

The Effects of Study Buddies and Study Hours in a First-Year Course on Operating Systems

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Abstract. Many university students, especially first-year students, struggle to efficiently manage their study time which results in lower academic achievements. This paper empirically examines the effect that the number of self-preparation hours of students has on their final grade. In addition, the influence of studying with a friend in preparation for tests and exams is analysed, in order to determine if it has any notable impact on students' academic performance. Five tests and exams of a first-year computer science module, namely operating systems, which is considered a difficult subject by students, were analysed for this study. Students were recommended to prepare for a certain number of hours, and before each test, students were asked how much they actually studied and whether or not they prepared together with a friend. It was found that students who studied with a friend had a higher pass rate for all the tests compared to those who studied alone. Additionally, academic performance is by-and-large a matter of investing the recommended number of study hours, while in reality most students come to the exams underprepared. Students who passed the course had typically put in more preparation hours than their failing counterparts. Borderline students were also not able to substantially increase their marks with additional preparation.

1 Introduction

Operating systems (OS) are perceived by many students as a ‘difficult’ topic [8,11], especially at our university where OS are already taught to computer science (CS) and computer engineering (CE) students in their first year of study.¹ To support our first-year students in coping with these difficulties, we continuously reminded them of putting enough study hours into the preparation of their various tests, and we also recommended the formation of pair-studying with a so-called ‘study buddy’ for mutual motivation and preparation time control among the two members of a study pair. At the end of the course we wanted to know how effective our advice has been, such as to be able to decide whether or not to continue such practice in the future.

¹ For comparison, we are aware of several other institutions in which OS are presented only in the third study year.

In this paper we explain the ‘design’ of our investigation, report our observations, and draw conclusions concerning recommendable future practices. Our initial assumption — simply as a matter of common sense — was that very weak students will not benefit from even the highest numbers of study hours, whilst highly intelligent students will always do well even with little preparation, hence it should be the ‘mediocre’ students, who are neither very weak nor very bright, for which some extra efforts in preparation time can have the most rewarding effects.

This paper firstly recapitulates what other experts have discovered in this context in section 2, followed by the design of the case study in section 3. The observations are listed in section 4 with the discussion and recommendations for future educators given in section 5. Finally, the conclusion is presented in section 6.

2 Related Work

The effects of intrapersonal factors, such as stress [6] and motivation [7], on students’ academic performance has been widely studied. Especially first-year students struggle with the transition from secondary to tertiary institutions due to a change in required skills, learning styles, and time management [9], which in turn leads to higher stress levels, reduced motivation, and lower academic achievements. Blair found that the workload and independent learning is broadly in line with students’ expectations when entering a university, however, students do not fully comprehend what is expected from them in various assessments and therefore often do not manage their time properly [2]. This section discusses existing research with regard to two primary factors impacting students’ academic performance, namely the time spent on self-study, as well as studying with fellow students in preparation of upcoming assessments.

2.1 Impact of Study Hours

An important factor influencing the academic performance of students is the time spent on preparing for classes and exams. Besides the extracurricular activities of most first-year students in South Africa, the available study time is further reduced by a lack of financial support, requiring students to get a part-time work to pay their bills and support their families at home. A study in the Western Cape and the Free State found that both students and lecturers rated the support from home and other financial issues as two of the main factors influencing academic performance [9]. On the other hand, class attendance and preparation hours were ranked lower than the financial factors.

A study at the University of Johannesburg found that outside their regular class attendance, between 50% and 60% of students put less than 15 hours per week into their academic work [15]. Between 25% and 36% of students studied for 15 to 25 hours per week, with only around 15% to 19% studying more than 25 hours a week. Similar observations were made by the Indiana University where a survey found that on average students utilized 13.8 hours a week for studying and class preparation, with a standard deviation of 8.1 hours [4].

When considering the study hours, it is important to determine if there is a statistical correlation between the time students spent preparing for assessments and the corresponding grades they obtain for those assessments. A 20-year study at various German universities found that the time spent on attending courses was positively associated with grades for females, high ability students, and students of social sciences, hard sciences, and engineering [5]. Spending time on self-study was positively correlated with grades for almost all students.

Contrary to the German study, a single year survey at 413 universities in the United States found that there was no statistically significant influence of the time spent on self-study, as well as the time spent on outside work, on the final semesters grades of the students [10]. Below average students performed slightly worse with more study hours compared to fewer study hours. Medium ability students had no notable difference in their grades when working for longer or shorter periods of time. Only high ability students had a statistical significant grade increase when studying longer.

