following categories: fail or absent (FL-AB) representing the failure rate of the subject; pass (PS), good (GO) and excellent (EX). The first category encompasses both the fail and the absent rate, since both in the online and blended learning modalities the online work and activities

performance represent 70 % or 100 % of the final grade respectively. Thus, the learner who does not perform correctly would be graded as absent, but for practical purposes, it would be equivalent to a failing grade. The latter category, excellent, also includes students getting top marks.

3.1 .- Course taught in the three modalities: face-to-face, blended and online.

The results obtained per academic year are shown in Table 3. It shows the development of students enrolled in the course Cadastre, which has ranged from a minimum of 9 and a maximum of 27 students, being enrolled an average of 21.6 students. The increasing inflow in recent years is due to the fact that it is followed by students from the same university but doing a stay in a foreign university within the framework of different mobility programmes, such as Erasmus.

Table 3. Academic results obtained per academic year for Cadastre (Fail or absent (FL-AB) representing the failure rate of the subject; pass (PA), good (GO) and excellent (EX)).

Year	Modality	FL-AB	PA	GO	EX	TOTAL
2002-03	Face-to-face	4	6	5	7	22
2003-04	Face-to-face	1	2	7	9	19
2004-05	Face-to-face	5	4	4	3	16
2005-06	Blended	11	3	0	11	25
2006-07	Blended	4	0	3	2	9
2007-08	Blended	5	2	4	3	14
2008-09	Online	3	3	4	9	19
2009-10	Online	3	7	8	9	27

3.2 .- Course taught in two modalities: face-to-face and online.

The results obtained per academic year are shown in Table 4. It shows the development of students enrolled in the course Remote Sensing, which has ranged from a minimum of 9 and a maximum of 41 students, being enrolled an average of 17 students. The increasing inflow in recent years is due to the same mobility exchanges occurred in the previous course.

Table 4. Academic results obtained per academic year for Remote Sensing (Fail or absent (FL-AB) representing the failure rate of the subject; pass (PA), good (GO) and excellent (EX)).

Year	Modality	FL-AB	PA	GO	EX	TOTAL
2002-03	Face-to-face	0	2	9	2	13
2003-04	Face-to-face	2	0	10	0	12
2004-05	Face-to-face	3	6	4	3	16
2005-06	Face-to-face	4	1	4	0	9
2006-07	Online	4	2	5	4	15
2007-08	Online	1	0	2	7	10
2008-09	Online	0	4	2	14	20
2009-10	Online	6	0	23	12	41

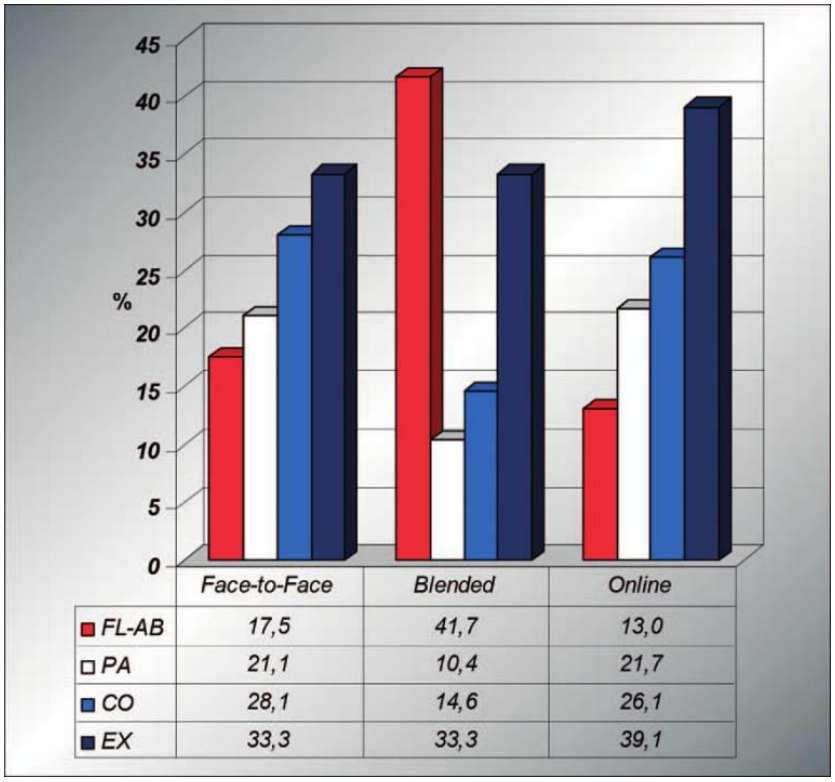
3.3 .- Results for the course taught in the three modalities: face-to-face, blended and online.

