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SURVIVAL AND RISK ANALYSIS IN MOOCS

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ABSTRACT

The most significant disadvantage in the use of MOOCs is their high drop out rates, which reaches between 88.3% and 90%. This research examined the desertion from 15 MOOCs, the following factors and their relation to desertion were assessed, characteristics of the students (gender, language, educational level, age, interest in the final certificate) and aspects of the courses (data lost at the time of registration, duration of the MOOC, course discipline, number of total questions and by evaluation). The results, based on survival analysis, indicate the probability of desertion is the highest on the first and last weeks of the MOOC. Our findings show that the probability of dropout is affected by the number of questions in each evaluation, the educational level of the participants, their age and their interest in the certificate. Missing data in the registration form was found to be associated with desertion being a significant pre-dictor of risk of quitting. Finally, the lack of interest in the certificate was found to be a predictor of the highest risk of dropping out. Possible strategies to reduce the desertion behavior at MOOCs are discussed.

Keywords: MOOC, desertion, survival analysis, risk analysis.

INTRODUCTION

MOOCs have become an efficient way to bring knowledge to different populations. These courses are popular since no previous knowledge on the course content is needed. MOOCs optimize time, reduce costs and can be taken wherever and whenever the student finds convenient (Gütl, Rizzardini, Chang & Morales, 2014). By 2015, the worldwide enrollment in MOOCs reached 17 million students, while the range of subjects reached 2,400 (Sanchez-Gordon, Calle-Jimenez & Lujan-Mora, 2015, Sanchez-Gordon & Lujan-Mora, 2016). The biggest disadvantage in MOOCs is student desertion (between 88.3-90%) (Carey, 2012; Chang & Wei, 2016; Gütl et al., 2014), which may come from the experiences suffered by students during the course (Chiappe-Laverde, Hine & Martinez-Silva, 2015; Mabuan, 2018). MOOCs are designed to last

several weeks and are divided in learning modules. A module usually extends for a week, at the end of which an evaluation is made. The weekly evaluation is one of the ways to know if the participants are active within the course or have defected. Desertion or dropout is understood as a decrease in the number of participants during the weekly development of the course until the end (Angelino, Williams & Natvig, 2007; Berge & Huang, 2004; Lewin, 2013).

Desertion from MOOCs has been studied from several models, among them the AMOES (Gütl, Chang, Rizzardini, & Morales, 2014; Gütl, Rizzardini et al., 2014). AMOES gathers a group of variables such as age, academic level, interest in the final certificate, study discipline, number of evaluations, online socialization, previous knowledge of the student, registration data and communication technology previously used by the student, these variables have been associated with MOOCs desertion by other models.

The expression Survival analysis refers to a set of methods for studying data where the outcome variable is time until the occurrence of an event of interest. For instance, survival analysis allows the determination of the probability that an individual exceeds a particular given time of life; and the risk represented by the probability per unit of time of an individual surviving in the preceding segment of time (Ferschke, Yang, Tomar & Rose, 2015; Greene, Oswald & Pomerantz, 2015; Rose et al., 2014; Yang, Wen, Howley, Krayt & Rose, 2015). In education, survival analysis techniques have been used as predictors of attrition and the determinants associated with it (Stool-miller, 2016). Among the applications of survival analysis of the dropout, the results of Rose et al., (2014) indicate that the probability of desertion in MOOCs is associated with variables such as low interaction with supervised activities, the division of students into sub-communities and the opinions of unmotivated students.

According to Ferschke et al., (2015) the probability of dropping out is related to the number of clicks in the videos (the greater the number the clicks the larger the risk of dropping out) and in the forums where the higher the participation, the lower the dropout rate. Similarly, the risk of dropping out increases when participants have failed MOOC evaluations. Greene et al., (2015) show that the probability of dropping out decreases with the increase of: age, level of schooling, previous participation in MOOCs and the number of hours dedicated to the course. They establish that the probability of dropping out increases when there is low interest in the certificate and commitment during the course, their survival curves determine that attrition is higher during the first week. On the other hand, Yang et al., (2015) found that the probability of dropping out is low depending on the joint experiences in synchronic reflection exercises and the risk of dropping out increases with the number of attempts needed to solve the examination questions correctly.

