

Students' networks influence on academic performance: An exploratory study

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Abstract – Social networks can have a significant influence on students' academic performance. This exploratory study details a study performed at a Portuguese university to assess the role of social networks in the students' academic performance. We used an online questionnaire to collect. From the variety of network centrality measures considered, findings suggest that students with high centrality positions within the friendship network tend to present lower academic performance, except for eigenvector centrality (i.e., being connected to students who are themselves well connected). On advice and working group networks, there was minimal evidence of the relation between key positions and grades. Although there was not an overall homophily towards grades – neither through selection nor influence mechanisms – students with lower academic achievement tended to establish friendship ties between themselves.

Keywords - Social Network Analysis; Student Academic Performance; Selection effect; Centrality measures

I. INTRODUCTION

Peers play a major role on a student's academic life. They can provide resources, knowledge, and support, encouraging to take a certain path and to make decisions that may influence academic success. Homophily, the tendency for individuals to connect with peers that share similar characteristics, or attributes [1], plays an important role in determining how individuals establish social relationships. In that sense, homophily can also be related with other less tangible characteristics such as student academic performance (SAP).

Homophily embodies two effects: selection, and influence. Selection effect happens when students tend to develop connections with peers with similar levels of performance, that is, the tendency of individuals to form ties with the ones that share a similar prior academic performance from a period they did not know each other. Influence effect, on the other hand, is observed when a group of peers tend to assimilate each other's level of academic performance, visible by the end of a certain period since the relationship formation. Therefore, when a group of students have identical academic achievements, it might be a result of the selection process or peers influence effect or both. These effects can coexist within the same group of students, where usually the selection process comes prior to the influence effect [2]. However, it seemed difficult for researchers to isolate the

selection and influence mechanisms from one another, which led the majority to focus on either one of them or finding inconclusive results on this matter [3].

Previous research has largely focused on studying a single type of network (friendship, roommates, classmates), missing one crucial point which is the evaluation of different types of relationships within the same group of students. That is, since selection or influence mechanisms can occur in both intimate relationships and less intimate (professional). Despite the fact most researchers indicate that there is a positive correlation between centrality and SAP [4], [5], others found no relationship or even opposite results [6], [7]. In fact, by even evaluating distinct types of ties – e.g., friendship versus study links - within the same group of students, it can almost certainly produce disparate outcomes.

This study performs a Social Network Analysis (SNA) to investigate how social networks of first- and second-year undergrad students in a Portuguese University (including third year students that still take at least one curricular unit in first or second year). We examine the link between students' performance and their peers' performance by considering the selection and influence effects individually. Our research, despite existing limitations in the sample size, contributes to the body of knowledge by identifying the impact of the distinct students' social relations on their academic performance.

II. BACKGROUND AND DATA

Social networks are a powerful framework to examine social relationships between individuals, such as friendship, professional, or interest, in a population. In our case, nodes represent students and edges represent reported relationships between the students. We combine measures of density, reciprocity and transitivity as indicators used to characterize the social network. These metrics, however, are not taken into consideration by most researchers. Nonetheless, evidence suggests that social network density is positively correlated with academic performance [8].

- Density captures the ratio between the number of links on the network and the total possible number of links the network can accommodate. The higher

the density score, the denser a network is and the greater the degree of connectedness. Denser networks are usually found in small and stable communities composed by strong relationships and higher levels of social cohesion, which translates in greater information flow within the networks [9].

- Reciprocity measures the extent to which network relationships are reciprocal or mutual. One example is student A mentions student B as a friend and B mentions A, the result is a reciprocal relationship. Mutual relations are known to be more reliable and stable, which translates in stronger network ties [10]. High levels of reciprocity are usually found on friendship networks with more than half of ties being reciprocal [11].
- Transitivity, in turn, refers to the tendency of forming groups within networks. It is an indicator of the presence of tightly connected clusters. It looks to the number of closed triplets and compares to the maximum number of closed triplets the network could form. Previous studies found a strong propensity for friends to create cohesive subgroups; however, when reciprocity is present, this measure loses significance [11] [12].

