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learning platform: A case study
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Keywords: Facebook, learning platforms, academic performance

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Facebook as an academic learning platform: A case study in Mathematics

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Abstract

The paper discusses the impact of the use of Facebook as a supporting learning platform for a course in Mathematics at the undergraduate level. After the examination of some critical issues of Facebook in a learning framework, we analyze data on the usage the page (total reach and number of engaged users) and the results of a survey taken by 217 students. Their appreciation for Facebook in such a context is stark and improvements of qualitative aspects of academic performance are perceived. Studying a subset of data tagged with ID information, we also investigate the quantitative performance (i.e., grades) in connection with the level of Facebook activity and usefulness. We find some evidence of positive correlation of grades and several variables. This is at odds with other studies, where active users experienced poorer performance when the use of Facebook is not related to academic work.

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1 Introduction

Facebook is the most popular social network in the world with more than 845 million active users, [Wikipedia, 2012]. Its presence pervades the life of users who interact with friends, exchange links and text messages, upload and share photos, enjoy games just to mention only a few of the typical online activities that can be pursued. Estimates in [Cauwels and Sornette, 2012] predict that the number of users may reach 1.1 billion in a few years. Such a phenomenon has obviously attracted a lot of attention and a vast body of literature, of particular interest for this study, is comprehensively reviewed in [Hew, 2011] as far as Facebook (FB) use by students and teachers is concerned. The

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analysis of FB in relation with education was so far mainly focused on the effects on the qualitative and quantitative outcomes of its usage. A few studies stress that more active users experience lower grades and poorer academic results that are mainly due to reduced time spent on studying and other curricular activities, [Kirschner and Karpinski, 2010] and [Junco, 2012]. It is also pointed out that multi-tasking, which may be frequent in the rapid-fire communications occurring in FB, is often a cause of substandard results, for a recent account see [Junco and Cotten, 2012].

Clearly, not all uses of FB are the same as far as academic performance is concerned, and while the previously mentioned results are expected when FB plays the role of attention- and time-killer, few studies have investigated the specific use of FB as a tool for learning. Despite the fact that faculty report regular use of social media and FB for professional non-class use, it is surprising that according to [Moran et al., 2011] only 3% use FB for reading assignments and 2% actually asked students to post.

This paper describes a pilot test in which we substantially use a FB page as the unique online platform to support students who were enrolled in a first year lecture-based course in Mathematics in a faculty of Economics. The social network, here, does not necessarily subtract time to the academic effort and can potentially offer advantages in boosting students' outcomes. In particular, the almost universal presence of students on FB (97% of the subjects analyzed in this paper were already registered users and similar high levels appear in other recent surveys, [Dahlstrom et al., 2011]) suggests that participation and engagement could be stimulated because of the popularity of the tool.

One paper that has an approach similar to ours is [Kabilan et al., 2010], where a FB environment for learning English is evaluated. Ease of communication, interaction and the building of a network of acquaintances can be useful assets to enhance linguistic competence and over 60% of the students agree (or strongly agree) on all items implying a positive evaluation of FB regarding improvements in language writing and reading skills, motivations and confidence.

[Bosch, 2009] is another insightful work that reviews early seminal research FB in a learning environment and discusses in more detail the case of students and lecturers at the university of Cape Town. The analysis of 200 profiles and interviews with 50 undergraduates and 5 lecturers suggests that formal and informal academic use of FB was welcomed by both groups: students claimed it was easier to find material and to get answers to logistic questions. Lecturers noticed that FB is a quick and easy way to reach the whole class and realized that shy students, which in particular would never ask a question in class, "on Facebook they say it boldly".

As it is often the case, however, these and other works do not investigate or have data on the quantitative outcomes (i.e., the grades) that resulted from the various experiments, but limit the analysis to a qualitative assessment of FB, which appears to be quite positive on the part of the students.

Our use of FB as a learning tool can be regarded in different ways. There may be specific issues related with the learning of mathematics and the conceptions students have on this subject, [Crawford et al., 1998]. The support offered on FB can fill gaps in knowledge in a timely manner along the course and avoid the feeling of fragmentation often sensed by

some students when studying math. Moreover, facilitated interaction with instructors and other peers should help in facing the required workload and relieve anxiety.

At some higher level of abstraction, the use of one social network in a learning context is “just” another instance of computer-mediated or information-technology enhanced course delivery. Such classes do provide immediate and practical advantages to some students, like part-time workers or the ones that have to resort to self-study for a variety of reasons. Residential students as well appreciate the use of Internet technologies that have a positive impact on engagement and on qualitative outcomes, [Chen et al., 2010].