In this study, we present an analysis of the dropout from a set of 15 MOOCs offered by a Colombian university, these courses were available on the web and their language was Spanish. The scope of the study was centered on survival analysis using gender, age, student's academic level and interest in the certificate, subject of the course, duration of the course in weeks, number of evaluations, number of questions per evaluation and the amount of missing data in the registration form. The effect of the latter three variables has not been reported in previous studies. The research questions were: Which data are associated with the dropouts from MOOCs? Can the amount of missing data in the registration forms be considered as a predictor of dropping out? Is there a time where the probability of dropping out of MOOC becomes higher? Can the number of evaluation questions be predictors of the risk of dropping out? What is the best predictor (if any) of the risk of desertion among this set of variables? In this study, we used an analytical survival approach to answer these questions. In this study we used an analytical survival approach to answer these questions, our main goal was to predict the probability and risk of attrition.

METHODOLOGY

This study used a quantitative methodology. This study has a quantitative methodology. An inferential study was included in 15 MOOCs with two relational faces with the demographic variables and the registration in the course, finally a non-experimental longitudinal design was completed with a part of analysis of the survival, risk and estimation of the variables Predictors of the desertion. The participants were recruited by the offering university using social networks. The interest on the certificate was asked after the registration form; the cost was 49 USD.

Participants

The analyzed population came from an open code learning online platform for MOOCs. During the period from February to December 2017 the platform reported a total enrollment of 41,473 students. Participants who took the course at their own pace were excluded from the study, for a total of 39,073 participants. The gender of the participants was female (60%), male (36.2%) and lost data (3.8%). The age group of the population ranged between 18 and 78 years ($M = 31.87$, $SD = 10.15$), this range was in turn distributed as follows 18 to 28 (39.8%), 28 to 38 (30.5%), 38 to 48 (14.3%), 58 to 68 (7%), greater than 78 (0.2%) and the remaining percent-age were lost data. The educational level variable was categorized in years of schooling according to the United States Educational System. The average level of schooling was 12 years ($SD = 2.13$), represented in ranges of years: 8 (2.5%), 10 (14.2%), 12 (24.9%), 14 (28.2%), 16 (20.8%), 18 (1.4%), 22 (0%), others (3.1%), lost (5%). The data requested at the time of registration was one to four ($M = 0.84$, $SD = 1.23$). Most of the participants were Colombians, the rest belonged to 33 different countries. The 15 MOOCs belonged to different disciplines: Health (27%), Business (20%), Philosophy (20%), Communication (13%), Ecology (13%) and Law (7%) (As shown in Figure 1).