III. CONTEXT AND DATA COLLECTION

A. Context description

The study focus are undergrad students from the 2019 and 2020 cohorts and that are attending the 1st and 2nd academic years at a Portuguese public university, including students of 3rd year that are repeating subjects from 1st and 2nd years. The academic year consists of two semesters of six months each. When having presential classes, students easily engage in and out of the classroom, spending a lot of time together interacting and exchanging information and knowledge. Relationships are usually formed not only because of personal interests but also because of being exposed to or gaining access to students, which means that taking classes on campus serves as a catalyst for this phenomenon. But when considering the pandemic context, it became harder to establish connections, even with students from the same classes.

B. Data Collection and Social Networks

Data was collected between May 2021 and July 2021 through an online survey. To comply with privacy policies and regulations, it was ensured collected data would be processed in order to not allow back-tracing of subjects' identities. Hence, the final working dataset contains a set of Tokens (one per student), and a set of pairs of Tokens (which identify the relationships between students). The study assesses social relationships of different nature to clarify the role played by each as a conduit for social influence and academic performance. Accordingly, four relationship types

were considered: friendship, study buddy out, study buddy in, working group.

Data collection was done through the following questions:

- Friendship: Please indicate the classmates you consider to be friends with (For example, classmates with whom do you go out, you like to spend your free time with, have lunch together, have personal or informal conversations).
- Study buddy out: Please indicate the classmates that you typically turn for help or that provided you with school-related information (classmates who have aided or guided related to study matters).
- Study buddy in: Please indicate the classmates that typically turn to you for help or that you provided with school-related information (classmates who you have aided or guided related to study matters).
- Working group: Please indicate the classmates with whom you most often participate in working groups in the context of curricular activities.

Participants were asked to nominate up to 5 peers from the same academic year in each question. Names of peers are selected from an autocomplete list in the questionnaire.

Friendship and working group networks are treated as undirected networks, while study buddy networks as directed. In undirected networks it takes only one individual to mention the other for the relation to be considered reciprocal. In contrast, for a connection to be considered mutual in a directed network it is necessary for both individuals involved to mention each other [13].

C. E-I homophily index

We evaluate the student's differences in terms of number of links, density, reciprocity, and transitivity and homophily. The homophily analysis uses the External-Internal (E-I) homophily index, which is a relative rate that measures in- and out- group preferences. It considers the number of ties external to the group minus the number of internal ties divided by the total number of ties. Calculation of the E-I homophily index is as follows:

$$E - I = \frac{\text{External} - \text{Internal}}{\text{External} + \text{Internal}}$$

Results on this measure vary from -1 to 1, representing complete homophily – all the alters are of the same group as the ego – and complete heterophily – all the individual's relationships are from a different group –, respectively.

IV. RESULTS AND DISCUSSION

A. Descriptive Analysis of demographics and grades

In total, 48 students completed the questionnaire properly. Table 1 considers participants that filled the questionnaire and all students mentioned in the questionnaire by those 48

students. From the 48 valid responses, 29 were female and 18 were male with a mean age of 19,79 years and a standard deviation of 0,97. In terms of their parents' education level, 39,6% of fathers and 68,8% of mothers have a higher education level, and 29,2% of fathers and 12,5% of mothers have a High School degree. Highly correlated independent variables will be excluded from the models in order to reduce multicollinearity and also because there is no need to select two variables that provide the same information to the models, therefore not enhancing them.

TABLE 1. FRIENDSHIP, STUDY BUDDY IN, STUDY BUDDY OUT AND WORKING GROUP NETWORKS DESCRIPTIVE STATISTICS.

Network type	Friendship	Study Buddy In	Study Buddy Out	Working Group
Number of students	151	149	135	154
Number of links among students	340	154	157	300
Density	0,015	0,007	0,009	0,013
Reciprocity	1	0,065	0,076	1
Transitivity	0,097	0,217	0,284	0,085

B. Social Network Analysis

Density levels are considerably lower than expected for all networks when compared to the results obtained in previous studies [10], [14]. Nonetheless, density is slightly higher for friendship (1,5%) and working group (1,3%). It may be inferred that students develop more friendship than assistance relationships, which confirms the initial assumption of students having a more rigorous criterion in selecting individuals for study matters, and therefore the links will be more restrictive but highly specialized and strategic. For group projects, students must form groups with a specific size – usually between three to five students, depending on the project –, otherwise they will be subjected to grade penalties. In addition, some groups are randomly formed by professors while others are students who choose the classmates they want to work with. As a result, it is expected a higher number of connections because it translates the courses requirements.