A study at the Colorado State University and Front Range Community College investigated the ratio of self-study hours to lecture hours required to achieve a certain exam mark [1]. The study determined that students had to study between 3 to 4.4 hours for the exam to achieve the average class grade. Additionally, the study found that in order to achieve a 90% exam mark, the ratio of self-study to lecture hours should be between 1.5 and 2.1. In addition, a study at the University of Uyo found that students who studied longer had a significantly higher academic achievement than their counterparts studying for shorter periods of time [14]. A recommendation was made that students should at least study for two to three hours a day outside regular lectures.

2.2 Impact of Study Groups

Some students prefer studying alone, while others engage with fellow students, also known as study buddies, in preparation of assessments. Naong found that about half of the students consider the ability to work independently as having a noticeable impact on their performance, with only a third of the students considering it having a great impact [9].

A study at the University of Washington noticed that especially engineering students tend to study alone, either by choice or as a result of feeling like an outsider [3]. The authors argued that those students who study alone due to feeling like an outsider are more likely to drop out of university. A small survey across four United States universities observed that engineering and computer science students typically start the semester by working alone [16]. After realising that their expectations of the work difficulty are unrealistic, many students seek out a study buddy, therefore starting the semester alone and ending the semester together.

A study at the University of South Australia investigated the effect of studying with a fellow student, as well as the effect of hierarchical senior tutoring, on students' pass rates [13]. The survey found that 74% of students with a study buddy passed, whereas only 49% of students studying alone passed. Similarly, Reid et. al. found that students at risk of failing who participated in a study buddy support program improved their

academic performance by 28%, compared to non-participants who only gained an 8% improvement [12].

On the other hand, the previously mentioned 2-decade study at various German universities found that devoting time on work groups was negatively correlated with grades for science and engineering students, and students with below average abilities [5].

3 Case Study Design

During the observed semester our first-year OS students had to write several tests in each of which we also asked the students to voluntarily provide some answers about their own study behaviour before the tests. Several tests were thus evaluated by us, namely:

During the semester, the so-called *semester tests* were assessed, two of which were compulsory for every student as follows:

- First semester test: compulsory,
- Second semester test: compulsory,
- Aegrotat test: optional only for those students who had been ill with a medical certificate, or who were otherwise engaged with a valid justification, during any of the two previous tests.

After the semester, several types of *final exams* were written only by those students who had sufficiently high semester marks to be allowed into the final exams (i.e. weak students excluded). Those exams were the:

- Normal exam: compulsory,
- Aegrotat exam: optional only for those students who had been ill or otherwise unavailable with a valid medical certificate during the final exam,
- Supplementary exam: optional only for those students who had failed the final exam with a sub-minimum grade of 40%–49%. All even weaker students were excluded from taking part in this supplementary exam,
- Special final-chance exam: optional only for those students who had failed the final exam with a sub-minimum mark of 40%–49%, who had also failed the subsequent supplementary exam within 40%–49%, and who only needed to pass this one course (OS) in order to obtain their entire bachelor degree. This special exam is thus written only by students who had repeatedly failed and re-failed the OS course during several preceding years of studying.

Due to the insignificantly low participation, the *aegrotat* exam for the previously ill students (with only 12 participants) and the *final-chance* exam for the ‘degree aspirants’ (with only 3 participants) are not taken into account in the subsequent analyses.

All in all, we will assess three semester tests and two after-semester exams (subsequently called ‘the five tests’) in which the participation numbers were large enough to yield sufficiently reliable observation results.

During the semester we had the highest proportion of weak students in the cohort, including those ones who were eventually not allowed to sit in the final exam. After the

semester we had the relatively weakest students accumulated in the supplementary exam.

For each of these five tests, we lecturers had released a study time recommendation — based on our many years of academic experience — of n hours, whereby the value of n could vary from test to test, due to different quantities of covered study material, and/or different levels of difficulty. In each test paper we asked the students to voluntarily indicate to us whether or not, or to what extent, they had adhered to our previously provided study time recommendation², and whether or not they had studied together with a ‘study buddy’.

For the remainder of this paper we use the following encoding of the data which we have gathered as mentioned above.

Preparation Hours: For a specifically given advice n concerning ‘highly recommended’ number of preparation hours (for example: $n = 30$), the students’ (self-indicated) actual preparation hours h are encoded as follows.