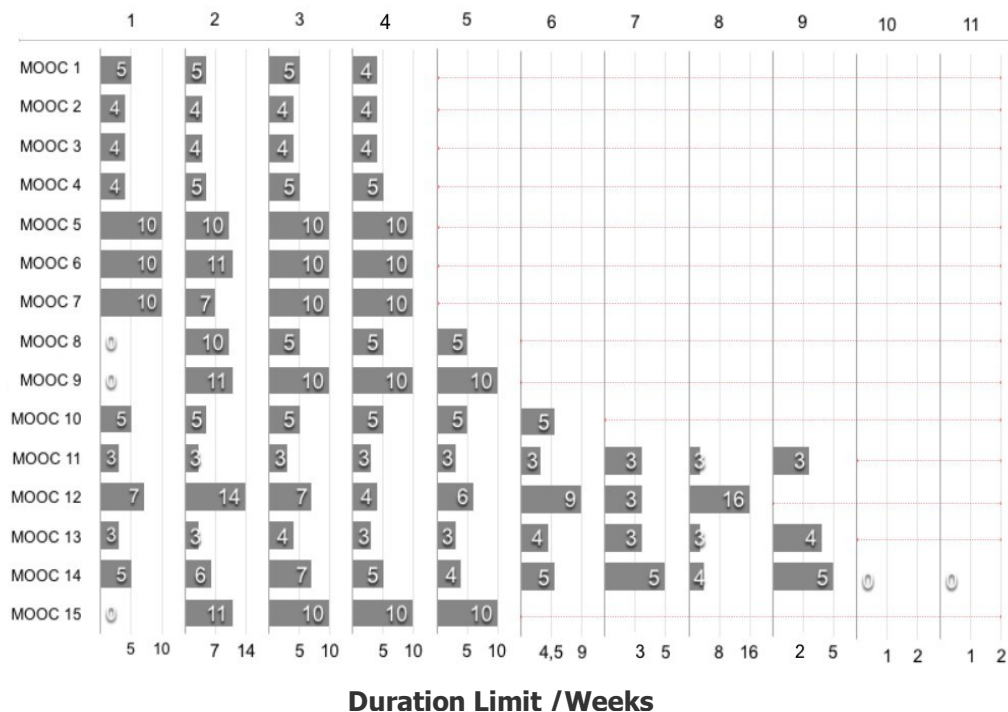


Figure 1. Distribution of questions per week each MOOC. Cells are empty when the MOOC was inactive.

Instruments

The data collection instruments were created by the platform used and the MOOC professors. Five instruments were applied: Registration form: collected the demographic characteristics and previous experience of the students. Evaluation of the weekly content 1, 2,3 and 4: recorded re-sponses from zero to 11 multiple-choice questions. These instruments do not have results of psychometric tests and do not correspond to an evaluation research design, but to an exploratory design.

Data Collection and Analysis

For each MOOC, form 1 gathered information on gender, age, academic level and country. The amount of missing data from Form 1 was determined according to the absence of student answers at the time of enrollment. Form 2, was assessed by payment or not of the certificate at the time of registration. Form 3, grouped the number of questions that were made at the end of each module/week. The variable to predict was desertion. The evaluation forms were filled in at the end of each week through the offering platform. The participants responded weekly with an evaluation with different questions until the end of the course, this allowed to follow the periodic and final desertion.

FINDINGS

We used SPSS version 25 for data analysis. The analysis were carried out in two stages: (a) relational and (b) survival analysis. The relational stage was actually executed in two phases: in Phase 1 the statistically significant differences between the selected variables and the attrition were determined to obtain the covariates of the survival analysis. In Phase 2, the analysis of lost data from the registration form was carried out to determine if the amount of lost data could be considered predictors of dropping out. The categorical variable used for this procedure was desertion and patterns with less than one percent of cases were omitted. Subsequently, a de-scriptive analysis was carried out omitting variables with less lost values than five percent of the cases; and finally an expected maximization analysis to determine the means, the covari-ance matrix and the correlation of the quantitative variables with the lost values.

The survival analysis stage, was performed in three phases. In Phase 1, the univariate survival analysis was performed for all the data seeking to predict the probability and risk of dropping out at the end of each week (Allison, 2014). The follow-up time was between four and eleven weeks. The final state was categorized with the value of 1, those who abandoned the course and 2 for those who did not drop out. Likewise, the risk analysis (Hazard ratio) was performed with the same covariables to determine the probability per unit of time of the desertion occur-ring (Gomez & Langohr, 2004; Harrell, 2015). In Phase 2, the survival functions of the popula-tions were compared taking as reference the duration of each of the MOOCs through the Kaplan-Meier estimator to evaluate the survival function at each moment when a dropout ap-pears and not at the end of each MOOC and the log-rank test to know if the variable was relat-ed to dropping out (Lacny et al., 2017). In Phase 3, the semi-parametric Cox risk regression model was used for all the selected data and covariates, which allowed for the sequential na-ture of the data to be taken into account and for estimating survival as predictors of the risk of dropping out (Rubio & Martinez, 2016; Sanchez-Villegas, 2014).

