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The Effect of Student Time Allocation on Academic Achievement

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Technische Universität Dortmund, Department of Economic and Social Sciences
Vogelpothsweg 87, 44227 Dortmund, Germany

Universität Duisburg-Essen, Department of Economics
Universitätsstr. 12, 45117 Essen, Germany

Rheinisch-Westfälisches Institut für Wirtschaftsforschung (RWI)
Hohenzollernstr. 1-3, 45128 Essen, Germany

Editors

Prof. Dr. Thomas K. Bauer
RUB, Department of Economics, Empirical Economics
Phone: +49 (0) 234/3 22 83 41, e-mail: thomas.bauer@rub.de

Prof. Dr. Wolfgang Leininger
Technische Universität Dortmund, Department of Economic and Social Sciences
Economics – Microeconomics
Phone: +49 (0) 231/7 55-3297, email: W.Leininger@wiso.uni-dortmund.de

Prof. Dr. Volker Clausen
University of Duisburg-Essen, Department of Economics
International Economics
Phone: +49 (0) 201/1 83-3655, e-mail: vclausen@vwl.uni-due.de

Prof. Dr. Christoph M. Schmidt
RWI, Phone: +49 (0) 201/81 49-227, e-mail: christoph.schmidt@rwi-essen.de

Editorial Office

Joachim Schmidt
RWI, Phone: +49 (0) 201/81 49-292, e-mail: joachim.schmidt@rwi-essen.de

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Barbara S. Grave[1]

The Effect of Student Time Allocation on Academic Achievement

Abstract

There is a large literature on the influence of institutional characteristics on student academic achievement. In contrast, relatively little research focuses on student time allocation and its effects on student performance. This paper contributes to the literature by investigating the effect of student time allocation on the average grade of undergraduate students, by gender, ability and field of study. The results suggest that time spent on attending courses is positively associated with grades for females, high ability students and students of Social Sciences and Sciences/Engineering. Spending time on self-study, on other study-related activities or on working as a student assistant or tutor is positively correlated with grades for almost all students. Devoting time for attending tutorials or student work groups is negatively correlated with grades if the ability of the students is below average or if they study Sciences/ Engineering. Using a translog production function, the results indicate that spending time on courses, on self-study, and on other study-related activities are substitutes. However, time spent on courses and time spent on working as a student assistant or tutor are complements.

JEL Classification: I21, J2

Keywords: Student time allocation; student performance; educational production function

December 2010

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1 Introduction

A vast number of empirical studies analyze students' academic performance in the context of an educational production function, concentrating on the effect of characteristics of educational institutions, such as student-teacher ratio, class size, expenditure per student, and on the contrast between public and private institutions (for an overview, see Hanushek, 1997, 2003). Relatively little is known about students' time allocation and its effect on students' academic achievement. However, this could be of importance for both the students themselves and the educational institutions. For students, it is important to know how to allocate their time most efficiently to maximize high academic performance. The educational institutions may be interested in knowledge about the efficiency of, for example, increasing instruction time for students or increasing the supply of tutorials because of the competitive nature of scarce of financial resources.

The issue of the allocation of financial resources in the higher education system has recently received much attention in Germany because universities were only allowed to charge limited tuition fees quite recently. In 2005, the Federal Constitutional Court lifted the general ban on charging tuition fees with the result that each federal state could decide independently whether to charge tuition fees. Indeed, some federal states now charge tuition fees of up to 500 Euros per semester which has opened up a new source of financial resources for universities.[2] Universities are restricted in using theses revenues for the improvement of teaching by, for example, improving the student-professor ratio or increasing the supply of courses.[3] The University of Bochum, for instance, spent 48% of the revenues from tuition fees for additional teaching and 15% for tutorials and mentoring programs.[4] Against this background, it is of crucial interest how students' time allocation affects their academic achievement.

This paper tries to shed some light on the effectiveness of attending courses or tutorials by investigating the effects of student time allocation on academic achievement using a student survey conducted from 1986 to 2006 by the AG Hochschulforschung at the University of Konstanz. The main contribution offered here is the analysis of this issue for the whole group of undergraduate students in different fields of study at different universities. Further-

[2] Lower Saxony and North Rhine-Westphalia have charged tuition fees since the Winter Semester 2006/07, Baden-Wuerttemberg, Bavaria, and Hamburg since the Summer Semester 2007 and Saarland since the Winter Semester 2007/08. Hesse charged tuition fees only in the Winter Semester 2007/08 and the following Summer Semester.

[3] On average, tuition fees contribute 10% to total revenues.

[4] The remaining revenues from tuition fees were spent on the improvement of equipment (28%), on Student Advisory Service (5%), on pilot projects for new forms of learning (3%) and on the administration of tuition fees (1%).

more, the relatively big sample size facilitates a detailed investigation for different subgroups, namely male and female students, below- and above-average ability students (measured by the final high school grade), and students of Arts/ Humanities, Social Sciences, and Sciences/ Engineering. Since time use is endogenously determined, the results presented here are of a predominantly descriptive nature. Nonetheless, important associations between student time use and academic achievement and between the different types of time use themselves can be uncovered. This knowledge can support the universities in improving the learning environment of students, e.g. regarding the supply of courses and tutorials or the time provided for self-study.