- A** for $h > n + 5$ (highly diligent),
- B** for $n - 5 \leq h \leq n + 5$ (diligent),
- C** for $n - 10 \leq h < n - 5$ (negligent),
- D** for $h < n - 10$ (very negligent),
- ?** for no voluntary answer provided.

Study Buddies: Only the follow three possibilities needed to be encoded.

- Y** for ‘I prepared myself together with a study buddy’,
- N** for ‘I prepared myself alone without a study buddy’
- ?** for no voluntary answer provided.

Academic Success: Along the lines of the ‘tradition’ of our university, we encode a student’s academic achievement aa on the basis of percentages ($p\%$) as follows, whereby 100% is the absolutely highest mark which a student could possibly obtain.

- A** for $aa \geq 75\%$ (pass with distinction),
- B** for $50\% \leq aa \leq 75\%$ (pass),
- C** for $40\% \leq aa < 50\%$ (sub-minimum failure),
- D** for $aa < 40\%$ (severe failure).

4 Observations

In the following section we measure the effects of study buddies and preparation hours *separately* for two methodical reasons:

- A combined analysis with two input variables (buddies and hours) would have been too cumbersome, i.e. obfuscating which output effect is due to which input variable;
- The study buddy scheme turned out to be not very popular, i.e. most of our students indicated that they had preferred to study alone; see [3] for comparison. Hence the

² Students had thus the opportunity to be untruthful when providing answers; this is from a methodological point of view a ‘weak spot’ in our ‘design’.

very small number of study buddies among our entire cohort might have distorted the significance of our findings altogether if combined with the study hour variable.

The details are described in the following paragraphs for each of our five tests.³

4.1 About the Effect of Study Buddies

In each of the following five test cases we first show the *proportion* of study buddies (code **Y**) in the entire cohort, followed by a comparison of how well the study buddies were faring academically in comparison against the single students (code **N**) and the no-answer students (code **?**).

Test 1. Our observations from this test are captured in tables 1 and 2. We see that the study buddies (code **Y**) seem to have had a noteworthy performance gain over the single workers (code **N**) especially at the academic ability level *B* (pass) — although our observations might have differed if the many students who did not provide an answer (code **?**) had provided explicit responses.

Table 1. Groups of participants of test 1, in absolute numbers, sorted: study buddies are the minority with $\frac{73}{566} \approx 13\%$ of all participants.

N	?	Y	all
375	118	73	566

Table 2. Academic Performance of study buddies versus others in test 1: study buddies seemed to be most beneficial for students at performance level *B*. Incompetence at performance level *D* is especially frequent among the non-answerers (code **?**).

Group / Performance	<i>A</i> :pass	<i>B</i> :pass	<i>C</i> :fail	<i>D</i> :fail	all
Y	$\frac{1}{73} \approx 1\%$	$\frac{23}{73} \approx 32\%$	$\frac{18}{73} \approx 25\%$	$\frac{31}{73} \approx 42\%$	$\approx 100\%$
N	$\frac{10}{375} \approx 3\%$	$\frac{94}{375} \approx 25\%$	$\frac{89}{375} \approx 24\%$	$\frac{182}{375} \approx 49\%$	$\approx 100\%$
?	$\frac{2}{118} \approx 2\%$	$\frac{18}{118} \approx 15\%$	$\frac{24}{118} \approx 20\%$	$\frac{74}{118} \approx 63\%$	$\approx 100\%$

Test 2. Our observations from this test are captured in tables 3 and 4. The results are reasonably similar to the ones of the foregoing test 1, whereby the large number of non-answerers (code **?**) brings some uncertainty into this result. Among the non-answerers were also, again, the highest proportion of incompetent students at academic performance level *D*.

³ All data sheets, with all their internal further details, can be obtained from the authors via e-mail request.

Table 3. Groups of participants of test 2, in absolute numbers, sorted: study buddies are the minority again with $\frac{75}{507} \approx 15\%$ of all participants.

N	?	Y	all
280	152	75	507

Table 4. Academic performance of study buddies versus others in test 2: Again the buddy system seemed to be most beneficial for students at academic performance level *B*.

