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Modeling the Spanish Bachillerato academic underachievement using a random network

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Abstract. In this paper, we propose a random network to model the evolution of the academic performance focused on the educational level of *Bachillerato* in Spain. For that, we will build a random network. Once the random network is stated, it will evolve according to a set of evolution rules and this allows us to simulate the academic behavior of *Bachillerato* students in order to determine whether they promote or not to the next academic level. Finally, this simulation process will allow us to provide predictions given by 95% of confidence intervals of the *Bachillerato* academic results over the next few years. Our predictions provide good results since, for each academic subpopulation, the new real data appeared during the development of this study corresponding to the academic year $2009-2010$ lie inside the confidence intervals.

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1. Introduction

In this paper, we propose a random network to model the evolution of the academic performance focused on the educational level of *Bachillerato* in Spain. To be more precise, we simulate the academic evolution of *Bachillerato* students in an average high school in terms of number of students at this educational level throughout the Spanish territory [1]. These students are classified by gender (Girl (G) or Boy (B)), academic level (First (1) or Second (2) Stage of *Bachillerato*) and if they are in conditions to promote (P) or do not promote (NP) to the next level according to the educational law in force [2].

The paper is organized as follows. In Section 2. we show how the random network model is built and the conclusions can be seen in Section 3.

2. The random network model

The available data considered to build the network correspond to the academic results belonging to the students of the First and Second Stage of *Bachillerato* during the academic years from $1999-2000$ to $2008-2009$, in both, state and private high schools all over Spain [3].

We will build a random network in which, in addition to consider autonomous behavior of students, we assume that academic underachievement is a socially transmitted behavior [4, 5]. These social contacts have an influence on the probability of transmission of good or bad study habits. To build the random network, we consider a set of nodes and edges of the graph, which represent the students and the friendly relations among them, respectively. In this graph, it is considered, both the interactions (edges) among students in the same academic level and the interactions among students in the different academic level. These interactions (edges) are assigned randomly considering more likely the friendly relations among students in the same academic level [6].

The evolution of the random network, in each Spanish academic year, is made up of 45 weeks and the model time step is 1 week. The threshold of change of state of each student will depend on the assignment of a randomly probability (number between 0 and 1) over the values of the different parameters stated in the model (contacts in the same level, contacts in different levels, negative autonomous decision, negative habits transmission, positive autonomous decision, positive habits transmission, passing level and graduation, abandon, access). If the selected value is lower than the value of the corresponding parameter, the student's change of state occurs and the corresponding node label will be updated.

Once the network is stated, it will evolve according to the evolution rules

and this allows us to simulate the academic behavior of *Bachillerato* students in order to determine whether they are in conditions to promote (P) or not (NP) to the next level.

Finally, this simulation process will allow us to provide predictions given by 95% of confidence intervals of the *Bachillerato* academic results over the next few years as can be seen in Figure 1.

Moreover and as a validation of the model, during the development of this study, new academic results have been published, in particular, the academic results of students of *Bachillerato* in the academic year $2009-2010$, data that could not be used initially to fit the model because they were not available at that time. These new data allow us to compare the obtained predictions from our model with the new real data (black square in the graphs in Figure 1. To point out that our predictions provide good results since, for each academic subpopulation, the real data lie inside the confidence intervals (see Figure 1).

3. Results and Conclusions

In this paper we propose a random network model to study the students' academic performance in high school in Spain, taking into account gender, stages and academic results. The main idea behind our approach is to consider that academic performance depends on both student own study and their classmates' habits.

We fit the random network model to the available data from de Spanish Ministry of Education corresponding to the academic years $t = 1999-2000, \ldots, 2008-2009$.

The obtained predictions can be seen in Figure 1. These results tell us that there is a slight decreasing of the number of students in the non–promotable groups and who leave the high school, and it seems to reach a stationary situation. Moreover, the proposed model improves the results because of the new available real data corresponding to the academic year $2009-2010$ lie entirely inside the 95% confidence intervals presented compared with previous published articles [7], in which our previous predictions do not collect the total of the available real data.

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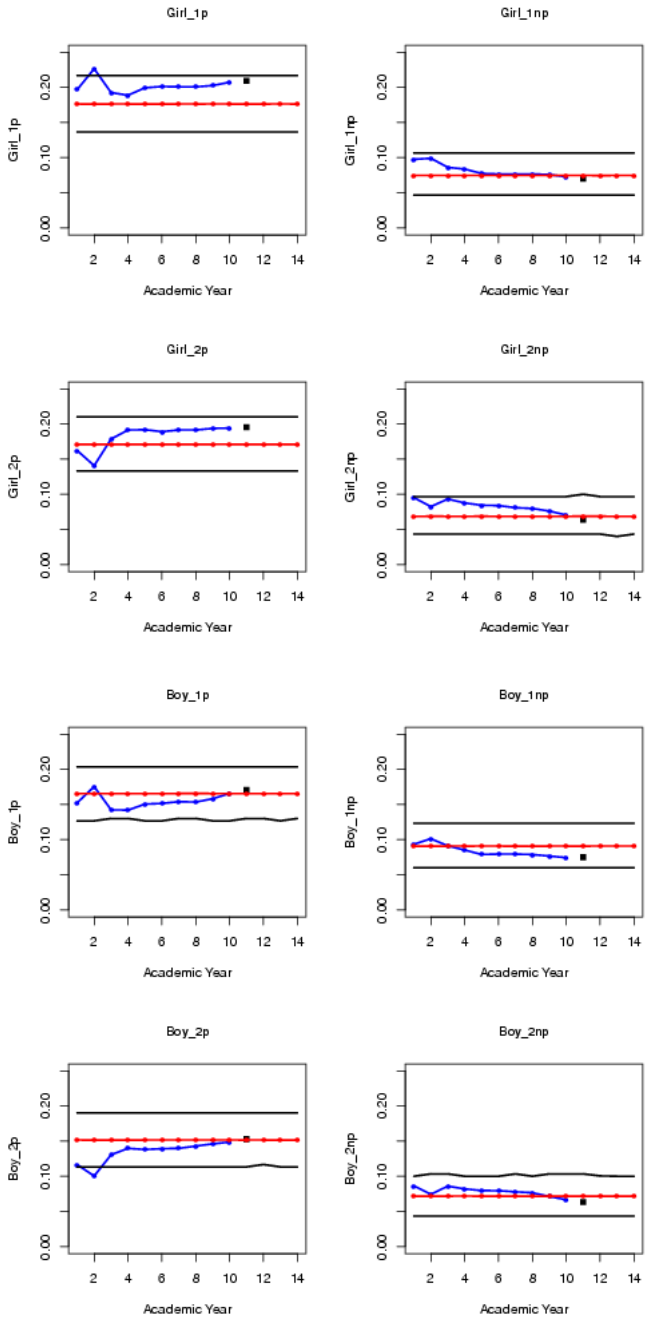

Figure 1: Fitting and prediction of the Spanish *Bachillerato* students academic results over the academic years $t = 2009 - 2010, \ldots, 2012 - 2013$. The blue lines are the real data, the red lines are the mean values and the black lines determine the 95% confidence intervals for each time instant. The fitting and predictions have been obtained. The black square represents the real data corresponding to the academic year 2009-2010.