The empirical results suggest that the time allocation matters for educational achievement, even after controlling for a number of variables, including ability, motivation, characteristics of the study, and the university. Regarding the different types of time use considered here, time devoted to courses seems to affect educational achievement positively for female and for high ability students. The same holds true for students of Social Sciences and Sciences/ Engineering. Time use for self-study is positively associated with grades and the effect is similar by gender, ability, and field of study. Only for students of of Sciences/ Engineering the correlation appears to be insignificant. In contrast, time devoted to student groups or tutorials appears to be negatively associated with academic achievement. Splitting the sample into subgroups, this result holds true only for students with low ability and those of Sciences/ Engineering. Time spent on other study-related activities and on working as a student assistant is positively correlated with grades irrespective of gender, ability or field of study. An exception are students of Arts/ Humanities. For these students no significant association between grades and time spent on other study related activities can be found. Working in other than student employment has no effect on student performance. Using a translog production function shows that time spent on attending courses and on self-study are substitutes as well as time use for courses and for other study-related activities. However, time spent on courses and time spent on working as a student assistant or tutor are complements.

The remainder of this paper is organized as follows. Section 2 gives an overview on the related literature, in section 3 the empirical framework and the data are described. Section 4 presents the results and section 5 concludes.

2 Related Literature

Understanding the technology of combining schooling inputs to create educational achievement outcomes has been the focus of research in recent years. A common framework to investigate this productivity relationship is the educational production function. Taking students' educational achievement as output, which is mostly measured by test scores, there seems to be a consensus that family background, peer inputs, and school inputs are important determinants. Most of the research is focused on the input-output relationship for school-age children. Yet, little is known about the factors affecting student outcomes in higher education. Additionally, in the discussion about the determinants of educational, only little attention is paid to student time allocation as an input factor. Becker (1965) raised the problem of individuals' time allocation assuming that households are consumers and producers at the same time. With respect to students, the time allocation problem can be seen as the problem of maximizing the output (measured in grades) by choosing the optimal input of time for different (competing) activities.

Levin and Tsang (1987) address this problem by developing a theoretical model of the student time allocation problem using an educational production function that is expanded by variables representing student effort and time. It is assumed that the student has resources in terms of both time and effort at his personal disposal. They can combine these resources to produce activities efficiently so as to maximize their utility. Using an example with two activities, namely learning activity in school and out-of-school activity, they suggest that an increase in instructional time leads to a decrease in effort per unit of time and therefore the net effect on educational performance will be small. They conclude that a mechanical increase in instructional time does not automatically lead to an increase in student achievement.

Regarding the empirical evidence on student time use, several studies deal with the effect of course attendance on academic achievement. To a great extent, these studies are based on samples of students in specific courses (mostly economics courses). The overall finding is that attendance positively affects academic performance (e.g. Schmidt, 1983; Park and Kerr, 1990; Romer, 1993; Durden and Ellis, 1995; Devadoss and Foltz, 1996; Chan, Shum, and Wright, 1997; Bauer and Zimmermann, 1998). Determinants of lecture attendance and self-study are analyzed by Ryan, Delaney, and Harmon (2010). Estimating separate regressions for both types of time use, they find that non-cognitive abilities such as future-orientation and conscientiousness are important for the amount of time students spent on both attending lectures and self-study.

Looking explicitly at students' time allocation, little evidence is available. Schmidt (1983) uses a sample of students in a macroeconomic principles course and finds that the effect of lecture attendance is higher than the one for study hours. Stinebrickner and Stinebrickner (2008) investigate the causal effect of spending time for studying on academic achievement for first year students at Berea College (US). Using whether one of the randomly assigned roommates brings a video or a computer game with them as an instrument, they find evidence that an increase in study quantity by one hour increases the performance significantly.

Using more than one time use variable, Lassibille, Navarro-Gomez, and Paul (1995) compare the average amount of time that is spent on different types of student activities for Brazil, France, and Spain and find indeed country specific disparities. Dolton, Marcenaro, and Navarro (2003) find that time spent on lectures is more productive than time spent on self-study, time used for private tuition has a negative effect, and time used for employment has no effect. They use data on first- and final-year students collected in the classroom at the University of Malaga (Spain). However, their results might be affected by a selection bias since their data are collected during class. Bratti and Staffolani (2002) investigate the effects of students' different time use using data on first-year economic students at the University of Ancona (Italy). They find that the relative importance of attendance and self-study varies across exams. Attendance seems to improve performance especially in quantitative disciplines such as Mathematics and Economics, whereas self-study seems to be more important for non-quantitative disciplines such as Law and Economic History. The relationship between students' time use and self-assessed discipline-specific and generic competencies is analyzed by Meng and Heijke (2005). They use data on higher education graduates from nine different European countries and find that attending courses solely increases the efficiency of acquiring discipline-specific competencies whereas it is harmful for generic competencies. However, self-study and subject-related work increase both types of competencies.

The focus in the present study lies on the way in which the students' time allocation transforms into academic achievement, departing from the existing literature in three aspects. First, the allocation of time is analyzed for the whole group of undergraduate students in several fields of study at different universities. Furthermore, six different types of student time use are distinguished. Second, the relatively large sample size facilitates the estimation of the effect of students' time allocation for different subgroups, namely men and women, below- and above-average ability students (measured by their final high school grade), and students of different fields of study. Third, the analysis is augmented by using a translog production function to investigate whether the different activities are substitutes or complements.