Group / Performance	A:pass	B:pass	C:fail	D:fail	all
Y	$\frac{6}{75} \approx 8\%$	$\frac{55}{75} \approx 73\%$	$\frac{11}{75} \approx 15\%$	$\frac{3}{75} \approx 4\%$	$\approx 100\%$
N	$\frac{38}{280} \approx 14\%$	$\frac{152}{280} \approx 54\%$	$\frac{45}{280} \approx 16\%$	$\frac{45}{280} \approx 16\%$	$\approx 100\%$
?	$\frac{12}{152} \approx 8\%$	$\frac{66}{152} \approx 43\%$	$\frac{29}{152} \approx 19\%$	$\frac{45}{152} \approx 30\%$	$\approx 100\%$

Test 3. This was the aegrotat test for those students who had been missing any of the two foregoing tests due to illness. Because of the rather small number of participants, our result observations in this case might have to be taken with a pinch of salt as far as their significance is concerned: see tables 5 and 6 for the details.

Table 5. Groups of participants of test 3, in absolute numbers, sorted: study buddies are the minority again with $\frac{2}{42} \approx 5\%$ of all participants.

N	?	Y	all
29	11	2	42

Test 4. As explained above, this test was the first after-semester exam, for which the weakest students from the foregoing semester tests had no entry permission. This explains the somewhat lower total participation number. The details of our observations from this exam are summarised in tables 7 and 8.

Table 6. Academic performance of study buddies versus others in test 3, with similar observations as in the two foregoing tests.

Group / Performance	A:pass	B:pass	C:fail	D:fail	all
Y	$\frac{1}{2} \approx 50\%$	$\frac{1}{2} \approx 50\%$	—	—	$\approx 100\%$
N	$\frac{2}{29} \approx 7\%$	$\frac{12}{29} \approx 41\%$	$\frac{10}{29} \approx 34\%$	$\frac{5}{29} \approx 17\%$	$\approx 100\%$
?	$\frac{1}{11} \approx 9\%$	$\frac{6}{11} \approx 55\%$	$\frac{2}{11} \approx 18\%$	$\frac{2}{11} \approx 18\%$	$\approx 100\%$

Table 7. Groups of participants of test 4, which was the first after-semester exam, in absolute numbers, sorted: study buddies are the minority again with $\frac{76}{428} \approx 18\%$ of all participants.

N	?	Y	all
225	127	76	428

Table 8. Academic performance of study buddies versus others in test 4, which was the first after-semester exam, *without* participation of the weakest students from the foregoing tests. Again the buddy system seemed to be most beneficial for students at performance level *B*.

Group / Performance	A:pass	B:pass	C:fail	D:fail	all
Y	$\frac{3}{76} \approx 4\%$	$\frac{49}{76} \approx 64\%$	$\frac{19}{76} \approx 25\%$	$\frac{4}{76} \approx 5\%$	$\approx 100\%$
N	$\frac{13}{225} \approx 6\%$	$\frac{122}{225} \approx 54\%$	$\frac{58}{225} \approx 26\%$	$\frac{32}{225} \approx 14\%$	$\approx 100\%$
?	$\frac{5}{127} \approx 4\%$	$\frac{58}{127} \approx 46\%$	$\frac{31}{127} \approx 29\%$	$\frac{33}{127} \approx 26\%$	$\approx 100\%$

Test 5. This was the above-mentioned optional supplementary exam (second chance) only for the weak students at level *C* (however not for the very weak *D* students). Hence the number of participation in this test was rather small. Our observations are summarised in tables 9 and 10. For the first time the non-answerers (code **?**) were in the majority in this test, seemingly indicating some correlation between academic weakness and not answering the voluntary survey question.

Table 9. Groups of participants of test 5, which was the second-chance after-semester for our weak students, in absolute numbers, sorted: study buddies were the minority again with $\frac{5}{115} \approx 4\%$ of all participants, whereas the non-answerers (code **?**) were now for the first time in the majority.

?	N	Y	all
57	53	5	115

Table 10. Academic performance of study buddies versus others in test 5, which was the second-chance exam for our weak students.