Regarding reciprocity, it is a quantitative measure that evaluates the number of links that are reciprocal within the network. Reciprocity is expected to be 1 in undirected networks because the links are all mutual, which is the case of friendship and working group networks. Although, the information provided by this metric is not very relevant for this type of network, when considering directed networks, it gives a sense of how stable and reliable the connections are. Results show low reciprocity levels in both study buddy in network (6,5%) and study buddy out network (7,6%), which means that a small percentage of connections are mutual. Research on advice networks have found reciprocity values of 24% [12], [15], whereas other researchers have found a reciprocity index even higher (42%) [10], indicating a significant divergence from the findings in the field.

Transitivity, which measures the tendency of nodes to befriend nodes of its nodes' connections, it presents higher results in the study buddy out network (28,4%), followed by study buddy in network (21,7%) and then friendship network (9,7%) and working group network (8,5%). The findings are surprising, because this phenomenon is more prominent in friendship networks with friends forming ties with their friends' friends [15]. The opposite is observed with the students from our sample. This finding suggests that students tend to form groups of study, even though their connections might be unidirectional. Figure 1 represents the four social networks obtained (friendship, working group, study buddy in, study buddy out).

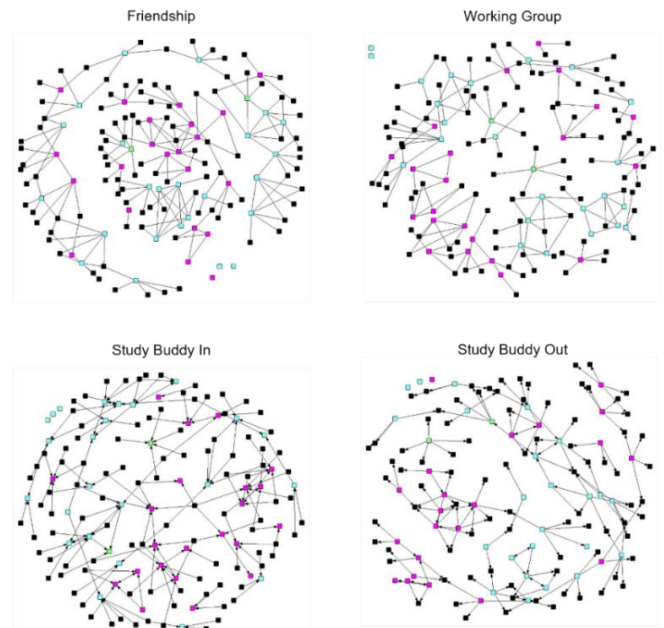


Figure 1. Friendship, Study Buddy In, Study Buddy Out and Working Group networks. Node color: bachelor year (1st year – pink, 2nd year – blue, 3rd year – green, unknown – black).

C. Centrality measures and academic performance

One of the main questions concerns the relationship between centrality measures and SAP. The friendship network shows an average of 4 direct connections per node, which is the highest from all social networks followed by the working group network with 3,5 connections. Both the study buddy in and study buddy out network present lower average levels of in degree and out degree, being in accordance with previous research on advice networks, where greater exclusivity was found in the formation of these ties [2]. Interestingly, closeness levels are, in average, smaller in the friendship network, which translates as being the most efficient to spread information through the entire network. To test the influence of a student's position within the distinct networks and its academic performance, we used linear regression (See Table 2).

TABLE 2. RESULTS OF REGRESSION ANALYSIS TESTING THE ASSOCIATION BETWEEN CENTRALITY MEASURES (INDEPENDENT VARIABLES) WITH STUDENT'S AVERAGE GRADE AND EXPECTED GRADES IN SEXTILES