We feel that the previous results cannot be immediately generalized to FB without further scrutiny for two main reasons: on the first hand, FB is different from common learning platforms like, say, Moodle. The kind of actions that are possible or typical on FB are somewhat more limited than what can be routinely done on other more nuanced online tools. Often, short posts or status updates are the main (or even unique) means to participate to FB threads and, while this can be of some value, it is far from clear whether the benefits outweighs these technical limitations. In the case of Mathematics, indeed, the extreme simplicity of the standard FB environment poses a challenge and casts doubts on its efficacy as a learning tool. On the other hand, the use of FB in learning frameworks vividly breaks the assumed “leisure-only” nature of this kind of social network that is cool, fun and not for actually doing work, [Lewis and West, 2009]. Demonstrating that FB can be used to support the academic work (or suggesting that it is potentially beneficial to students’ outcomes) can tickle the users and unleash a fresher involvement in the taught subjects. Along the same lines, [Mazer et al., 2007] has shown that, despite some reason for care, simply self-disclosing the teacher’s profile on FB can have positive impacts on the motivations of students and classroom climate. The same observation was made in [Duboff, 2005], at a time when Facebook was still referred as `thefacebook.com`.

We collected two kinds of information on the FB page, namely the traffic data provided by FB to administrators and the results of a questionnaire with 10 questions on FB, which was available clicking on a link on the page of the course. While traffic can be used to infer general success, activity or patterns of usage, the survey allows a more detailed focus on perceptions and motivations of students. Some of the answers will be related to the learning approach taken by the users (or a part thereof), whereas others offer the chance to tackle another subtle research question: can the use of FB quantitatively improve the outcome of students? In fact, some students voluntarily provided additional personal identifiers making possible to gather information on the grades they eventually received. This subset of data can then be used to directly link the answers with a relevant quantitative measure of performance.

The paper is organized as follows. Next Section gives details on the course and on the page, named “Matemates 2011”, that was setup to provide information and support to students. Section 3 discusses in some depth a few critical issues that arise when FB is employed as a learning platform and outlines drawbacks and advantages of such a choice. Some practical “tricks” are described and a brief comparison to other platforms is given.

The subsequent section is devoted to the analysis of the data and has three subsections that explore the traffic time series, the questionnaire data and the subset of records for

which grades are available, respectively. Subsection 4.1 describes the total reach of the page and the number of engaged users on FB. Subsection 4.2 presents survey data, showing the remarkable appreciation of students for the FB page and relating the usefulness score to two activity measures and to the perceived expected increment in the final grade. We try in Subsection 4.3 to understand how grades are affected by FB, testing if the mean grade is the same for different users' activity. The assumption can be rejected at 5.5% significance level and, hence, there is some ground to state that a more intense activity on FB is positively correlated with the obtained grade. The finding is backed up by a principal component analysis of the data, even though we are aware that proper causation cannot be proved at this stage.

Some perspective and discussion of the results is contained in Section 5 and, finally, Section 6 has some conclusive remarks.

2 The course and the page

The course “Mathematics” was taught to first-year undergraduates enrolled in the Economics degree on “Foreign commerce” of the Ca’ Foscari University in Venice, Italy. Learning activities took place from mid-September to mid-December 2011 in 30 two-hours meetings for two terms (3 per week), for a total of 30 lectures.

Typically, only 150 students could attend the course in the past, but in the academic year 2011-2012 a much larger number of applications was received and accepted. As a consequence, 370-380 students¹ attended the lectures putting some strain on the organization of the course because of initial limited availability of adequately spacious rooms. After the first week, all the remaining lessons were held in a 400-seats lecture theatre and, in the second term, the course was split and an additional instructor took care of roughly half of the attending students in a nearby venue.

There were two basic motivations to setup a Facebook page for the course, named “Matemates 2011”, M2011 from now on.² Firstly, it was an attempt to offer a quick and effective way to provide information about practical aspects of the course (that was considerably crowded in the first week), including time-table information and timely notification of the lecture room that was to be used. The page was then used to advise students facing organizational and administrative issues even after the first, quite critical, week.

Secondly, taking inspiration from [Gabriel, 2011], the page was meant to offer students an alternative communication channel with the instructors and to get technical support related to the taught subject. In fact, mathematics is often perceived as a difficult topic in an Economics degree that is open to a variety of students with diverse background and quantitative skills. The course covered calculus, functions of one and two variables, linear

¹On the top of 300 freshmen, there were roughly 80 senior students that had to retake the exam, because of poor performance in the previous years or other reasons.

²The name blends *matematica*, the Italian word for “mathematics”, and *COMES*, the acronym of the degree “COMmercio EStero”, i.e., foreign commerce. The result is also an across-language pun: mate of math.

algebra and rudiments of financial discounting. The syllabus was made available on the page with weekly updates, together with selected exercises, mock exams and several sets of background problems to test whether students were proficient in some basic tasks (involving exponentials, logarithms, inequalities and the ability to draw lines and parabolas). Moreover, as direct interaction in a class with nearly 400 students can be limited and asking a simple question can require some braveness, M2011 was an auxiliary opportunity to ask clarifications, advice and help on the problems given in the textbook.

Facebook users can open and take the administrator responsibility of “groups” as well as “pages”. In the former case, users willing to see and contribute to the discussion must ask for permission to the administrator who has the right to deny it. If, instead, a “page” is selected all internet users can read the material and any Facebook user can post or comment existing threads. The administrator has in both cases the power to delete offensive or otherwise inappropriate contributions but this feature was very rarely used only to correct material errors. The main motivation to prefer a page to a group was that no sign-up is needed, allowing students more freedom to take both a passive (read-only) or active (read-and-write) position.