If we group the data in Table 3 by marks and in accordance with the teaching modality: face-to-face (2002-03 to 2004-05), blended (2005-06 to 2007-08), and online (2008-09 to 2009 - 10), and if we represent them as percentage of students in each modality to establish a comparison, we obtain Figure 2.

Figure 2 shows that the model with lower success rate or higher rate of failure (FL) is the blended format influenced by data from the first year in which it is implemented: the academic year 2005-06 with a failure rate of 44 %, the highest of the eight years studied, being the average 25.42 %. For learners, this modality has demonstrated to have the shortcomings of the other two: need to attend classes regularly and have to work through the Web platform. On the other hand, we observe that the blended format equals the face-to-face mode in percentage of learners with highest marks (Excellent) and stays below the online modality.

Taking the traditional face-to-face model as a reference, we see that the online has slightly better success rate with 4.5 % more students who pass the course, and, although

it has approximately the same ratio in the passing grade, it is remarkable the increase in the highest mark: a shift from good (GO) to excellent (EX).



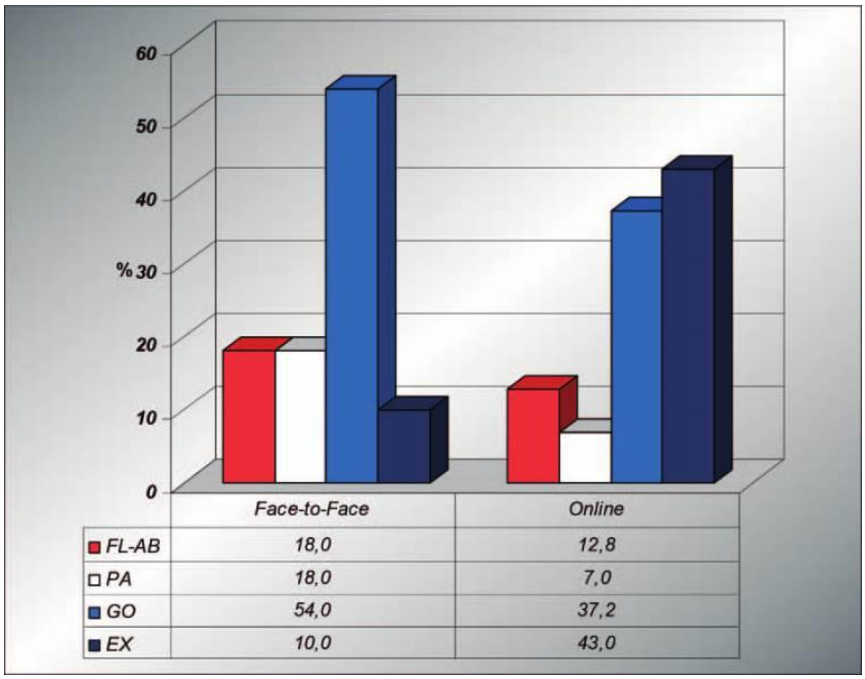
	Face-to-Face	Blended	Online
FL-AB	17,5	41,7	13,0
PA	21,1	10,4	21,7
CO	28,1	14,6	26,1
EX	33,3	33,3	39,1

Figure 2. Course academic results in the three teaching modalities: face-to-face, blended and online. (Fail or absent (FL-AB) representing the failure rate of the subject; pass (PS), good (GO) and excellent (EX)).

3.4 .- Results for the course taught in two modes: face-to-face and online.