Network type	Centrality measure	Student's average grade in sextiles			
		F (1,46)	R ²	β	Sig.
Friendship	Degree	0,024	0,001	-0,023	0,879
	Closeness	1,031	0,022	-0,148	0,315
	Betweenness	1,915	0,04	-0,2	0,030
	Eigenvector	4,569	0,09	0,301	0,038
Study Buddy In	In Degree	0,285	0,006	0,078	0,596
	Out Degree	0,011	0	0,015	0,917
	Closeness	1,383	0,029	0,171	0,246
	Betweenness	0,073	0,002	0,04	0,788
	Eigenvector	0,003	0	-0,008	0,959
Study Buddy Out	In Degree	3,067	0,063	0,25	0,047
	Out Degree	1,273	0,027	-0,164	0,265
	Closeness	2,329	0,048	0,22	0,134
	Betweenness	0,03	0,001	-0,025	0,864
	Eigenvector	0,57	0,012	-0,111	0,454
Working Group	Degree	0,298	0,006	0,08	0,588
	Closeness	0,601	0,013	-0,114	0,442
	Betweenness	1,581	0,033	-0,182	0,215
	Eigenvector	1,946	0,041	0,201	0,017

Note: β = beta coefficients. R²= coefficient of determination. F = F-statistic

As shown in Table 2, there is no significant association between degree centrality and closeness centrality and average grade on the friendship network. However, the results show significant associations between eigenvector and betweenness centralities and average grade. For each 1 increase in betweenness centrality there is a 0,0215 decrease in sextile average grade, and it explains about 4% of variance on the dependent variable, which is a small percentage. These findings suggests that students on brokerage positions on the friendship network have lower academic achievement; however, being connected to students who are themselves well connected is beneficial for obtaining higher grades and it is in accordance with prior research [5], [16].

All centrality measures obtained from the study buddy in network are not significant and have a close-to-zero effect size. None of the centrality measures referring to the study buddy out network is statistically significant, except for in degree centrality, which is statistically significant, and it explains 6,3% of variance. This finding suggests that students who are asked a lot for help on study matters present better academic performance. This results is aligned with other studies that found that being more central in the peer network for advice is correlated to higher academic performance [5]. Taking central positions in the advice network from more theoretical courses is usually associated with better academic performance, because these students are capable of getting more information, knowledge and access to resources [6], [17]. However, the same position in practical courses is

detrimental of academic achievement considering the extra effort it must be put on the establishment and maintenance of relations, which implies a higher consumption of resources that are critical for projects' development and the creative process, therefore resulting in poorer grades [14].

Regarding the working group network, only one centrality measure is statistically significant, eigenvector. Being part of a working group where peers are also members of other well-connected working groups is advantageous for achieving better academic results. A possible explanation for this event lies in the fact that peers manage to obtain relevant information from other groups and bring this knowledge to the student, and the latter indirectly manages to have access to different resources that otherwise would not be able to, thus improving its academic performance.

D. Selection and influence mechanisms

Table 3 shows the E-I Index for every grade measure and for each of the four social networks considered in the research.

TABLE 3. ANALYSIS OF HOMOPHILY TOWARDS GRADES THROUGH EXTERNAL-INTERNAL INDEX

Network type	Grade (in sextile)	E-I Index
Friendship	GPA	0,571
	Entry Grade	0,500
	Average Grade	0,500
	Expected Grade	0,429
Study Buddy In	GPA	0,583
	Entry Grade	0,750
	Average Grade	0,833
	Expected Grade	0,583
Study Buddy Out	GPA	0,6
	Entry Grade	0,6
	Average Grade	0,533
	Expected Grade	0,533
Working Group	GPA	0,500
	Entry Grade	0,600
	Average Grade	0,100
	Expected Grade	0,800

Regarding the selection mechanism, results from analysis show a substantial and positive E-I Index for friendship relations in both High School GPA and entry grade, which translates in heterophily amongst ties. The findings contrast from those of earlier studies, who were able to prove a tendency towards forming friendships with peers sharing the same levels of prior academic performance [2], [5], [18], [19]. However, these results are in line with those obtained by Dokuka et al. (2020) who found no evidence of a student preference to develop friendships with other similar students in terms of academic achievements.

Results concerning the influence process, suggest there is a slight decrease in the values obtained for the E-I Index (0,5

for average grade and 0,429 for expected grade) when compared to those obtained for analysing the selection effect. However, these remain positive, indicating heterogeneity of connections. Once again, this conclusion contradicts findings from a large body of prior research in this field, in which there was a clear tendency of students to assimilate the academic performance of their friends [12], [15], [20] and that this mechanism succeeds the selection process [2]. According to [12], friends with lower academic performance will provide a downward pull and thus the student will end up being harmed and exhibit a decrease in grades over time. When looking at this sample, it appears that this is likewise the case.