Group / Performance	A:pass	B:pass	C:fail	D:fail	all
Y	—	$\frac{2}{5} \approx 40\%$	$\frac{1}{5} \approx 20\%$	$\frac{2}{5} \approx 40\%$	$\approx 100\%$
N	—	$\frac{5}{53} \approx 9\%$	$\frac{21}{53} \approx 40\%$	$\frac{27}{53} \approx 51\%$	$\approx 100\%$
?	—	$\frac{7}{57} \approx 12\%$	$\frac{24}{57} \approx 42\%$	$\frac{26}{57} \approx 46\%$	$\approx 100\%$

Intermediate Summary: Pass Rates of the Study Buddies. If our students have provided truthful answers in the voluntary survey, then we can see that the *pass rates* (*A* and *B* combined) of the study buddies (code **Y**) was notably the highest in all our five tests:

- Test 1: buddies' pass rate = 33% (Y) versus 28% (N) and 17% (?)
- Test 2: buddies' pass rate = 81% (Y) versus 68% (N) and 51% (?)
- Test 3: buddies' pass rate = 100% (Y) versus 48% (N) and 64% (?)
- Test 4: buddies' pass rate = 68% (Y) versus 60% (N) and 50% (?)
- Test 5: buddies' pass rate = 40% (Y) versus 9% (N) and 12% (?)

Nonetheless only a small minority of our students participated this beneficial study buddy scheme.

4.2 About the Effects of Preparation Hours

In each of the above-mentioned 5 test cases we will now first show the proportion of diligence-levels in the entire cohort (codes *A, B, C, D*), followed by a comparison of how well the more-or-less diligent students were faring academically in comparison against each other and against the no-answer students (code *?*).

Test 1. With the same participants as described above, our observations of the relations between preparation hours (codes **A, B, C, D, ?**, with regards to some given number n = 'strongly recommended') and the resulting academic performance levels (*A, B, C, D*) are summarised in tables 11 and 12. Here it is interesting to note that the long-time preparers (code **A**) did *not* reach the highest academic level *A*: the highly intelligent students at the academic top level *A* are probably *not in need* of overly many preparation hours, due to their being 'gifted' with 'natural' intelligence.

Test 2. Our observations in this test, similar to the previous one, are summarised in tables 13 and 14.

Test 3. Our observations in this aegrotat test, with only few participants, are summarised in tables 15 and 16.

Table 11. Participants of test 1, in absolute numbers, grouped by their self-inflicted levels of preparation diligence. Diligent (code **B**) and highly diligent preparers (code **A**) were in a small minority: $\frac{8+64}{566} \approx 13\%$.

A	B	C	D	?	all
8	64	207	145	142	566

Table 12. Academic performance of diligent preparers versus others in test 1: Highly diligent long-time preparers (code **A**) did *not* reach the academic level *A*; very high diligence levels are especially indicative of academic level *B*. The highest pass rate was observed at diligence level **B**. Incompetence at performance level *D* was especially frequent among the negligent students and the non-answerers. The performance effects of diligence (or lack thereof) are clearly visible throughout the entire table. Only a few very intelligent students did not need many preparation hours to obtain the highest performance level *A*.

Diligence / Performance	<i>A</i> :pass	<i>B</i> :pass	<i>C</i> :fail	<i>D</i> :fail	all
A	—	$\frac{5}{8} \approx 63\%$	$\frac{2}{8} \approx 25\%$	$\frac{1}{8} \approx 13\%$	$\approx 100\%$
B	$\frac{4}{64} \approx 6\%$	$\frac{19}{64} \approx 30\%$	$\frac{15}{64} \approx 23\%$	$\frac{26}{64} \approx 41\%$	$\approx 100\%$
C	$\frac{4}{207} \approx 2\%$	$\frac{55}{207} \approx 27\%$	$\frac{53}{207} \approx 26\%$	$\frac{95}{207} \approx 46\%$	$\approx 100\%$
D	$\frac{2}{145} \approx 1\%$	$\frac{34}{145} \approx 23\%$	$\frac{35}{145} \approx 24\%$	$\frac{74}{145} \approx 51\%$	$\approx 100\%$
?	$\frac{3}{142} \approx 2\%$	$\frac{22}{142} \approx 15\%$	$\frac{26}{142} \approx 18\%$	$\frac{91}{142} \approx 64\%$	$\approx 100\%$

Table 13. Participants of test 2, in absolute numbers, grouped by their self-indicated levels of preparation diligence. Diligent (code **B**) and highly diligent students (code **A**) were again in a small minority: $\frac{23+59}{507} \approx 16\%$.

A	B	C	D	?	all
23	59	122	140	163	507

Table 14. Academic performance of diligent preparers versus others in test 2, with similar observations as in the foregoing test, although here the highest pass rate was achieved at diligence level **B**, (*not A*). The difficulty of this test (in Bloom's taxonomy) was somewhat *easier than the difficulty of the foregoing test*, such that reasonably high pass rates could be achieved also with rather low preparation effort.