3 Empirical framework and data

In this analysis, an expanded educational production function,

$$g = h(\mathbf{T}, \mathbf{A}, \mathbf{M}, \mathbf{R}, \mathbf{X}), \tag{1}$$

is utilized. It regards educational achievement g as a function of the time devoted to different activities $\mathbf{T}$, ability $\mathbf{A}$, motivation $\mathbf{M}$, level of learning resources $\mathbf{R}$, and socioeconomic characteristics $\mathbf{X}$. The data used is the Student Survey 1983-2007 collected by the AG Hochschulforschung at the University of Konstanz.[5] This survey is a representative sample of German students enrolled at universities or universities of applied science (*Fachhochschulen*). It started in the Winter Term 1982/1983 and was repeated in a two-year and three-year cycle, respectively. In every wave, between 7,000 and 10,000 German students at different universities and universities of applied science were asked about different topics related to their study, e.g, their time use, their study behavior, the quality of teaching, and some socioeconomic characteristics.[6] The main strength of this dataset is the combination of characteristics of the course of study with students' socioeconomic characteristics. I concentrate on the period between 1986 and 2006, including eight waves of the survey because some time use variables are available only since 1986. The outcome variable is measured as the average grade the student has earned during their undergraduate study up to the day of the interview. The grade is measured as a continuous variable from 1.0 to 5.0.[7]

The vector $\mathbf{T}$ includes several variables that measure the time students devote to different activities. Time is measured in average hours per week the students spent in the current semester on the specific activity. The activities considered are (1) attending courses including lectures, exercises, seminars, and laboratories, (2) self-study, (3) attending student work groups or tutorials, (4) other study-related activities like attending a computer course, borrowing books, or attending office hours (5) working as a student assistant or tutor, and (6) working in other employment. Squared measures of the time variables are also included due to possibly declining marginal productivity of time use for some activities.

Table 1 documents average hours spent on these six activities between 1986 and 2006

[5] The data set and its documentation (Simeaner, Dippelhofer, Bargel, Ramm, and Bargel, 2007) is distributed by the GESIS-ZA Central Archive for Empirical Social Science (GESIS-ZA Zentralarchiv für empirische Sozialforschung) or by the AG Hochschulforschung at the University of Konstanz.

[6] The survey started in 1982 with eight universities and three universities of applied science. In 2006, students at 16 universities and ten universities of applied science were surveyed.

[7] The German grading scheme ranges from 1.0 in 0.1 steps up to 5.0. The grade is (by substraction from 7) transformed such that a positive sign in the estimation output indicates an improvement.

Table 1: Differences in average student time use, by gender and year

Year	1986	1989	1992	1994	1997	2000	2003	2006
				Courses				
Male (M)	18.486	18.583	18.832	18.756	18.542	18.816	18.065	19.189
Female (F)	18.170	18.171	19.210	19.595	20.207	19.724	18.842	19.084
t-value: (M)=(F)	-0.756	-0.959	1.035	1.858	3.642	2.130	2.108	-0.243
				Self-study				
Male (M)	14.683	14.776	13.173	11.104	10.820	10.269	10.596	11.966
Female (F)	13.954	13.742	12.391	11.036	11.430	11.468	11.110	12.497
t-value: (M)=(F)	-1.440	-1.946	-1.787	-0.149	1.193	2.659	1.281	1.022
				Student work groups/ tutorials				
Male (M)	2.812	2.497	2.307	2.948	3.235	2.931	3.182	3.008
Female (F)	2.034	2.072	1.728	2.379	2.232	2.114	2.287	2.466
t-value: (M)=(F)	-4.204	-2.493	-3.915	-2.905	-4.886	-4.294	-5.018	-2.716
				Other study relates activities				
Male (M)	2.337	2.018	2.276	2.674	2.520	2.448	1.928	2.168
Female (F)	2.816	2.659	2.740	3.061	3.242	2.683	2.267	2.433
t-value: (M)=(F)	2.543	4.628	2.993	2.072	3.908	1.561	3.078	1.910
				Student assistant/ tutor				
Male (M)	0.201	0.375	0.366	0.271	0.422	0.551	0.483	0.524
Female (F)	0.289	0.288	0.169	0.581	0.336	0.436	0.320	0.374
t-value: (M)=(F)	1.108	-0.958	-2.152	2.627	-0.794	-0.993	-1.831	-1.224
				Employment				
Male (M)	3.579	4.162	4.212	4.914	4.983	4.231	3.439	2.997
Female (F)	3.764	4.883	4.308	4.730	5.191	4.518	4.550	4.377
t-value: (M)=(F)	0.556	2.043	0.306	-0.459	0.498	0.828	3.662	4.045

Source: Student survey 1983-2007, AG Hochschulforschung, own calculations.

between male and female students. Men spend on average more time on student work groups or tutorials, while women spend more time on other study-related activities. Over time, the amount of time spent in these different activities stayed quite stable. Comparing 2006 to 1986, time spent on attending courses increased slightly whereas time spent on self-study decreased slightly. While women allocated in 2006 more time to attending student work groups or tutorials, and less time to other study related activities, men spent more time for working as a student assistant and less time on other employment.

Across different ability strata, distinguished by the final high school grade, contrasts are more pronounced (Table 2). Above-average ability students devote significantly more time to both attending courses and self-study while they spend less time on employment. Comparing the amount of time spent on different activities between 1986 and 2006, the amount stayed quite stable over time. For high ability students the amount of time spent on courses increased slightly, whereas the amount spent on other study related activities decreased. For both types of students the amount spent on self-study decreased while that spent on working as a student assistant increased.