Students had the chance to pass the exam in two ways: solving two written midterms (on the first and second half of the program, respectively) or by means of a unique written final. The two midterms were scheduled on November 3rd and December 21st 2011. Two separate finals were held on January 9th and 23rd 2012.

An article³ on M2011 appeared on the blog of a marketing firm owned by a university alumnus on December 7th. The story was then echoed in the university web site on the 22nd and finally attracted some online and press coverage on and after December 28th. On the 29th, there was a piece about M2011 on the local pages of “Corriere della Sera”, the most popular national newspaper in Italy, [D’Este, 2011].

Because of the various reports, the number of “likes” increased from about 400 to over 500 in the first two weeks of January and, clearly, a lot of non-students “liked” the page. Therefore, we will stop the statistical analysis of the traffic on M2011 at December 27th to avoid effects presumably driven by the media exposure.

3 Facebook as a learning platform

The use of FB page to support learning has clear drawbacks and advantages. Most of the subsequent discussion is subject independent and is relevant for any discipline but there are issues that can be more specifically related to mathematics. The standard FB users’ interface was and is often subject to modifications (sometimes suddenly and with no notice) and it’s possible to alter the visual layout considerably using apps but this opportunities require computer proficiency that is not for everyone. Hence, we stick to the most basic default interface that is commonly experienced by the average user. We try to order the subsequent issues according to their perceived degree of importance and will sometimes

³See <http://whatthetribes.com/una-tribu-alluniversita/>, in Italian.

make comparisons with the possibilities that would have been offered by Moodle, a very well-known learning platform that may be familiar to most readers.

3.1 Drawbacks

1. *Some media files cannot be uploaded on Facebook and, in particular, pdf files are banned.* This is just painful. Indeed, pdfs are extremely common and are universally used to conveniently display and print written texts, slides and pictorial material. Virtually all electronic books, handouts and exercises related to mathematics are produced in ways that easily deliver a pdf file with professional notation and appearance. Other convenient formats, like doc or rtf files produced by word processors, cannot be uploaded as well.

At least two methods to circumvent this shortcoming are available. Files can be converted to jpg pictures or similar graphical formats and then posted pretending that they are images. The process can be time-consuming and frustrating when many pages are to be handled. Alternatively, a link to a pdf may be easily given in a post so that interested users can download the file from a different server. Needless to say, this solution requires the uploader to deposit the file elsewhere by ftp or other methods before the link can be used. This was by far the most frequent choice for the many pdf files that were published on M2011 during the course.

By contrast, Moodle easily allows for the upload of pdfs and, really, of any other kind of files.

2. *Fresh posts and information rapidly sink and are no longer visible.* New contributions may very quickly “disappear” from the top portion of the page as soon as other messages arrive. If the interaction is intense, this can happen in a very short time and, moreover, scrolling to the end of the page may not reveal all the posts unless “Older posts” is clicked, often again and again. The problems in retrieving valuable information is exacerbated by the lack of a search box⁴ that may help at least when some key words of the text or the author is known (often, taking the part of a student, posts by the instructor are looked for.)

In the case of M2011, posts were in the hundreds and some of them were needed by students weeks after they have been published (think, say, to critical files like the syllabus or simulations of the actual exam). The recent introduction of the “Timeline” feature may provide some effective way to surf back in time, though this can still be hard in an ocean of past posts.

One powerful, but *ad hoc*, fix for this problem is to tamper with the photo uploads. In fact, Facebook creates an icon if a picture is uploaded and the last icons usually appears in the top part of the page, called “photo strip”, see Figure 1. Clicking on one of the icons will show the selected image that can be augmented with comments

⁴By contrast, searches can be performed in a “group” page.

Figure 1: Visual layout of M2011. The “photo strip” is the horizontal bar collecting 5 images in the top portion of the page.

to form an index of relevant posts and links. With this methods, the photo strip can be used to host quick pointers to well-organized lists that can be effectively used for navigation purposes.

Other platforms, like Moodle, content managements systems and blogging tools simply allow for enhanced display of relevant material and most often posts can be browsed and searched much more smoothly.

3. *Users may fail to recognize that only some posts are shown.* At login, a page is usually displayed in “Top Posts” mode, meaning that only important posts are shown. In the case of M2011, they were almost invariably only the ones entered by the administrator. Some users may fail to notice this fact, thus seeing only some of the content and students could not see questions asked by other students when they were not classified as “Top”. The result was that a few identical inquiries were posted several times to get more and more rushed answers by other users who were aware that the question/answer had already been addressed. A way to see all posts is to click on “Everyone (Most recent)” on the right of the horizontal bar at the beginning of the page. Despite its simplicity, this was not routinely done by many users that often ended up in looking at a limited set of posts.