If we group the data in Table 3 by marks and in accordance with the teaching modality: face-to-face (2002-03 to 2005-05) and online (2006-07 to 2009 - 10), and if we represent them as percentage of students in each modality to establish a comparison, we obtain Figure 3.

Figure 3 shows that the online modality has slightly better success rate than the face-to-face one at 5.2 %, but it especially improves the excellent (EX) rate by 33 %. A high rate of Good (GO) marks is remarkable in the latter modality, despite the fact that higher marks in online outgrow it.



	Face-to-Face	Online
FL-AB	18,0	12,8
PA	18,0	7,0
GO	54,0	37,2
EX	10,0	43,0

Figure 3. Course academic results in two teaching modalities: face-to-face and online. (Fail or absent (FL-AB) representing the failure rate of the subject; pass (PS), good (GO) and excellent (EX)).

4 .- ANALYSIS THROUGH CLASSIFICATION TREES (CART).

Classification and regression trees (CART) are used for prediction. In the last two decades, they have become popular as alternatives to regression, discriminant analysis, and other procedures based on algebraic models (Loh, 2014). Trees are directed graphs beginning with one node and branching to many. They are fundamental to many fields, e.g: for data structures in Computer Science (Li et al. 2010); for classification in Ecology (De'Ath and Fabricius, 2000), Photogrammetric Engineering (Lawrence and Wright, 2001) or Remote Sensing (Xu et al. 2005); or for decision theory in Psychology (Strobl et al. 2009). Classification trees include those models in which the dependent variable (the predicted variable) is categorical. We have analyzed the data from the two courses through classification trees, CART. This is a nonparametric statistical analysis procedure that performs a binary recursive partitioning able to process continuous and nominal attributes as prediction objectives and factors. From the root node, data are divided into two 'child' nodes, and each of them is at the same time divided into 'grandchild' ones and so on (Steinberg and Colla 1997). Notice that the predicted variable is the final grade, and the predictor variable is the course modality or the alternative methods for teaching: Online, Blended or Face to Face. So, the predictor and

predicted variables are labeling the nodes and branches of the tree. The software used was XLSSTAT 2009.3.02. The Gini coefficient was used, as well as a 4 maximum tree depth, a 5 % significance level and 5 intervals.

4.1. CART analysis for the course taught in the three modalities.

The qualitative variable was the course modality and the quantitative variable the final grade. The following frequencies were obtained: 37.748 % face-to-face, 31.788 % blended and 30.464 % online.

The CART analysis has been represented in Figure 4. At node 3 it is observed that if the mark is between [9; 10] the face-to-face and blended modality stay at 33.85 % and 30.19 % respectively, and at 39.96 % for online cases. This corresponds to the excellent (EX) defined rate, thus a drift towards this grade is observed with the online model.

At node 7, if the mark is between [7; 9] then the dominant modality is face-to-face, at 45.71 %, closely followed by online at 34.29 % and finally by blended at 20 % of cases. This corresponds to grade Good (GO).

At node 6, if the mark is between [5; 7] then a rapprochement between face-to-face and online occurs (44.44 % and 37.04 % respectively). The blended modality stays well below the previous ones at 18.52 % of cases. This mark corresponds to pass grade (PA). As occurred at node 7, percentages for face-to-face and online approach and separate from the blended modality.

At node 4, if the mark is between [3; 5] then there is a clear dominance of blended modality at 55.56 %, followed by 27.78 % face-to-face and 16.67 % online. This would be the failure rate or the worst marks, students who do not get the pass grade. That is the fail or absent marks (FL or AB).

A global analysis indicates that the worst rates appear in the blended modality, followed by face-to-face and finally by online. Furthermore, higher marks are more abundant in the latter one.