In Table 3 the differences in time use pattern are depicted for students of different fields

Table 2: Differences in average student time use, by ability and year

Year	1986	1989	1992	1994	1997	2000	2003	2006
				Courses				
Below average (A1)	17.738	17.642	17.771	17.855	18.268	18.158	17.781	17.974
Above average (A2)	19.059	19.208	20.096	20.328	20.320	20.361	19.161	20.219
t-value: (A1)=(A2)	3.446	3.791	6.654	5.669	4.514	5.207	3.773	5.263
				Self-study				
Below average (A1)	13.663	13.115	12.403	10.430	10.505	10.568	10.443	11.349
Above average (A2)	15.302	15.624	13.360	11.746	11.680	11.195	11.285	13.050
t-value: (A1)=(A2)	3.506	4.930	2.254	2.962	2.310	1.389	2.106	3.289
				Student work groups/ tutorials				
Below average (A1)	2.721	2.188	2.339	2.651	2.797	2.503	2.601	2.831
Above average (A2)	2.403	2.493	1.862	2.799	2.750	2.518	2.782	2.647
t-value: (A1)=(A2)	-1.856	1.857	-3.333	0.769	-0.229	0.079	1.012	-0.921
				Other study relates activities				
Below average (A1)	2.296	2.265	2.371	2.798	2.972	2.632	2.169	2.285
Above average (A2)	2.685	2.245	2.518	2.856	2.742	2.507	2.058	2.362
t-value: (A1)=(A2)	2.242	-0.146	0.978	0.318	-1.238	-0.833	-1.010	0.530
				Student assistant/ tutor				
Below average (A1)	0.188	0.320	0.221	0.312	0.255	0.358	0.298	0.380
Above average (A2)	0.270	0.365	0.359	0.474	0.503	0.620	0.486	0.507
t-value: (A1)=(A2)	1.118	0.515	1.554	1.399	2.297	2.285	2.119	1.038
				Employment				
Below average (A1)	4.279	5.517	5.616	5.944	6.218	5.336	4.988	4.743
Above average (A2)	2.954	3.370	2.961	3.733	3.979	3.455	3.132	2.737
t-value: (A1)=(A2)	-4.323	-6.382	-9.005	-5.702	-5.428	-5.490	-6.192	-5.927

Source: Student survey 1983-2007, AG Hochschulforschung, own calculations.

of study, namely Arts/ Humanities, Social Sciences, and Sciences/ Engineering. Comparing these three fields of study with each other, students of Sciences/ Engineering invest more time in attending courses and in self-study and less time in employment, while students of Arts/ Humanities spent more time on other study related activities. Regarding time spent on student work groups or tutorials, students of Social Sciences spent most time, students of Sciences/ Engineering second most and students of Arts/ Humanities the least time. Comparing the time allocation pattern of 1986 with that of 2006, the differences are moderate. Arts/ Humanities students spent in 2006 more time on attending courses and less time on other study related activities. While students of all three fields of study invested less time in self-study, students of Social Sciences and Sciences/ Engineering spent more time on working as a student assistant or tutor. Regarding time spent on other employment, students of Social Sciences invested in 2006 more time in this activity while those of Sciences/ Engineering invested less time.