Facebook by default displays only two comments for every post, even though the discussion may include dozens of contributions. Again, there is a way to disclose the whole list of comments but this must be explicitly “asked” by clicking on “View all comments” on the top part of the light blue box that contains comments.

Finally, a brief comment on the possibility to read the page for non-registered users.

Pages should naturally allow such users to read the material (without the right to post) but typically, after some time or while scrolling, the page is blanked at some stage and login is solicited through a pop-up “Not Logged In. Please log in to continue”. As there is a unique button “Log in”, the user feels some pressure and must be prepared to open another window quite often to continue his session if he is determined not to give up and register.

4. *Writing technical material or formulas is hard.* If mathematical formulas are to be displayed without the recourse to externally linked pdf files, then an ascii representation must be used. This is possible as it is exactly what’s routinely done when writing code in any programming language. However, complex formulas require, for example, many nested parenthesis and may be hard to grasp immediately, especially if the standard precedence rules among mathematical operators are not well-known. Some agreed notation is needed to deal with more complex objects: integrals, say, can be denoted by `int` so that $\int \frac{x}{2(x-1)} dx$ is written as `int(x/(2x-1))` or `int x/(2x-1)`. In any case, students may need some time and practice to correctly understand the meaning of the formulas and avoid mistakes or ambiguities, like in `int(x/2x-1)`.

3.2 Advantages

1. *Simplicity of the interface.* Very few things are most often done by the vast majority of FB users. The interface immediately spurs the user to enter text in the “Status update” cell, that has the prompt “Write something. . .”. If a link or a photo are to be uploaded, a simple click allows to add the media material to the text. Pressing “Share” ends the procedure that is perceived as more straightforward and direct than the ones found in more nuanced platforms, where say forums, wikis, and other sections are available and/or can be browsed. While these possibilities offer a much bigger variety, users can be intimidated and feel the lack of proper training or knowledge to use all the features. Furthermore, FB was often used and already well-known to most of the users, who thought it was a familiar tool.
2. *Pushed content.* It turns out that a considerable number of students replied or reacted to posts right away because the updates or contents were pushed to their mobile devices. As far as we know, Moodle or other learning platforms do not feature yet push technologies, that may call for additional costs to be implemented in some “home-made” academic environments. We would like to stress that the practicability of rapid-fire questions/answers is not at all essential in many sound learning frameworks but, anyway, many students appeared to be thrilled by this possibility and reacted swiftly to changes in the page.
3. *Easy feedback system.* Facebook users can easily insert comments or remarks, clicking on the appropriate gray link below any content. They can also famously express their appreciation by clicking on “Like”. This communication method is quick and powerful, despite being somewhat crude and oversimplified with respect to more

developed feedback strategies and methods, [Duijnhouwer et al., 2012]. “Likes” can convey several senses that are almost effortlessly grasped from the context. Indeed, they can mean “I have the same problem/question”, if attached to an open inquiry, or “Thank you” after a reply. Administrators or instructors, moreover, can signal their positive assessment of correct content posted by students for other students. In this case, the “Like” is both a reward for the poster and a confirmation that the content is reliable.

4 The data

We collected two sets of data on M2011. First, Facebook provides administrators with data regarding the traffic on the page, aggregating data at the daily, weekly and monthly level. Time series data record, among other things, new users, how many “likes” were assigned, the total reach (the number of unique users who have seen any content associated with the page) and the engaged users (the number of unique users who engaged with the page, clicking or creating a story). We will mainly concentrate on the daily versions of the last two measures that reasonably proxy the number of passive and active users on the page.

Data at the post level can be downloaded as well and, in this case, several statistics relative to each entry are available. Figures can be used to gauge the reach of a single post but this is less relevant to this work and, hence, post level data will not be used.

As a second source of data, we collected 217 questionnaires using a form that could be filled following a link on M2011 from December 13th 2011 to January 4th 2012. Students were asked specific questions about their use and perception of the page, together with optional identification tags. Tables 3 and 4, in Appendix A, show the wording of the questions and the choices at students’ disposal. The whole statistical analysis was performed using R, [R Development Core Team, 2011].

The next three subsections will be devoted to the analysis of the data, starting from the time series of accesses. Subsection 4.2 discusses the answers to the questionnaires and 4.3 attempts to put under the spotlight the subset of students that reported their identity. The final performance of such students is known in this case and we try, in particular, to check whether the perceptions of the students regarding the effect of the page on the grade can be empirically verified.

4.1 Time series FB data

Figure 2 displays the daily total reach of M2011, namely the number of unique users who have seen any content associated with the page.

Apart from the transient initial period, attendance fluctuates widely but no less that 100 users visited the page on a single day, with 250 being a rough estimate of the standard usage (median total reach is 276). There are several peaks with many more readers: some of them, in the last part of the depicted time span, can be attributed to the media coverage that we described before. As such, they are not really relevant or otherwise

Figure 2: Total reach.

especially meaningful. Other episodes can be related to specific events: the plot has vertical dashed lines at November 3rd and 19th, December 7th and 21st. The two midterms were held in the first and last date, and visibly some intensity is mounting on and before these times. The results of the first midterm were published on November 19th (second line).