The MOOCs under study lasted between 4 to 11 weeks, the courses were distributed accord-ingly with their time span as follows (see Figure 1) four(26.7%), five (26.7%), six (6.7%), sev-en (13.3%), eight (6.7%), nine (13.3%) and eleven (6.7%). The total number of questions was (between 19-68) per MOOC and the number of questions per week from zero to 16 weeks. The final dropout percentage of MOOCs was found to be between 89.5-98.9 %. For the inferen-tial stage the results allowed to identify that the desertion is related to the variables: MOOC subject, MOOC duration in weeks, missing data in the forms, interest in the certificate, number of questions evaluated per week , educational level and age range (see Table 1). The MOOC participants who defected the most, depending on the variable analyzed, were those not inter-ested in getting the certificate, people with eight years of schooling, participants in the 18 to 28 years of age range, people coming Communications subjects, and the group with questions to be evaluated distributed (10,7,10 and 10) . The amount of missing data in the registration in the participants who did not approve the MOOC was $M = 0.85$ data ($SD = 1.27$) and those who approved $M = 0.55$ data ($SD = 0.88$), with statistically significant differences $t(40.244) = 2.68$, $p < .01$; $d = 0.27$.

Table 1. Relation of variables and dropout

Variables	Relations
Subject	$\chi^2 (5, N = 39.073) = 111.26, p < .01$
Number of questions (group)	$\chi^2 (13, N = 39.073) = 454.66, p < .01$
Interes in certification	$\chi^2 (1, N = 39.073) = 17368.54, p < .01$
Years of study	$\chi^2 (7, N = 37.149) = 22.59, p < .01$
Age range	$\chi^2 (7, N = 37.341) = 123.07, p < .01$

**Figure 2.** Survival function for confidence limit 0.952

The time span of the MOOCs for participants who approved was $M=4.97$ weeks ($SD=1.56$), for those participants who did not approve we found a time span of $M=5.94$ weeks ($SD=1.72$) with statistically significant differences $t(40.244)=7.78, p < .0, d=0.59$. The variables gender and number of total questions were not related to the dropout and therefore were not taken into the survival analysis.

The null hypothesis for the analysis of the missing data was: the data values of the related variables behave randomly. Subsequently, based on the expected maximization analysis (EM) and the Little MCAR test, the null hypothesis $\chi^2 (4, N = 38.489) = .00, p < .01$ was rejected, confirming that the data are not distributed randomly, and that the pattern of the lost data is related to the observed data. For

the survival analysis stage, 33,411 students of the 15 selected MOOCs were analyzed, using the weekly time as the moment of the desertion occurrence and desertion as state. The attrition probability density function at each MOOC was found within the range of 84% to 93% for the first week. The median survival time in all MOOCs indicated that the highest probability of desertion occurs during the first week. Likewise, the risk function indicated that the highest risk of dropping out is in the first week of the course, within the interval of 1.15 to 1.73 times (see Figure 2). In the same way, Figure 2 shows that the risk of desertion increases again in the last week 0.77 times.