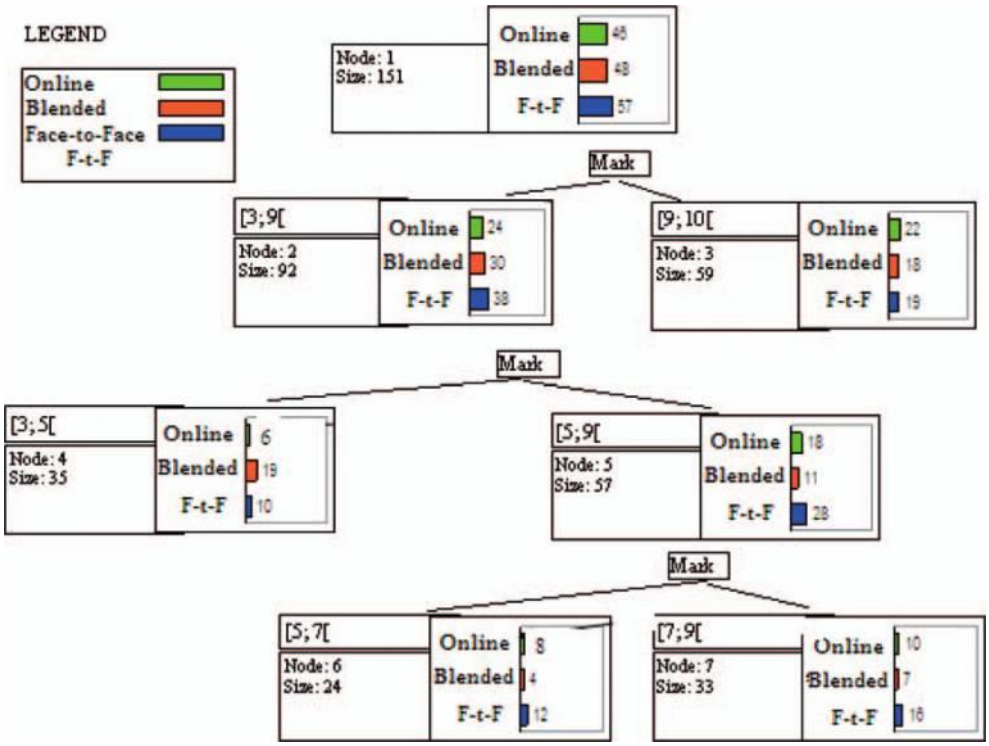


Figure 4. Decision tree obtained from the course taught in the three modalities: grade vs. modality.

4.2. CART analysis for the course taught in two modalities.

The qualitative variable was the course modality and the quantitative variable the final grade. The following frequencies were obtained: 36.8765 % face-to-face and 63.2 % online.

The CART analysis has been represented in Figure 5. At node 7 it is observed that if the mark is between [9; 10] then the face-to-face modality gets a 9.6 % percentage, a very low rate with regard to that obtained in the online one, 71.15 % of the cases with excellent (EX) marks.

At node 5, if the mark is between [7; 9] then Good marks (GO) are not such unequal. 45.76 % face-to-face and 54.24 % online.

At node 6, with pass grade between [5, 7] there is a 20 % increase in the face-to-face modality than in the online one (40 % of cases).

At node 4, if the mark is between [3, 5] then face-to-face has fewer cases than online (25.71 % and 31.43 % respectively). Thus, online provides greater overall failure rate, but it should also be considered the greater number of students involved (50 students in face-to-face and 86 students in online).