On December 7th, M2011 was the subject of an article that described its participants as a “tribe”, with reference to the marketing literature where the term is used for a community with a shared goal, language and leader. The students were thrilled with the article and the number of likes rapidly exceeded 100.

Observe that the total reach measures the number of (passive) readers but some of the aforementioned effects are more evident looking at the number of engaged users (the number of unique users who engaged with the page clicking or creating a story), shown in Figure 3.

The number of active users rose before the midterms, and the activity reached, as somewhat expected, frantic heights especially before November 3rd. The median value of engaged users over time is 74 and, hence, less than 30% of readers are active on average. This is confirmed by the plot of the ratio engaged over total users that is visible in Figure 4.

The fraction of engaged users steadily increased to more than 30% before the first

Figure 3: Engaged users.

midterm, and then generally stayed in the 20%-30% range, with peaks corresponding to midterms.

4.2 Questionnaire data

We collected survey data on the users of M2011 with a questionnaire posted on the page itself on December 13 2011. Overall, 217 students provided information and 104 optionally provided ID tags that can be used to trace their academic performance. This subsample of 104 observations will be analyzed in the next subsection. Tables 3 and 4, in Appendix A, list the questions (Q1, Q2, ..., Q11) that were asked, the possible answers, together with the fraction of users that picked each reply in the third column. The file containing the original data can be downloaded at <http://virgo.unive.it/paolop/facebook.csv>

Almost two thirds of respondents were female (Q2, the proportion of female students in class was approximately the same) and over 97% were already Facebook users, see Q3. While 75.1% of students claimed they were “active FB users”, 65.9% admitted they were “not very active” as far as M2011 is concerned (Q4). People self-reporting as “most active” or “fairly active” were 31.8%, a figure that is in pretty good agreement with the fraction of engaged users depicted in Figure 4. Activity is also monitored in Q5 and more than 60%

Figure 4: Ratio engaged/total users.

of students visited the page once per day or more often, 35.9% did that more seldom with a tiny 2.8% that popped in only when exams were approaching. As a whole, the page is often visited even though the majority of users passively contented themselves to read the posted material with no need or desire to upload or react to the content.

Questions Q6, Q7 and Q8 assess the perceived usefulness of the page. Figure 5 graphically represent how helpful was the page on a 0 to 10 scale, see Q6, where 0 means “not at all useful” and 10 expresses a “very useful” judgement, with red and orange bars denoting replies of female and male students. The highest value was selected by 115 students (53%) and no answer was below 6. The following questions Q7 and Q8 tentatively single out specific reasons that explains why the page is deemed beneficial. Nearly 91% of users believed the page was useful because of the provision of logistic and organizational info. Such a high fraction stresses the importance of delivering timely and accurate guidance to students, mostly in their first year. M2011 was the source of additional exercises for 68.2% of the students and almost 40% found help in tackling difficult problems that they would not have been able to solve alone. One third of the users believe that the page is useful to fuel motivations and keep the pace (say, knowing the details of the covered material after a missed lecture). The page appears to be a networking facility where practical information, exercises and help is available. At the same time only 12% of the students emphasizes

Figure 5: Question Q6: How useful was the page? Replies are given in a 0-10 scale, with 0 meaning “not at all useful” and 10 is “very useful”. Red and orange bars denote replies of female and male students, respectively, and the total number of occurrences appear above every couple of bars.

the social opportunity to know peers better, pointing to a general perception of “focus” on the subject that was studied. Q8 is a control question and checks if there are grounds for dissatisfaction. Given that the overwhelming majority of users think the page is useful in Q7, not surprisingly, 85.2% of the students find no reason for claiming that the page is useless. A small fraction, though, acutely suggest that information in FB is difficult to retrieve (4.1%), with smaller numbers stating M2011 was distracting or that interaction with peers and instructors was limited.

The ninth question asked to evaluate the incremental effect of M2011 on the final grade.⁵ Even though nearly 10% of the students were not able to quantify the impact of the activity on FB, most of the students have the opinion that one, two or more points were gained because of M2011. By contrast, only 5% of users think that the page had no effect or was harmful.

⁵In Italy, the grade is routinely expressed in thirtieths: failing to reach the pass grade of 18/30 forces the student to retake the exam. We further assume in what follows that 32 is equivalent to the top grade 30/30 *cum laude*.

We believe that Q9 remarkably depict the satisfaction of the students who self-estimate and measure the expected outcome of their activity. Understanding to what extent this feeling can be verified and tested is the main target of Subsection 4.3. Q10 shows, in another way, the appreciation for the choice of FB that is perceived as innovative as a teaching aid. It is interesting to notice that users, as seen previously, knew FB very well and were already actively engaged in the social network but, still, declared that *this use* of the tool was innovative. In our opinion, the scope of M2011 was perceived as novel and non standard because FB was no longer used for “leisure” and more or less casual networking, which may still be the prevalent conceptions of FB users, see [Madge et al., 2009]. Users acknowledged that FB has an edge for its simplicity of use and, to a lesser degree, because of the sustained presence of students on the social network. FB, moreover, appears superior and clearly dominates other more mature tools like blogs and mailing lists for 50% of surveyed persons. The answers to the last question, finally, reveal that one third of students have not asked nor accepted friendship request, whereas the remaining part did that once ore more often.