Diligence / Performance	<i>A</i> :pass	<i>B</i> :pass	<i>C</i> :fail	<i>D</i> :fail	all
A	$\frac{2}{23} \approx 9\%$	$\frac{14}{23} \approx 61\%$	$\frac{4}{23} \approx 17\%$	$\frac{3}{23} \approx 13\%$	$\approx 100\%$
B	$\frac{8}{59} \approx 14\%$	$\frac{37}{59} \approx 63\%$	$\frac{10}{59} \approx 17\%$	$\frac{4}{59} \approx 7\%$	$\approx 100\%$
C	$\frac{9}{122} \approx 7\%$	$\frac{76}{122} \approx 62\%$	$\frac{23}{122} \approx 19\%$	$\frac{14}{122} \approx 11\%$	$\approx 100\%$
D	$\frac{25}{140} \approx 18\%$	$\frac{72}{140} \approx 51\%$	$\frac{19}{140} \approx 14\%$	$\frac{24}{140} \approx 17\%$	$\approx 100\%$
?	$\frac{12}{163} \approx 7\%$	$\frac{75}{163} \approx 46\%$	$\frac{29}{163} \approx 18\%$	$\frac{48}{163} \approx 29\%$	$\approx 100\%$

Table 15. Participants of the aegrotat test 3, in absolute numbers, grouped by their self-indicated levels of preparation diligence. Diligent (code **B**) and highly diligent students (code **A**) were again in the minority: $\frac{2+2}{42} \approx 10\%$.

A	B	C	D	?	all
2	2	13	12	13	42

Table 16. Academic performance of diligent preparers versus others in test 3.

Diligence / Performance	<i>A</i> :pass	<i>B</i> :pass	<i>C</i> :fail	<i>D</i> :fail	all
A	$\frac{1}{2} \approx 50\%$	$\frac{1}{2} \approx 50\%$	–	–	$\approx 100\%$
B	$\frac{1}{2} \approx 50\%$	$\frac{1}{2} \approx 50\%$	–	–	$\approx 100\%$
C	–	$\frac{6}{13} \approx 46\%$	$\frac{4}{13} \approx 31\%$	$\frac{3}{13} \approx 23\%$	$\approx 100\%$
D	–	$\frac{5}{12} \approx 42\%$	$\frac{5}{12} \approx 42\%$	$\frac{2}{12} \approx 17\%$	$\approx 100\%$
?	$\frac{1}{13} \approx 8\%$	$\frac{7}{13} \approx 54\%$	$\frac{3}{13} \approx 23\%$	$\frac{2}{13} \approx 15\%$	$\approx 100\%$

Test 4. As mentioned above, this test was the regular after-semester exam from which the weakest students were already excluded. Tables 17 and 18 summarise our observations of this test.

Table 17. Participants of test 4 (the first after-semester exam), in absolute numbers, grouped by their self-indicated levels of preparation diligence. The weakest students from the foregoing tests were excluded from participation. Diligent (code **B**) and highly diligent students (code **A**) were again in the minority: $\frac{24+60}{428} \approx 20\%$.

A	B	C	D	?	all
24	60	102	108	134	428

Test 5. This was the second-chance exam which our university grants (as mentioned above) to the weak students who had found themselves in the academic range *C* after the foregoing regular exam. Tables 19 and 20 summarise our observations of this test.

Intermediate Summary: Pass Rates of the Diligent Students. If our students have provided truthful answers in the voluntary survey, then we can see that the *pass rates* (*A* and *B* combined) of the most diligent students (preparedness codes **A**, **B**) were notably high in many of our five tests, whereby some exceptions to this observation can be explained by varying circumstances: highly intelligent students do not need many preparation hours to do well, whilst desperate students can spend many futile hours of hopeless cramming if their intellectual capacity is not sufficient to grasp the materials to be studied for the tests. However, in spite of the generally well visible advantages of diligence in preparation time, only a small minority of our students listened and obeyed

to our repeatedly uttered warnings about the importance of diligence and a sufficiently high number of preparation hours before every test. The large majority of our students did not follow our advice for any of those 5 tests.

Table 18. Academic performance of diligent preparers versus others in test 4, the first after-semester exam from which the weakest students were already excluded. Again we see that the highest level of preparation time (code **A**) does *not* guarantee highest academic achievements (level *A*). Classified in terms of Bloom's taxonomy, this exam was moderately difficult.