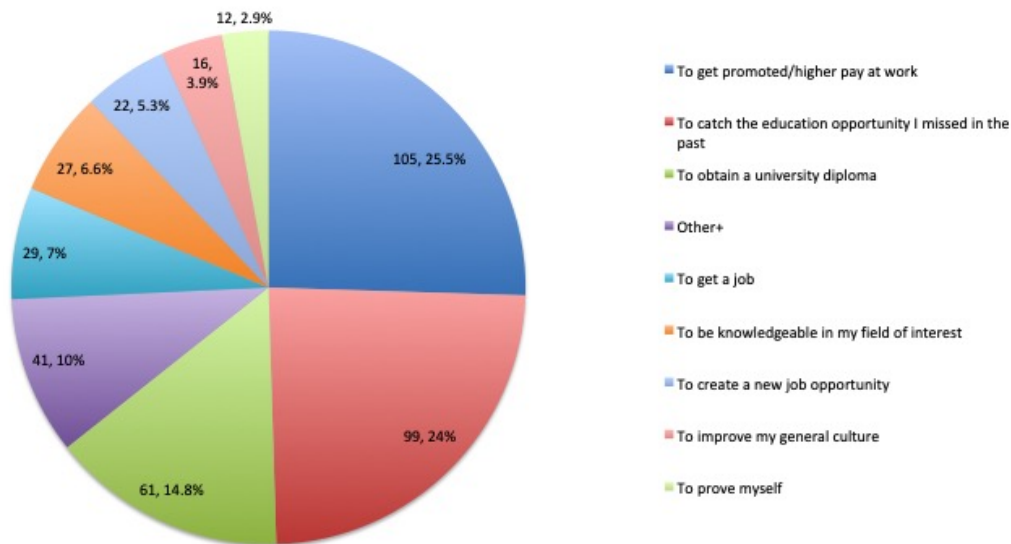


Figure 3. Risk function for 0.95 confidence interval

The results of Phase 2 of the survival analysis estimated the attrition probability density function, depending on the duration of the 15 MOOCs and the different covariables selected on the relational stage. Attrition was evaluated independently for each student and the probability of dropping out in each given week was calculated by the multiplicity of probabilities. The survival functions were calculated using the Kaplan-Meier estimator during the maximum period of weeks. The statistical differences between the survival functions with the covariates were made through the Log-Rank test and the degree of significance. No gender influences and the amount of missing data at the time of registration were found on the probability of desertion of MOOC participants over time. The results indicated that the probability of increased MOOC defection is affected by: the number of questions in the evaluation for MOOCs of four to five weeks ($p < .01$); the educational level for courses of four to six weeks ($p < .01$); the age range for MOOCs between four and eight weeks ($p < .01$); and interest in the certificate regardless of the duration of the course ($p < .01$).

To know the predictors of risk and the effects of covariates on dropout we used the semiparametric Cox risk regression model. We included the covariates: gender, educational level, age range, interest in the certificate, number of questions and amount of missing data. As a moderating variable of time, the durations of MOOCs (from four to eleven weeks) were estimated and as a state variable: desertion. The cases available in the analysis were 29,846 and the censored data 1023, that is, those students who do not show the dropout in the course of the time determined for the study, but may manifest it in the future. The forward step regression method was selected: likelihood ratio to determine the framing of the model.

Three iterations were performed and the model fitted in the first step, finding that there were no changes with respect to the previous step to the next block. The omnibus test in step one indicates that all the variables are contributing significantly to the model $\chi^2(1, N = 29,846) = 823.14, p < .01$. The variable in the prediction equation of the attrition risk was the interest in the certificate, with a coefficient of $B = 3.11$ significant, $\chi^2_{\text{Wald}}(1, N = 29,846) = 353.13, p < .01$. This result indicates that the lack of interest in the certificate is a predictor of dropping out. The weighted average global Hazard ratio $\text{Exp}(B)$ was 22.55. This means that overall the dropout rate is 22.55 times higher in the group of students with no interest in the certificate than in those who were interested.

DISCUSSIONS AND CONCLUSION

MOOCs have revolutionized education, getting many students interested and optimizing the time and cost resources of both the bidders and the participants. However, the majority of MOOC abandonment rates remain high (86% to 93%) (Carey, 2012; Chang & Wei, 2015; Gütl et al., 2014). In this study, 15

different Colombian MOOCs were examined with 39,073 participants who presented a dropout between 89.5% and 99.9%, although part of this range belongs to those found in the literature reviewed, 60% of the MOOCs analyzed are found by above the upper limit of attrition of 93%, evidencing the importance of the analysis of desertion behavior and the variables that are related to abandonment.

The inferential findings associated with desertion also correspond to those reported in previous empirical works: gender (Adamopoulos, 2013), educational level (Adamopoulos, 2013), age (Gomez-Zermeño & Aleman de la Garza, 2016), discipline (Hone & El Said, 2016) and duration of the MOOC (Adamopoulos, 2013; Jordan, 2014). In this study we were able to use survival analysis to show that the highest probability of desertion occurs in the first week's development and that the highest probability of desertion risk is found in the first and last week of the MOOC as described in the investigations of Greene et al., (2015). In contrast to previous literature, we assessed MOOCs of a duration of up to 11 weeks.