The replies to questions Q4, Q5, Q6 and Q9 can be naturally ranked in their intensity and a correlation matrix can be computed for the ordered factors (excluding the observation with “don’t know” in Q9). The Spearman correlation matrix is shown in Table 1

	Q4	Q5	Q6	Q9
Q4	1.000	-	-	-
Q5	0.159*	1.000	-	-
Q6	0.069	0.219**	1.000	-
Q9	0.073	0.159*	0.383**	1.000

Table 1: Spearman correlation matrix of (ranked) variables Q4, Q5, Q6 and Q9. 21 observations with “don’t know” in Q9 (last row and column) were discarded. The symbols “*” and “**” denote non null correlations at significance levels below 0.05 and 0.01, respectively.

Q4 and Q5 are variables that measures different “activities” on the page: the former relates more with writing posts (against reading only), the latter with the number of visits. The two are correlated but Q4 does not significantly help to predict any of the other two variables. Q5 instead is more strongly correlated with the overall perceived usefulness of the page, in Q6.

The added value of the page, expressed in grade units, is in Q9. This variable is correlated with the frequency of visits and, quite strongly, with the perceived usefulness. This discloses that the students might recognize benefits in relationship with the grade they are ultimately getting. While this does not exclude the presence of advantages associated with other cognitive or psychological domains, students show a utilitarian approach in which the link between helpfulness and grade is clearly in sight.

4.3 Academic performance

How much the use of technology and computer-assisted teaching quantitatively enhance the performance of students is a *vexata quaestio* that is still extremely relevant in our view. There is no doubts that students can reap benefits from a computer platform in many ways, strengthening their familiarity with IT tools, improving their cooperative skills and perceiving an increased coherence of the material and general satisfaction.

We focus here on the *grades* of the students, exploiting a subset of the observations tagged with ID info that allowed us to analyze the grade that was ultimately obtained. In detail, we seek here to clarify to what extent the activities on M2011 were responsible of increments in the final grade of the math course. Preliminarily, recall that the vast majority of users have the opinion that their grade will be higher because of M2011, see Q9.

Even though 104 students voluntarily provided ID, we analyze the 81 successful cases (i.e, the ones that have a passing grade to date). Figure 6 shows boxplots of the performance of the students, as a function of some of the ordered categorical variables that were collected. Boxplots, also known as box-and-whisker diagrams, visualize the entire distribution displaying the first and third quartiles (the box), the median (the thick line inside the box) and the lowest/highest points still within 1.5 times the interquartile range (the whiskers). Outliers can also be plotted, even though there is none in the shown data. Roughly speaking, the box depicts the center of the distribution whereas the whiskers illustrate the tails of the data.

The left panel of Figure 6 provides some visual evidence that students self-reporting themselves in Q4 as “moderately active” get higher grades than the “not very active” ones. Yet, the data are very dispersed, as indicated by the wide whiskers, and both groups have 18s, the minimum passing grade, together with some 32 (30/30 *cum laude*). The same trend is visible in the right panel relative to Q5, where the frequency of the visits and the grade comove.

Testing the equality of means of the groups “not very active” and “moderately active” with a *t*-test does not allow to reject the null hypothesis (the *p*-value is 0.093). As the distribution of “not very active” students’ grades departs from normality⁶, we use the more robust non-parametric Wilcoxon test that yields a *p*-value of 0.055. Again, we cannot formally reject the null at the 5% confidence level, but there is some support to the claim that more active students have higher grades.⁷ Very similar considerations about the presence of some (not entirely conclusive) statistically significant difference could be reported for the data depicted on the right panel of Figure 6 or for the relationships between the grade and answers to question Q6 and Q9.

We compute a principal component analysis, see [Mardia et al., 1979], on the results for

⁶A Shapiro-Wilk test rejects normality, *p*-level 0.00038. A look at the leftmost boxplot on the left part of Figure 6 indeed visually confirms the existence of a marked positive skewness, as the upper whisker is more extended than the lower one.

⁷For instance, including the grades of the two “most active” subjects in the “moderately active” set would make the means of the two groups significantly different, *p*-value 0.019.

Figure 6: Boxplots of grade (on the vertical axis) as a function of answers given to Q4, left, and Q5, right. The horizontal ticks `leasta`, `nvact`, `modact`, `moa` and `exam`, `ftw`, `onced`, `seved` denote *least active*, *not very active*, *moderately active*, *most active* and *when exam approaches*, *a few times per week*, *once a day*, *several times per day*, respectively.

questions Q2 (sex), Q4 (kind of user), Q5 (how many visits), Q6 (usefulness), Q9 (added value) and grade. Integer values for categorical attributes were obtained as factors are ordered and, say, Q4 was coded in such a way that 1 = least active, 2 = not very active, 3 = moderately active and 4 = most active. The same straightforward procedure was used whenever needed for other variables and notice that 21 observations (out of 81) were removed because the “don’t know”s in Q9 cannot be meaningfully inserted in any rank. Sex is a variable taking two values and 1 = female, 2 = male.