Table 3: Differences in average student time use, by field of study and year

Year	1986	1989	1992	1994	1997	2000	2003	2006
				Courses				
Arts/ Humanities (F1)	15.136	15.653	17.334	18.055	18.051	17.311	17.324	17.127
Social Sciences (F2)	17.181	17.305	17.529	17.980	17.362	18.101	16.851	17.866
Science/ Engineering (F3)	20.162	20.251	20.644	20.249	21.253	21.234	20.366	21.003
t-value: F1=F2	4.227	3.440	0.467	-0.136	-1.276	1.579	-1.150	1.438
t-value: F1=F3	9.797	8.686	7.428	3.873	5.764	7.789	7.017	7.872
t-value: F2=F3	6.565	5.746	7.219	4.240	6.880	5.740	7.268	5.413
				Self-study				
Arts/ Humanities (F1)	13.330	12.409	11.352	10.486	10.646	9.190	10.245	10.724
Social Sciences (F2)	13.210	13.188	10.749	9.834	9.217	8.886	9.792	11.592
Science/ Engineering (F3)	15.506	15.874	14.893	12.137	12.492	13.119	12.039	13.507
t-value: F1=F2	-0.180	1.165	-1.212	-1.268	-2.362	-0.674	-0.961	1.316
t-value: F1=F3	3.372	5.247	6.580	2.810	2.869	6.951	3.721	4.679
t-value: F2=F3	4.222	4.319	8.034	4.191	5.257	7.294	4.317	2.710
				Student work groups/ tutorials				
Arts/ Humanities (F1)	1.566	1.653	1.323	1.586	1.868	1.481	1.538	1.860
Social Sciences (F2)	3.283	3.084	2.798	3.277	3.666	3.640	3.533	3.574
Science/ Engineering (F3)	2.558	2.268	2.092	2.996	2.822	2.504	3.063	2.914
t-value: F1=F2	7.101	6.115	8.378	7.724	6.566	8.704	10.540	7.673
t-value: F1=F3	4.510	3.180	4.471	6.008	3.983	5.230	7.608	4.635
t-value: F2=F3	-3.474	-3.951	-3.846	-1.138	-3.317	-4.383	-1.860	-2.299
				Other study relates activities				
Arts/ Humanities (F1)	3.641	3.103	3.121	3.842	3.498	2.875	2.636	2.868
Social Sciences (F2)	2.331	2.218	2.251	2.647	2.624	2.537	1.954	2.083
Science/ Engineering (F3)	2.148	1.904	2.204	2.420	2.591	2.378	1.810	2.080
t-value: F1=F2	-4.501	-4.458	-4.355	-4.298	-3.694	-1.801	-4.747	-3.837
t-value: F1=F3	-6.753	-6.889	-4.883	-5.959	-3.982	-2.728	-6.471	-4.525
t-value: F2=F3	-0.955	-2.113	-0.263	-1.255	-0.146	-0.829	-1.060	-0.019
				Student assistant/ tutor				
Arts/ Humanities (F1)	0.350	0.279	0.171	0.404	0.331	0.348	0.342	0.253
Social Sciences (F2)	0.135	0.195	0.106	0.233	0.441	0.360	0.309	0.430
Science/ Engineering (F3)	0.235	0.434	0.461	0.487	0.379	0.659	0.489	0.578
t-value: F1=F2	-2.032	-0.826	-0.975	-1.237	0.716	0.088	-0.303	1.179
t-value: F1=F3	-1.054	1.328	2.340	0.531	0.400	2.166	1.357	2.413
t-value: F2=F3	1.260	2.245	3.024	1.829	-0.456	1.981	1.596	0.836
				Employment				
Arts/ Humanities (F1)	4.900	6.382	5.308	6.216	6.299	5.393	5.066	4.630
Social Sciences (F2)	3.859	4.883	5.253	5.808	6.283	5.202	5.355	5.040
Science/ Engineering (F3)	3.062	3.288	3.120	3.573	3.607	3.207	2.444	2.477
t-value: F1=F2	-2.111	-2.813	-0.120	-0.697	-0.027	-0.388	0.665	0.803
t-value: F1=F3	-4.536	-7.501	-6.321	-5.807	-5.782	-5.549	-8.075	-5.707
t-value: F2=F3	-2.307	-4.217	-6.133	-4.900	-5.397	-4.867	-8.099	-6.062

Source: Student survey 1983-2007, AG Hochschulforschung, own calculations.

A major difficulty with time use data is measurement error. Persons often do not remember their time allocation accurately. Juster and Stafford (1986) state that there are many potential biases in asking people about their time use. They consider collecting time use data by using a diary as the preferred survey method. Unfortunately, in this study, only average hours per week are available. However, Juster and Stafford (1991) offer some reassurance for collecting time use data regarding questions like "How much time did you spend on average for activity X last week?", if activities follow a daily work pattern with regular schedules. For such data types, they conclude that the reporting error is negligible. For most of the activities considered here, this requirement can be seen as fulfilled, e.g., courses and student work groups follow a more or less regular schedule as well as hours spent on working either as a student assistant or in other employment.

Another problem is caused by different periods of reference for the information on time use and academic achievement. The students were asked about their time use for different activities in the current semester. The information about the average grades refers to the grades the students earned during their whole study up to the day of the interview. For this reason I have to assume that the time spent on different activities stays stable over all semesters.[8]

Other variables that might affect academic achievement are related to the educational background of the students and their parents. Vector $\mathbf{A}$ includes the students' final high school grade as well as the parents' educational background. Additionally, the occupational background of the parents is included as a proxy for their income.[9] As proxies for motivation, two variables are included, namely whether the main reason for going to university was the student's special interest in the subject or whether it was to earn more money afterwards. The quality of the university is captured in vector $\mathbf{R}$ by including the students perception of the quality of the courses, the procedure of the courses, and the mentoring at university. These three dimensions of quality are constructed by aggregating several quality related questions into the three categories "low", "medium", and "high". A problem with using students' perception

[8]To check this assumption I did some robustness checks by excluding freshmen from the data. For these students, it can be assumed that they first have to learn how to allocate their time most efficiently. The results change only marginally.

[9]The occupational background is categorized according to Hoffmann (2002). The category "low" comprises, e.g., unskilled, semi-skilled, and skilled workers; the category "medium", e.g., lower- and medium-grade civil servants, qualified employees, and small or medium size self-employed. In the category "high" are managerial employees, upper- and higher-grade civil servants, large self-employed, members of professions, and self-employed university graduates included. The category "other occupational status" comprises for fathers being in education, has never worked, or the occupation is not known. For mothers, this category comprises being in education or the occupation is not known. For mothers, that have never worked, an additional category is generated.

of the university's quality is that, on the one hand, it could be correlated with educational achievement, e.g., teachers could "buy" a better evaluation through better grading (e.g., Siegfried and Fels, 1979; Nelson and Lynch, 1984; Krautmann and Sander, 1999; Langbein, 2008). On the other hand, it is arguable how well students can appraise the quality, especially the academic quality, of the lecture (e.g., Husbands and Fosh, 1993).[10]

Vector $\mathbf{X}$ comprises age and gender of the student. Furthermore, variables are included that capture whether the student has a vocational degree, whether they have changed the field of study or the university since first enrollment, the student's field of study, the duration of the study, and the university the student is enrolled in. Year dummies are included to control for year effects. Fixed effects for both the university and the field of study control for bias resulting from time-invariant unobserved characteristics of the university or the field of study.