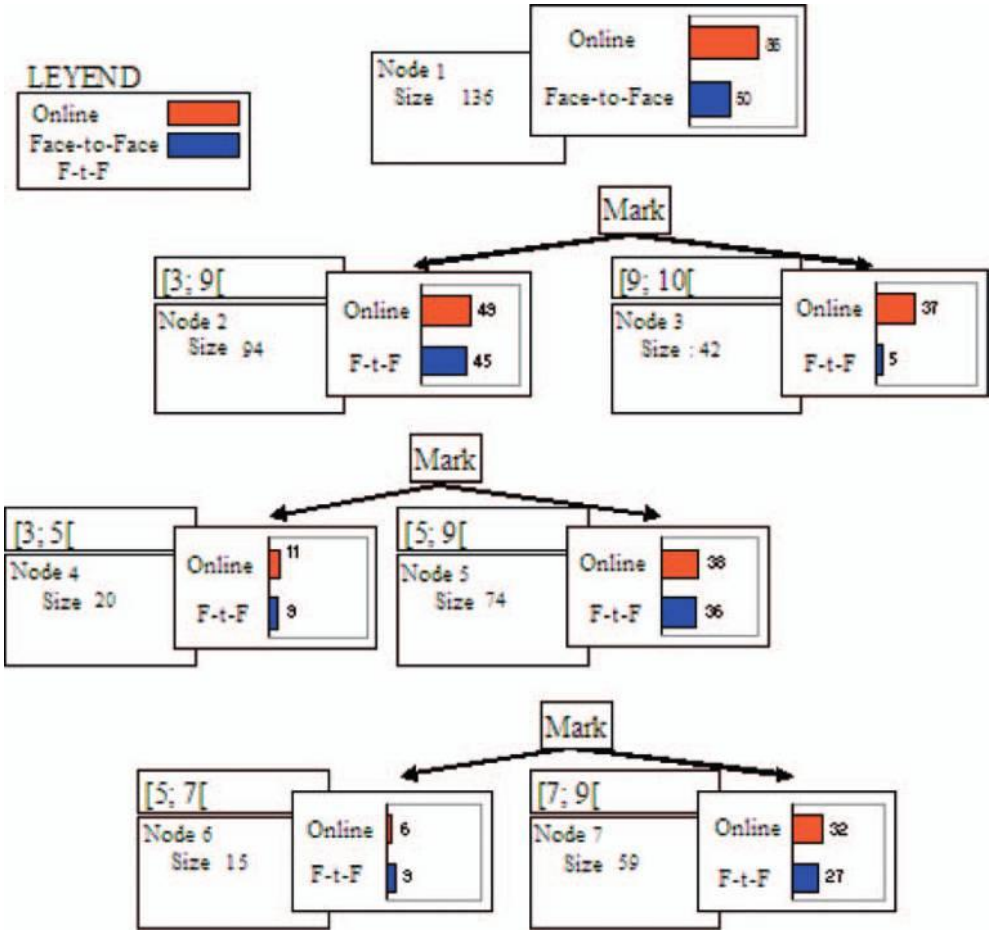


Figure 5. Decision tree obtained from the course taught in two modalities: grade vs. modality.

The overall results for this course indicate that there is only significant difference in excellent (EX) and pass (PS) results between both modalities. So, more pass marks (PS) were found in face-to-face and more excellent marks (EX) were found in online.

4. Gender analysis

There is considerable research showing that boys and girls differ in their ability and value beliefs for academic domains that are traditionally gender-typed as ‘‘male” or ‘‘female”, in patterns that are consistent with gender norms and stereotypes (Meece et al. 2006). In particular, research on ICT (Information and communications technology)

learning shows that girls tend to have less positive beliefs about the value of ICT and their own ICT skills compared to boys (Volman and van Eck 2001).

Venkatesh et al. (2000) suggest that men and women adopt very different decision-making processes in evaluating new technologies. Wehrwein et al. (2007) indicate that males and females have different preferences in learning which may affect their perceptions and satisfaction. Females reported a higher level of attention and felt that the content presented in the podcasts were more relevant than males (Bolliger, Supanakorn & Boggs 2010). Ong and Lai (2006) show differences in the processes of decision-making, acceptance and use of online learning between men and women. In summary, the studies seen so far show gender differences in attitude and acceptance of new technologies and a priori use of online learning. However, we have found no study that links online learning to academic performance of students depending on gender, in terms of success rates or better marks.

This section studies a gender comparison in academic performance, success rates and better marks. To make this comparison, the percentage of academic results by gender and subject were calculated in Figure 6. Although academic results may seem high, they are common in elective subjects, especially when they are taught through online learning; it is proven that this method produces better marks than those usually obtained in face-to-face classes (Levy 2007).