The first two principal components are reported in Table 2 and have been selected after inspection of the screeplot and keeping, as routinely done, the eigenvalues that are greater than 1.

The first principal component, explaining 33.0% of the variance, mainly contrasts the sex with all the other variables and suggests that female students on average are more active, visit M2011 more often, consider it more useful, expect a higher improvement because of it and get better grades than males. We did not further explore this gender characteristic of our data set.

Variables	PC1	PC2
Sex (Q2)	-0.339	-0.255
User (Q4)	0.184	0.630
Visits (Q5)	0.466	-0.346
Usefulness (Q6)	0.550	-0.149
Added value (Q9)	0.494	-0.259
Grade	0.295	0.573
Variance	1.980	1.210

Table 2: Loads of the first two principal components

The second principal component explains 20.2% of the variance and links the grade and the activity, as measured by the user variable collected in Q4. Negative (and relatively small) loads are given to the other variables. The examination of the correlation matrix and of the biplot, not shown here, confirms the previous interpretation of the principal components, which compactly offer a reasonably detailed picture of the data.

The previous analysis suggest that the grade may depend on sex and be coupled with various measures of activity, perceived usefulness and gain from the participation to M2011. We tried to fit several regression models to the data but were unable to find a satisfactory fit when the grade is the dependent variable against the set of just mentioned predictors. This clearly warns against the manifest risks of taking for granted that there is a causal dependence between the grade causally depends on the other variables. Just to provide a concrete example, the left panel of Figure 6 has two contrasting interpretations: *as they are more active, students get better grades* but also *if students are better (i.e., get better grades), then it turns out that they are more active*. It is by no means easy to figure out which, if any, of these and similar interpretations are accurate. Next Section provides additional discussion and perspective on this and other issues.

5 Interpretation

The experimental use of the FB page M2011 as a learning tool to supplement standard face-to-face teaching lectures offers some insights on the potential benefits and limitations of FB in this domain. To the best of our knowledge, few studies have investigated the effects of this pervasive social network when it is adopted as specific and unique platform for online activities. Typically, other studies pointed out the detrimental effects of FB on academic performance at large. This is mainly attributed to the reduced time available for study and to the fragmentary and hectic nature of the communications occurring on social networks, that basically are a powerful source of distraction and are detached from courses and academic learning. The present study presents an approach where Facebook is, on the contrary, likely to be a part of the solution instead of being a part of the problem.

Students unquestionably appreciated the page, both when they perceive themselves as active and even when they are passive. Probably, there were different ways to reap

benefits from M2011, depending on the level of skills and quality of previous mathematical training: students with a strong background may on average be in the group of more active persons, who get better grades and express higher levels of satisfaction. Other enrolled undergraduates, possibly coming from vocationally-oriented high schools, may possess fewer technical skills and typically strive to keep the pace in the standard math course taught in the faculty of Economics. As a consequence, it is possible that they belong to the not-very-active kind of user but, in spite of that, M2011 is still perceived as a valuable tool in many respects.

We often experienced the unresolved puzzle of tailoring a course in such a way that incentives, excitement and satisfaction are provided to all students, be them in the most brilliant group or in the set of the ones that have a hard time, because of a variety of reasons. The previous considerations suggest that FB can stimulate and foster additional participation of the most inclined persons to allow, say, more face-to-face attention on struggling students, who seem to read, use and value the page even at lower levels of participation. Indeed, this finding is supported by the fact some of the threads that developed on M2011 were in-depth discussions of more advanced material. Such conversations, prompted by the best students, are not frequent nor always advisable or possible in crowded classes and only the availability of M2011 may have made them possible.

Our results, in a way, surprisingly contradict previous findings as more active students exhibit better academic performance. We stress that there is no evidence yet that activity is the cause of improvements but nevertheless this case study reveals that, *when undergraduates use FB as a learning tool*, more usage is correlated to better grades.

We confirm the findings of other scholars with respect to other dimension of successful learning. Irrespective of the final grade, many users expressed satisfaction with the understanding of organizational issues, found incentives and additional exercises or practice material, received feedback on problems that “they would not have been able to solve alone”. Some of the items in Q7 can be interpreted as indicators of a deep approach to learning, nurtured by the alternative communication channel that was provided by M2011. This in turn may also influence the final grade of the students. Giving an example from our data, the median mark obtained by subjects who agree (disagree) with the second item of Q7 is 24.5 (22.0). If it is true that the grades of one group are better, standard deviations as large as 4.6 and 4.0, respectively, do not allow to draw definitive conclusions. As argued in [Ramsden, 1992], the association between learning approaches and quantitative performance is convincing though somewhat less evident than the one established when qualitative measures of outcomes are considered.