The sample is restricted to undergraduate students studying for their first degree. Only students at universities are considered because of the limited number of observations of students at universities of applied science. The analysis is restricted to undergraduate students because for graduate students only the grade in the intermediate exam (*Vordiplom/Zwischenprüfung*) is available, but without information on the date this exam took place. Furthermore, all students whose first enrollment took place after the age of 31 are excluded, since these students arguably differ from students that enter university at earlier ages. To remove extreme outliers from the sample, the amount of time allocated to courses, to self-study, to student work groups/tutorials and to other study-related activities is restricted to 80 hours per week. For the time devoted to working as a student assistant and employment the sample is restricted to 30 hours per week, concentrating on full-time students only. Robustness checks for these data restrictions did not change the results significantly. The final sample comprises 11,297 students. The summary statistics are presented in Tables 10 and 11 in the Appendix.

4 Results

Table 4 shows the estimation results for three different specifications of the educational production function[11]: Specification (1) includes only the time use variables, gender, and year

[10] I have to rely on the data on the students' perception of the university's quality, because there is no other data available for the whole period of time. I did some robustness checks using other more objective measures of university quality that are available for the years 2000 till 2006 only. The results did not alter significantly in sign and magnitude. Moreover, I aggregated the students' perception on faculty level, but the results did not change either.

[11] A stochastic frontier model is also estimated to account for inefficiency in the utilization of inputs. Following the general assumption that the inefficiency term of the error component is half-normal distributed,

dummies. The second specification additionally includes proxies for the student's ability (student's final high school grade as well as father's and mother's educational and occupational background) and Specification (3) additionally proxies for motivation, the quality of the university and other student-related characteristics.

Including only a gender dummy and the time use variables in the regression (Specification (1)) yields mainly positive effects for the time use variables. Exceptions are attending student work groups or tutorials, which are negatively associated with grades, and time spent on employment for which no significant correlation can be observed. Expanding Specification (1) by including proxies for ability decreases the magnitude of the time use variables' coefficients as well as the significance level. The coefficients for time spent on attending courses, on self-study, and on other study-related activities decrease when including the proxies for ability only, whereas the other coefficients decrease when including the whole set of variables.

Using the full set of variables (Specification (3)), some significant results for the time use variables are retained, even though the magnitudes of the coefficients are relatively small. Students that spend more time on attending courses have significantly higher grades than students that spend less. Whether this effect is due to higher numbers of hours provided by the university or due to a higher attendance rate of the students could unfortunately not be disentangled with this data. A similar association can be observed for devoting time to self-study, but here the marginal productivity is declining. Comparing these two effects, time devoted to courses and time devoted to self-study seem to be associated similarly with grades.

In contrast, the correlation between attending student work groups or tutorials and grades is significant and negative. Dolton, Marcenaro, and Navarro (2003) find a similar effect for attending private tuition. This negative association could be either caused by the inefficiency of such work groups or tutorials or by a selection effect. Unfortunately, with the data at hand, these two effects cannot be disentangled. Nevertheless, this result should be kept in mind when allocating the additional financial resources universities receive from charging tuition fees to, *inter alia*, increase the supply of tutorials. Students who spend more time on other study-related activities seem to have higher grades compared to students who invest less time. Time devoted to activities supporting learning seems to affect grades positively. Devoting time to working as a student assistant or a tutor is positively correlated with grades, but with a decreasing marginal effect.

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the model reveals indeed some inefficiency. However, the coefficients estimated by the stochastic frontier model do not vary from those estimated by OLS. Since OLS requires fewer assumptions, the OLS-results are presented only.

Table 4: Average university grade, OLS-estimation results (whole sample)