Diligence / Performance	A:pass	B:pass	C:fail	D:fail	all
A	—	$\frac{15}{24} \approx 63\%$	$\frac{5}{24} \approx 21\%$	$\frac{4}{24} \approx 17\%$	$\approx 100\%$
B	$\frac{3}{60} \approx 5\%$	$\frac{29}{60} \approx 48\%$	$\frac{20}{60} \approx 33\%$	$\frac{8}{60} \approx 13\%$	$\approx 100\%$
C	$\frac{2}{102} \approx 2\%$	$\frac{58}{102} \approx 57\%$	$\frac{31}{102} \approx 30\%$	$\frac{11}{102} \approx 11\%$	$\approx 100\%$
D	$\frac{10}{108} \approx 9\%$	$\frac{64}{108} \approx 59\%$	$\frac{20}{108} \approx 19\%$	$\frac{14}{108} \approx 13\%$	$\approx 100\%$
?	$\frac{6}{134} \approx 4\%$	$\frac{64}{134} \approx 48\%$	$\frac{32}{134} \approx 24\%$	$\frac{32}{134} \approx 24\%$	$\approx 100\%$

Table 19. Participants of test 5 (second-chance exam for the weak students), in absolute numbers, grouped by their self-indicated levels of preparation diligence. Diligent (code **B**) and highly diligent students (code **A**) were again in the minority: $\frac{14+19}{115} \approx 29\%$.

A	B	C	D	?	all
14	19	10	14	58	115

Table 20. Academic performance of diligent preparers versus others in test 5, the final-chance exam for some of the weak students who stood at academic level *C* after the foregoing regular exam. Stronger students did not participate in this test any more. For the weakest students in this cohort even the highest numbers of preparation hours (code **A**), presumably spent in panic, are futile.

Diligence / Performance	A:pass	B:pass	C:fail	D:fail	all
A	—	$\frac{2}{14} \approx 14\%$	$\frac{3}{14} \approx 21\%$	$\frac{9}{14} \approx 64\%$	$\approx 100\%$
B	—	$\frac{2}{19} \approx 11\%$	$\frac{11}{19} \approx 58\%$	$\frac{6}{19} \approx 32\%$	$\approx 100\%$
C	—	$\frac{3}{10} \approx 30\%$	$\frac{3}{10} \approx 30\%$	$\frac{4}{10} \approx 40\%$	$\approx 100\%$
D	—	$\frac{1}{14} \approx 7\%$	$\frac{3}{14} \approx 21\%$	$\frac{10}{14} \approx 71\%$	$\approx 100\%$
?	—	$\frac{6}{58} \approx 10\%$	$\frac{26}{58} \approx 45\%$	$\frac{26}{58} \approx 45\%$	$\approx 100\%$

4.3 Did the Buddies Prepare Themselves More Diligently?

In the foregoing two sub-sections we had seen

- that the overall pass-rate was notably high amongst members of the study buddy scheme,
- and
- that the overall pass-rate was notably high amongst diligent students with many preparation hours, too.

Hence the question arises whether there was perhaps some connection between being a diligent preparator and being a member of the study buddy scheme? This was, after all, the basic idea of the study buddy scheme: that the buddies motivate and monitor each other to be more diligent.

In order to find an answer to this question we had to retrieve from our data sheets about our above-mentioned five tests the information whether the *proportion of diligence* (codes **A**, **B**) among study buddies (code **Y**) was notably higher than the proportion of diligence within the remaining cohort. That is the topic of this sub-section, whereby all the subsequently presented findings must be taken with a pinch of salt because the *both* number of buddies *and* the number of diligent preparators were so very small in comparison with the large size of our entire cohort: statistical reliability is not to be expected under such circumstances. Again the following evaluations also suffer from the possibility of wrong information being provided by the students in their voluntary survey answers, and again our observations might be somewhat obscured by the high frequency of non-answerers (code **?**) in all our tests.

In the following paragraphs, $pd_{AB}(Y)$ denotes the proportion of diligence at preparation-hours level $\{A, B\}$ among study buddies, whereas $pd_{AB}(N?)$ denotes ‘ditto’ for all the other students.

Test 1. For this test we can retrieve from our data sheet:

- $pd_{AB}(Y) = \frac{20}{73} \approx 27\%$
- $pd_{AB}(N?) = \frac{52}{566-73} \approx 11\%$

Which is a noteworthy difference, *although* the *majority* of the buddies ($\approx 73\%$) was not particularly diligent either. Nonetheless, at least in some cases of preparation in pairs the mutual motivation idea seems to have worked.