It is interesting to notice that FB was perceived as “innovative” even though 97% of students were already registered users (and 75% describe themselves as active, see Q3). We believe the only “innovation” lies in the peculiar use of the page as a supportive and productive tool that shakes the (common?) belief that FB is only for fun and a waste of time, as much as work is concerned. Once one accepts that FB can be used to boost performance, bonuses like the simplicity and the widespread familiarity with the interface bring possible advantages over other platforms, see also Q10.

Finally, we feel that M2011 was one of the main drivers of a sense of unity in the class.

This may be of special importance for first-year undergraduates enrolled in a crowded class, where direct and personal relationships with many peers and instructors are not always at hand. The page (and even the metaphoric “friendship” that is nominally at the heart in FB) possibly encouraged the widespread perception of a group with common goals and shared membership. One poignant remark makes the point and was expressed by a student after a polite suggestion appeared on the media stating that other platforms could have been better: “We are legends! You rocket scientists should refrain from similar comments and, anyway, we totally snub any other platform...”. Clearly, this is more of an identity declaration than a serious judgement on the merits of other online tools. The appreciation of the “tribal” post, referred to in Section 2, quite effectively reaffirms this element.

6 Conclusion

This work is a case-study of Facebook-enhanced course in Mathematics for undergraduate students. FB does not seem to be often used in education setting, possibly because of the perception that it is “leisure-only” and an attention-grabber. Yet, students express satisfaction with the academic use of FB as a support tool and acknowledge that it can be used to retrieve logistic information but also get timely feedback, help on difficult problems and access to practice material. The widespread presence of students in FB potentially offers advantages over other platforms, that may be not perceived as similarly appealing.

Roughly one third of the students were actively engaged in the M2011: they may be mostly in the group of students with better skills and preparation and, in such a case, FB could be the source for more stimulating and advanced discussions. The remaining part of more passive readers still feel that the page is useful and improves the coherence of the course, as well as offering ways to acquire more basic skills.

We feel that FB gave the students the opportunity to feel themselves as a group with a shared goal, where help could be found if needed. This was valuable, especially in such a crowded situation. More generally, the use of technology can, in a seemingly contradictory way, humanize the course more than highlighting the distances among peers and teachers. Students could ask clarifications at any time, according to their own pace, and got more personalized replies, largely because of M2011.

Survey data provide some evidence that better grades are related to more activity and to the positive perception of the FB page. Whether this is a cause or an effect is extremely difficult to say as we have no control group. The validation of the belief, say, that two additional points were obtained because of M2011 (and, hence, would not have been gained without) is an open challenge. Furthermore, some caution is needed to generalize our results: we have a reasonable sample size but cannot control for a series of unobserved case-specific effects that may play a role in the outcomes.

Our work calls into question the reported adverse effects that FB should have on quantitative performance of active users, notably when the social network is used as a learning device.

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Appendix A

Q1: Student ID (optional)	-	0.479
Q2: Sex	Female/Male	0.659
Q3: Did you specifically sign up to FB to use M2011?	Yes	0.028
	No, I was already an active FB user	0.751
	No, I was already a FB user, though not very active	0.221
Q4: Which kind of user are you?	One of the most active	0.014
	Fairly active (I read and post material a few times)	0.304
	Not very active (I mostly read the content)	0.659
	One of the least active	0.023
Q5: How often did you visit the page?	Several times a day	0.161
	Once per day	0.452
	A few times per week	0.359
	When exams approached	0.028
Q6: Do you think the page was useful?	Numeric scale, from 0 (not at all) to 10 (very)	
Q7: The page was useful to:	Easily find general info about the course or clarify logistic and organizational issues	0.908
	Find help on math problems that I wouldn't have been able to solve alone	0.396
	Find additional exercises besides the ones given in class	0.682
	Interact with peers and know them better	0.120
	Find motivations and keep me on track with studying	0.332
	None of the previous answers / other	0.000

Table 3: Questions and answers asked in the questionnaire (part 1).

Q8: The page was useless because	Info were not easily found	0.041
	All needed info were given in class	0.039
	It is a distraction while we study	0.032
	Interaction with the peers on FB is limited	0.032
	Interaction with instructors on FB was limited	0.005
	None of the previous answers / other	0.852
Q9: Evaluate the usefulness of the page in terms of final grade (out of 30 points): which is the added value?	More than 2 points	0.364
	2 points	0.304
	1 point	0.184
	It made no difference	0.046
	Less than zero (it was harmful)	0.005
	Do not know	0.097
Q10: Which of the following sentences do you agree with?	The page was mainly useful because of the ease of use of FB	0.433
	The page was mainly useful because I use FB a lot anyway	0.267
	A blog or a forum would have produced the same result	0.046
	Emails or a static web page would have produced the same result	0.046
	FB has a clear edge on other tools available online	0.502
	I think that using FB as a aid to teaching is innovative	0.839
Q11: Did you ask any peer to become friends or accept requests from other students?	Yes, more than once	0.535
	Yes, once	0.138
	No	0.327

Table 4: Questions and answers asked in the questionnaire (part 2).