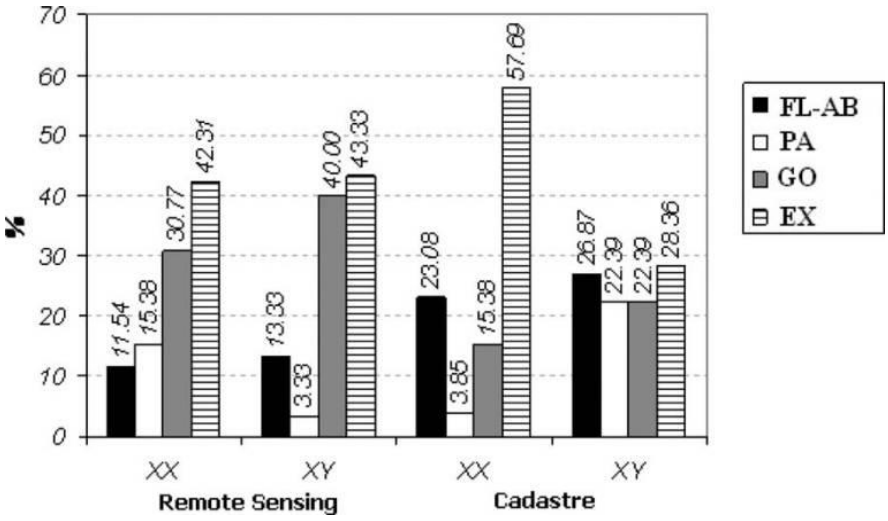


Figure 6. Percentage of academic results by gender and subject: (Fail or absent (FL-AB) representing the failure rate of the subject; pass (PA), good (GO) and excellent (EX)).

We observe that the failure rate (FL-AB) in the subject Remote Sensing is 1.79 % lower in gender XX, and it is essentially the same in Cadastre, the difference there being 3.79 %. Although the differences are small and these results should be taken with caution, we can assert that the failure rate is not unfavorable to XX or, at least, that is independent of gender. The “passing” results for each subject were opposite to each other; we therefore consider them to be the same. Regarding “good” marks, the results for XX are lower than those for XY in both subjects, but there is no doubt that this is because there is an equal or greater percentage of “excellent” marrks for XX. The variation in “excellent” marrks is 1 percent in the first subject, while in the second one there is a difference of 29.33 percent in favor of XX.

As in the previous analysis of the success rate, seeing as the trends are not the same for both subjects, we cannot make a firm conclusion in any direction. However, if we consider the fact that there are similar percentages of "passing" marks for both genders, a higher percentage of "good" marks for XY, and a higher percentage of "excellent" marks for XX, it would seem that this e-learning model is not, in fact, prejudiced against XX. Rather it is the opposite, as XX attains the highest marks at a rate similar to or better than XY. For the analysis of marks, “fail” results have been removed from the study. We have proceeded, firstly, to perform a normality test of the data by gender and subject using the Shapiro-Wilk test, since it is the best test for samples lower than 5000 entries.

In view of the normality tests, Table 5, it is observed that the data do not conform to a normal distribution, as the p-value is always below the level of significance (0.05). The average marks by gender are very similar in the first class, but the differences are more pronounced in the second, with a higher average mark in gender XX. If we perform the Mann-Whitney test – a non-parametric test for comparing populations that are not normal – in order to compare the marks by gender and subject, we obtain the values in Table 6.

The interpretation of the test (Table 6) shows that if the computed p-value is below the level of significance alpha = 0.05, we should reject the null hypothesis; that is, marks are statistically different. This is the case for the subject Cadastre. If the p-value is

greater than the level of significance alpha = 0.05, we should accept the null hypothesis; that is, marks are statistically the same. This is the case for the subject Remote Sensing.

Table 5. Passing mark statistics by gender and normality test.

	Remote Sensing		Cadastre	
	XX	XY	XX	XY
Average	8.150	8.461	9.337	7.813
Standard deviation	1.382	0.818	0.639	1.390
Shapiro-Wilk test				
W	0.858	0.784	0.890	0.916
p-value	0.005	< 0.0001	0.033	0.002
alpha	0.05	0.05	0.05	0.05

Table 6. Mann-Whitney test comparing both genders and subjects (non-parametric test).

	Remote Sensing	Cadastre
U	541.000	784.000
Expected value	598.000	490.000
Variance (U)	6818.277	5667.165
p-value (bilateral)	0.495*	< 0.0001**
alpha	0.05	0.05

* The p-value is calculated using an exact method.