This research makes a punctual contribution to the literature, estimating the predictive value of the final certificate in a MOOC. The global radio hazard indicates that the dropout rate is 22.55 times higher in groups of students who are not interested in the certificate. The results obtained on the interest in the certificate are consistent with those received by Adamopoulos (2013). The certificate acts as a motivator of achievement and increases enthusiasm, motivation and follow-up during the course, factors that had been reported by Armstrong (2012). This result broadens the horizon and implies that future investigations can be manipulated as a final or partial strategy that allows the student to feel the achievement of an achievement.

Future studies can estimate the effect of less effort at the beginning of the course and more at the end. The fact that students have to evaluate the possibilities to continue and then make a decision, can lead to overvalue the reinforcements of the future. The decision of the participants may be affected by cognitive biases or distortions of reality that prevent measuring the risk or estimate the benefits that will be achieved with the knowledge presented in the course. The results found on the effect of the number of questions, could be studied through the Pea-nut Effect, (Loewenstein, Leslie & Volpp, 2010), underestimate the results with small numbers, either of profit or loss (e.g. a student who invests little time to answer a test with few questions, will reassess the decision to continue or defect a MOOC based on the cost-benefit of their efforts). Likewise, underestimation of deferred consequences is included within this bias; allowing to see only the current benefits and not the consequences in the future; (e.g. a student who passes an exam with few questions will underestimate the gradual effect of the questions and the consequences in the future because they do not know the totality of the contents they should face).

There are multiple variables related to the desertion that in some way show the interest or motivation of the student. In particular, the relationship found between the amount of missing data at the time of registration and attrition the more missing data, the higher the probability of desertion can be very useful, since it allows designing strategies for retention. This finding supplements the relationship found by Gütl et al., 2014. On the other hand, the results could reflect the percentages of probability and risk of desertion depending on the duration of the MOOC, regard this observation as an advance to the investigations of Adamopoulos (2013).) and Jordan (2014) on the associations between high dropout rates according to the increase in the duration of the course and that they had recommended in Greene et al., (2015).

The results of the survival studies are consistent with the findings of Ferschke et al., (2015) regarding the influence of the evaluations on the probability of dropping out. An interesting aspect found in this research was discovering that the number of questions asked in each evaluation is an influence on the percentage of survival when the courses are only between four and five weeks long. On the other hand, age is related to attrition, being a predictor of its increase with greater risk in MOOCs from one to six weeks. In the same way, at a higher educational level, there is a greater risk of dropping out in courses of up to eight weeks duration. However, the predictor of the probability of survival that is independent of the duration of the MOOC is the interest in the certificate, a relationship that had been studied by Adamopoulos (2013), Gütl et al. (2014) and Hone & El Said (2016). The Cox regression analysis revealed that the highest risk of dropping out is found in participants who were not interested in the certificate and that the retention rate for this group after the first week is less than 20%.

LIMITATIONS OF STUDY

The findings of this study are limited to the fact that students took the courses in different periods of the year, some within the academic calendar and others in holiday seasons. Changes in seasons may have caused changes in the motivation for enrollment, discipline in the development of the course and interest in the certificate. Based on the findings obtained in this study, there are elements that can help reduce the behavior of desertion. It is suggested for future research, how to improve the registration process and customize retention strategies. It is also recommended to identify the influence on the risk of desertion of the number of questions in the evaluations and their distribution during the weeks that the MOOC lasts.

Given the growing consumption of MOOCs and the demand of the offering institutions, it is important to continue with the commitment to delve into the most important disadvantage of this kind of courses, which is desertion. The present research suggests the development of pedagogical strategies aimed at reducing the dropout during the first and last week, knowing the profile of the students who have a higher probability of retention from the moment of registration and following closely the group of participants who they are not interested in the final certificate. We believe that MOOCs can increase their success if: the needs of students environment, time management and particular students interest are better understood. We suggest that participation stimuli such as price discounts based on performance might help to reduce the risk of dropout

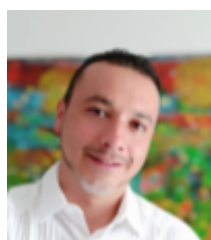
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