Test 2. For this test we can retrieve from our data sheet:

- $pd_{AB}(Y) = \frac{27}{75} \approx 36\%$
- $pd_{AB}(N?) = \frac{54}{507-75} \approx 13\%$

All in all, also in this test the study buddies were notably *less negligent* than all other participants.

Test 3. For this test we can retrieve from our data sheet:

- $pd_{AB}(Y) = \frac{2}{2} \approx \mathbf{100\%}$
- $pd_{AB}(N?) = \frac{2}{42-2} \approx \mathbf{5\%}$

These observations must be taken with a pinch of salt again, due to the rather small number of participants in this test.

Test 4. For this test (the after-semester exam) we can retrieve from our data:

- $pd_{AB}(Y) = \frac{30}{76} \approx \mathbf{39\%}$
- $pd_{AB}(N?) = \frac{54}{428-76} \approx \mathbf{15\%}$

Which makes a noteworthy difference with apparent significance.

Test 5. For this test we can retrieve from our data:

- $pd_{AB}(Y) = \frac{2}{5} \approx \mathbf{40\%}$
- $pd_{AB}(N?) = \frac{31}{115-5} \approx \mathbf{28\%}$

Even in this final-chance opportunity most students were negligent with their preparation hours, although also in this case the level of negligence was considerably less among the study buddies than among the other students.

Intermediate Summary. All in all, we might thus tentatively conjecture some triangular or ternary connection — even if it is not very strong from a rigorous statistical point of view — between the three properties of ‘being diligent’, ‘having a study buddy’, and ‘achieving good marks’ in a forthcoming test.

5 Discussion and Recommendations

The number of preparation hours and the buddy system were studied separately, due to the low number of participants in the buddy system. It would be false to mingle the two aspects together, because the collected sample sizes diverge too much. This study is qualitative in nature in which the precise numbers were not in the foreground of our interest.

The reliability of our results is on the one hand somewhat threatened by the comparatively large number of non-answerers (code ?) in every test, and on the other hand also by possibility for the students to provide false answers in the voluntary survey. Nonetheless we seem to be able to see from those five tests that poor academic performance is by-and-large a matter of not investing the recommended number of home study hours

on the side of the students, regardless of how fashionably ‘technologized’ and ‘electronically equipped’ our lecture halls are. During 4 of our 5 tests, maximally 20% of students came well prepared, in number of actual study hours h versus the recommendation n provided as pre-test advice by the lecturers. During those tests, at least 80% of the students came underprepared into every test, in spite of the many warnings and reminders which they had received again and again during the ongoing course. The only exception was test 5, the second-chance exam for the week students who are typically desperate. This situation motivated about 30% of the participants to prepare themselves really diligently, however, about 70% came still underprepared into this very last opportunity for them to pass the OS course.

In addition to what had already been mentioned in other literature, this shortage of preparation hours at the students’ home is perhaps due to overloading of the BSc-CS curriculum with too many course modules to be done in one academic year, and with too many assessments (written assignments, programming practicals, etc.) being demanded of our students in each and every course.

As far as the study buddy scheme is concerned, from what we have seen we may conjecture tentatively that studying with a friend improves the chances of passing. For each of the evaluated tests, students who studied alone had between 5% and 52% lower pass rates. Similar to [16] we observed that as the semester progressed, more and more students sought out a friend to assist them with the test preparation. Even with this increase during the semester, only about 13% to 18% of students participated in the buddy system.

We also conjecture that most of the non-answering students (code ?) might have been all too well aware of their own ‘academic poverty’ in these tests, and might thus have felt too frustrated to answer the voluntary survey questions especially for this reason.

For the future we recommend other educators to encourage students to seek out help from a friend as early as possible. Especially engineers and students of hard sciences lean toward introversion and therefore prefer studying alone. This is detrimental to students who struggle to understand the work on their own. Educators should also motivate students to put in more effort and longer study times. However, due to most students having a fully packed schedule, both academically and socially, this encouragement will mostly fall on deaf ears.

6 Conclusion

This paper investigated the correlation between the academic performance of students, and their preparation hours in addition to whether or not they studied with a friend. The data of more than 500 students in a first-year computer science course was evaluated. It was found that although the study buddy system is unpopular amongst computer science and engineering students, it did indeed increase the pass rate of the participants. A higher number of study hours also had a notable impact on the pass rate. However, the majority of students came to the tests underprepared and studied less than the recommended preparation hours.

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