	(1)		(2)		(3)	
Male	-0.1007 ***	(0.0193)	-0.0751 ***	(0.0200)	0.0402 ***	(0.0150)
Age					-0.0709 **	(0.0270)
Age, squared					0.0012 **	(0.0005)
Courses	0.0124 ***	(0.0036)	0.0084 **	(0.0035)	0.0061 **	(0.0026)
Courses, squared	-0.0002 ***	(0.0001)	-0.0002 **	(0.0001)	-0.0001	(0.0001)
Self-study	0.0087 ***	(0.0020)	0.0064 ***	(0.0020)	0.0060 ***	(0.0017)
Self-study, squared	-0.0001 ***	(0.0000)	-0.0001 **	(0.0000)	-0.0001 **	(0.0000)
Student work groups/ tutorials	-0.0143 ***	(0.0048)	-0.0155 ***	(0.0050)	-0.0056 *	(0.0031)
Student work groups/ tutorials, squared	0.0004 **	(0.0002)	0.0004 **	(0.0002)	0.0003	(0.0002)
Other study relates activities	0.0203 ***	(0.0040)	0.0208 ***	(0.0037)	0.0099 ***	(0.0032)
Other study relates activities, squared	-0.0004 ***	(0.0001)	-0.0004 ***	(0.0001)	-0.0002	(0.0001)
Student assistant/ tutor	0.0300 ***	(0.0064)	0.0166 ***	(0.0053)	0.0220 ***	(0.0050)
Student assistant/ tutor, squared	-0.0014 ***	(0.0004)	-0.0008 **	(0.0004)	-0.0009 ***	(0.0003)
Employment	-0.0010	(0.0033)	0.0045	(0.0031)	-0.0001	(0.0022)
Employment, squared	-0.0001	(0.0001)	-0.0001	(0.0001)	0.0000	(0.0001)
Final high school grade			0.2651 ***	(0.0156)	0.2669 ***	(0.0113)
Vocational degree, father			0.0406 **	(0.0201)	0.0289	(0.0176)
Tertiary degree, father			0.0272	(0.0215)	0.0417 *	(0.0211)
High occupational status, father			0.1248 ***	(0.0206)	0.0757 ***	(0.0163)
Middle occupational status, father			0.0789 ***	(0.0176)	0.0527 ***	(0.0163)
Other occupational status, father			0.0332	(0.0309)	0.0050	(0.0277)
Vocational degree, mother			0.0144	(0.0190)	0.0186	(0.0172)
Tertiary degree, mother			-0.0098	(0.0243)	0.0212	(0.0205)
High occupational status, mother			0.1014 ***	(0.0256)	0.0673 ***	(0.0228)
Middle occupational status, mother			0.0673 ***	(0.0190)	0.0431 **	(0.0174)
Other occupational status, mother			0.0869 **	(0.0333)	0.0551 *	(0.0300)
Has never worked/homemaker, mother			0.1147 ***	(0.0196)	0.0889 ***	(0.0173)
Relevance of career for choice of study					-0.0583 ***	(0.0136)
Relevance of interest for choice of study					0.1445 ***	(0.0091)
Quality of mentoring at university					0.0532 ***	(0.0112)
Quality of courses at university					0.0297 ***	(0.0064)
Quality of courses' procedure at university					0.0425 ***	(0.0087)
Completed vocational training					0.0567 ***	(0.0160)
Duration of study (semesters)					-0.0228 **	(0.0088)
Duration of study (semesters), squared					0.0010 *	(0.0006)
Change of university or major					0.0505 ***	(0.0132)
Constant	4.0929 ***	(0.0538)	2.7322 ***	(0.1014)	3.6874 ***	(0.4331)
Year Dummy	Yes		Yes		Yes	
Field of study fixed effects	No		No		Yes	
University fixed effects	No		No		Yes	
R^2 adjusted	0.042		0.127		0.271	
N	11,603		11,384		11,297	

Notes: Clustered standard errors in parenthesis. The time use variables are measured in average hours per week in the current semester. The final high school grade and the average university grade are transformed such that the best grade is a 6.0 and the worst grade is a 3.0 and 2.0, respectively. The parents' occupational status is classified according to Hoffmann (2002). The category "low" comprises, e.g., unskilled, semi-skilled, and skilled workers; the category "medium", e.g., lower- and medium-grade civil servants, qualified employees, and small or medium size self-employed. In the category "high" are managerial employees, upper- and higher-grade civil servants, large self-employed, members of professions, and self-employed university graduates included. The category "other occupational status" comprises for fathers being in education, has never worked, or the occupation is not known. For mothers, this category comprises being in education or the occupation is not known. For mothers, that have never worked, an additional category is generated. * $p < 0.10$, ** $p < 0.05$,*** $p < 0.01$.
Source: Student survey 1983-2007, AG Hochschulforschung, own calculations.

Male students have significantly better grades than their female counterparts. Age displays a U-shaped pattern, meaning that older students earn significantly lower grades than younger students with a turning point at the age of 28. Billari and Pellizzari (2008) find a similar result when looking at students at an Italian university. Whereas there is conclusive evidence that girls outperform boys in primary and secondary schools, less evidence is available for the case of tertiary education. The proxies for ability show the expected pattern. A good final high school grade is associated with a good average university grade. Students with better-educated fathers have higher grades. The same holds true regarding the occupational status, using a low occupational status as the reference group. The education of the mother does not seem to be important, but her occupational status matters. The highest positive effect could be observed if the mother has never worked.

Students who chose the field of study due to career opportunities earn significantly lower grades than students with other main reasons. This finding is in line with the findings of Dolton, Marcenaro, and Navarro (2003). The opposite is true for students whose main reason was the interest in the topic. The quality of the university measured by student perception is positively and significantly associated with grades and this holds true for all three dimensions captured. If the student has earned a vocational degree before entering the tertiary system, the average grade is significantly higher compared to a student without this degree. Regarding the duration of the study, a U-shaped pattern is observed, meaning that students in higher study-related semesters have significantly lower grades than students in lower semesters, but the negative effect decreases with a rising number of semesters. Students who have changed the university or the field of study since first enrollment appear to have significantly higher grades than students who have never changed. This result points to the fact that changing the university or the field of study leads eventually to a better match quality of student and university and student and field of study, respectively.[12]

Results for subgroups

Previous research shows that several differences between men and women with respect to education and educational outcomes exist, e.g., differences in educational performance, educational attainment or wages (e.g., Smith and Naylor, 2001; McNabb, Pal, and Sloane, 2002;

[12]To test whether the results are stable, the educational production function is estimated separately for students that do not invest time in attending student work groups/ tutorials or working as as students assistant or and in employment and for those who do invest some time in the respective activity. The results do not vary significantly between students that select into these activities and those who select out of them.