V. DISCUSSION

The first point dealt with the associations between multiple indicators of social network centrality of the four social networks (degree, closeness, betweenness and eigenvector) and students' academic performance. The key positions-grades association exhibited significant variations depending on the type of relation being considered. Curiously, no significant relationship was observed in the study buddy in network. In this case, it is thought that the small number of participants contributed to the results being less significant. When considering the study buddy out network, only two key positions were found to be significant: (i) Students who are asked a lot for help on study matters present better academic performance. (ii) Student that identifies numerous peers as sources of study aid or counsel is more likely to receive poorer grades. Regarding the working group network, it was verified that holding a brokerage position is detrimental to academic performance when considering expected grade, which means that having the power to control the flow of information works against them in terms of academic performance. In turn, being connected to students who are highly connected themselves is beneficial to academic performance. The friendship network, on the other hand, revealed that having too many direct connections is detrimental of academic performance. Likewise, taking brokerage positions in this network is also harmful of academic achievement. These results are consistent with previous research, which considered friendships as an academic liability since they may easily divert students' attention away from their studies [7]. On the other hand, being connect to friends who are themselves well connected has shown a positive impact on academic achievement.

Second, it was found that low-achieving students, or at least those in the lower sextiles, tend to form friendships with other low-performing peers. In addition, it was found clear evidence of low-achieving students' tendency to assimilate the performance of their low-achieving friends. It is crucial to note, however, that the current findings do not imply that students deliberately seek out friends who are academically like them. Nevertheless, we may infer that this choice may

contribute to the students' ongoing poor academic performance.

Third, there were more links than expected between students in the lowest sextile and the highest sextile in both advice networks. This result may mean that low-achieving students seek academic advice from high-achieving students and/or high-achieving students try to help low-performing students with study matters; however, these students continue to present considerably different academic performances, which indicates that advice networks do not serve as a channel for academic performance diffusion.

VI. CONCLUSIONS

Social interaction has been recognized as a conduct of knowledge, behaviours and exchange of information [21]–[23]. Four types of relationships were explored in a sample of 48 undergraduate students from a Portuguese public university, resulting in four unique social networks: friendship, study buddy in, study buddy out, and working group.

Despite the high number of nodes, density and reciprocity levels were low for all social networks. When considering transitivity, the results have been surprising, since the advice networks present higher values than the friendship network. The friendship network had the greatest density levels, supporting the idea that students readily develop friendship relationships and form more informal rather than strategic connections [14]. On the other hand, a substantial portion of the links showed to be reciprocal for the study buddy in and study buddy out networks, suggesting the establishment of stable ties and a sense of mutual support amongst peers. Transitivity levels were within expectations – around 34% for the friendship network –, which reflects a significant proclivity for an individual to befriend friends of its friends. The degree of overlap between the four networks – multiplexity – was also studied, and there was a tendency for students to develop various sorts of relationships with their classmates. Multidimensional relationships are long lasting and stronger than one-dimensional ones, due to the nodes' ability to interact in a variety of situations [4].

Even though the present exploratory research makes important contributions, the authors acknowledge two relevant limitations and suggestions for future research. First, the small sample size. Being questions of a relatively sensitive nature, it could hurt participants' susceptibility, leading them to leave the survey. In fact, it was noticed a high number of incomplete surveys from that point forward despite the assurance of data confidentiality, and those answers were immediately excluded. The lack of participants limited the measurement of pandemic situation impact on the development of social ties and its influence on academic performance. Future research should explore differences between pre and post pandemic students.

Second, a cross-sectional sample implies a static social network. In the future, it would be interesting to consider longitudinal data collection (for example, beginning of 1st semester, beginning of 2nd semester, ending of 2nd semester) to assess the evolution of the social networks along with SAP. Moreover, there was lack of information on existing relationship ties before entering the bachelor's degrees, which means some of the mentioned relations could already be formed during high school. Gathering this information would provide added value in terms of the relationships' depth.

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