** The p-value was calculated by approximation.

Therefore, according to the subjects studied, one of them does not show mark differences by gender, while the other does; the latter presenting the best mark for the XX gender, by 1.5 points of the final mark. Because of the fact that there is the same percentage of women in the subjects analyzed and those enrolled in the degree program, it is considered that the attitude towards online learning in our study is independent of gender. This is corroborated by other studies such as that of Bande and Canay (2001), in which the effect of gender on the probability of access to the virtual campus was insignificant.

6 .- DISCUSSION

In this paper we have analyzed the academic outcomes of two courses taught each of them always by the same teacher, and with the same evaluation criteria, only varying the teaching modality.

The comparative results obtained in all the three modalities show that face-to-face and online perform better in the higher marks, being higher in online with 5.8 % increase in the course taught in the three modalities and 33 % more in the other course. Regarding the blended modality, it has lower percentages in pass (PS), good (GO) and excellent (EX) marks than in the other modalities, with a shift towards the excellent (EX) mark.

In accordance with the analysis of data regarding the success rate, the blended modality was the worst with 41.64 % failure rate, confirming the tendency of some studies to online courses, which obtained 60 % dropout by students (Cabero 2006), or the analysis of Garcia and Galindo in a CVA course with a success rate of 66.7 %. Even being the online modality the best of three studies, only improved by between 4.5 and 5.2 % the success rate in comparison with the face-to-face one. An explanation of the so high failure rate in the blended format is that, although this method arises, according to Garcia (2004), to "pick up the advantages of good distance education, combined with the proved benefits of good face-to-face teaching", it has also inherited disadvantages from both teaching types reported in the literature as described in Cabero and Gisbert (2005). According to these authors, these disadvantages are that the learning process has a temporary and location stiffness. The teacher is the source of presentation, information structuring and domain on how the learning should occur. It is also necessary to master the technology and invest time outside the class schedule to create e-directed tasks and presentations at term, among others. Definitely, it fails in the development of the online advantages where the students are actively involved in their learning process being led by the professor.

With the models deduced by decision trees CART, is has been deducted that if the comparison is between face-to-face and online there is almost the same success rate, as suggested by Bartholomew (2004): "the methodological change does not intend to learn more (which in fact is amply demonstrated that it does not occur) but to learn

differently". The work of Cabero and Romero (2010) also states that there are not significant differences in performance between students following a traditional approach and those who have completed a technology-based course.

However, with this CART analysis, we observe that the excellent marks appear in 71.15 % of the cases in the online modality, versus the 9.62 % in the face-to-face one. On the other hand, if the comparison is between the three modalities, face-to-face, blended and online, the worst results appear with the blended method, with 55.56 % fail or absent (failure rate), compared to 27.78 % face-to-face and 16.67 % online, approaching the results obtained by Cabero (2006) and Garcia and Galindo (2009).

Since the blended format has the worst success rate and as its high scores improvement is low compared to the face-to-face modality, it is concluded that this modality has proven to be the worst for the courses studied. On the other hand, the online modality has obtained better or equal success rates and higher marks than the face-to-face modality, thus we can conclude that the model which offers better academic results is the online modality. This may indicate that the development of weekly-assessed activities makes students acquire the working habit in the course resulting in an increase in the highest results in online.

6 CONCLUSIONS

These results confirm the students' increasing commitment to the extra effort of acquiring other skills such as those developed by online models (e.g. online information search and finding, decision-making based on authoritative information, interactive group work, etc.). This model allows students to have a more active role in their learning process. It should also be considered that in the last decade these skills are being gradually introduced in basic studies and, with a more critical attitude, in Higher Education. In summary, once studied the academic performance of two courses for 8 academic years and analyzed through three different teaching modalities: face-to-face, blended and online, for one, and face-to-face and online for another, it has been observed that the blended modality is the one which offers worst results in terms of success rate. If we compare exclusively the face-to-face method to the online one, we can conclude that the latter shows better results in all respects, improving the success

rate and increasing the percentage of students who obtain highest marks. This opens new perspectives to teach in engineering studies.

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