Table 5: Average university grade, OLS-estimation (by gender)

	Men		Women	
	(4)		(5)	
Courses	0.0058	(0.0037)	0.0061 *	(0.0035)
Courses, squared	-0.0000	(0.0001)	-0.0001	(0.0001)
Self-study	0.0052 **	(0.0022)	0.0066 **	(0.0025)
Self-study, squared	-0.0000	(0.0001)	-0.0002 ***	(0.0001)
Student work groups/ tutorials	-0.0069	(0.0044)	-0.0070	(0.0047)
Student work groups/ tutorials, squared	0.0006 **	(0.0002)	0.0001	(0.0002)
Other study relates activities	0.0114 ***	(0.0041)	0.0087 *	(0.0052)
Other study relates activities, squared	-0.0002 *	(0.0001)	-0.0002	(0.0002)
Student assistant/ tutor	0.0192 ***	(0.0070)	0.0259 ***	(0.0083)
Student assistant/ tutor, squared	-0.0006	(0.0004)	-0.0015 **	(0.0006)
Employment	-0.0005	(0.0029)	0.0008	(0.0037)
Employment, squared	-0.0001	(0.0001)	0.0002	(0.0002)
R^2 adjusted	0.270		0.263	
N	6,443		4,854	

Notes: All other variables from Model (3) are included. Clustered standard errors in parentheses. The time use variables are measured in average hours per week in the current semester. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Source: Student survey 1983-2007, AG Hochschulforschung, own calculations.

Weichselbaumer and Winter-Ebmer, 2005). There could also be differences in the allocation of time and its effect on academic achievement. Table 5 documents the estimation results for male and female students (Specifications (4) and (5)).

Investing time in attending courses is positively associated with grades only for female students, while for time spent on self-study, a positive correlation can be observed for both genders. Spending time on student work groups or tutorials is not associated with grades. Devoting time to other study-related activities and working as a student assistant is positively correlated with grades, irrespective of the students' gender. There seem to be little differences in the association between time allocation and grades for men and women.

Alternatively, differences in the efficiency of time allocation between students of different abilities may persist. I run separate estimations for low- and high-ability students, measured by their final high school grade. In Table 6, the results are presented (Specifications (6) and (7)). According to these results, spending time on attending courses is only significantly and positively correlated with grades for high-ability students. For low-ability students no significant correlation can be found. Self-study is associated with higher grades for students with both types of ability. With rising hours, a decrease of the marginal productivity can be observed. Spending more time on attending student work groups or tutorials is negatively associated with grades if the student has an ability that is lower than the average. A positive correlation

Table 6: Average university grade, OLS-estimation (by ability strata)

	Below average ability		Above average ability	
	(6)		(7)	
Courses	-0.0014	(0.0039)	0.0118 ***	(0.0037)
Courses, squared	0.0001	(0.0001)	-0.0002 **	(0.0001)
Self-study	0.0075 ***	(0.0027)	0.0048 **	(0.0022)
Self-study, squared	-0.0001 *	(0.0001)	-0.0001 *	(0.0000)
Student work groups/ tutorials	-0.0094 **	(0.0037)	-0.0047	(0.0035)
Student work groups/ tutorials, squared	0.0006 ***	(0.0002)	0.0002	(0.0002)
Other study relates activities	0.0119 **	(0.0050)	0.0074 **	(0.0037)
Other study relates activities, squared	-0.0002	(0.0002)	-0.0001	(0.0001)
Student assistant/ tutor	0.0194 *	(0.0098)	0.0197 ***	(0.0072)
Student assistant/ tutor, squared	-0.0009	(0.0006)	-0.0007	(0.0004)
Employment	0.0022	(0.0033)	-0.0004	(0.0031)
Employment, squared	-0.0000	(0.0002)	-0.0001	(0.0002)
R^2 adjusted	0.216		0.265	
N	5,530		5,767	

Notes: All other variables from Model (3) are included. Clustered standard errors in parentheses. The time use variables are measured in average hours per week in the current semester. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Source: Student survey 1983-2007, AG Hochschulforschung, own calculations.

is found for devoting time to other study-related activities or to working as a student assistant for both low- and high-ability students.

Since there are structural differences in the course of study between different fields of study there might be also differences in the time use pattern. For example, the formal study time in Sciences/ Engineering is higher than in Arts/ Humanities. In Table 7 the results for the three fields of study Arts/ Humanities, Social Sciences, and Sciences/ Engineering are presented (Specifications (8), (9), and (10)). Differences in the correlation between time use and educational achievement are observable for all activities, except for working as a student assistant and other employment. On the one hand there exists no correlation between time spent on courses and average grades for students of Arts/ Humanities. On the other hand, for students of Sciences/ Engineering, no association between time spent for self-study and grades is revealed. Attending student work groups or tutorials is significantly and negatively correlated with grades only for Sciences/ Engineering. Expect for Arts/ Humanities the association between grades and time spent on other study related activities is significant and positive.

Table 7: Average university grade, OLS-estimation results (by field of study)

	Arts/Humanities		Social Sciences		Sciences/Engineering	
	(8)		(9)		(10)	
Courses	-0.0011	(0.0055)	0.0126 **	(0.0055)	0.0073 **	(0.0033)
Courses, squared	0.0001	(0.0001)	-0.0003 **	(0.0001)	-0.0001	(0.0001)
Self-study	0.0127 ***	(0.0029)	0.0060 *	(0.0033)	0.0023	(0.0022)
Self-study, squared	-0.0003 ***	(0.0001)	-0.0001	(0.0001)	-0.0000	(0.0000)
Student work groups/ tutorials	-0.0054	(0.0058)	-0.0004	(0.0049)	-0.0099 ***	(0.0037)
Student work groups/ tutorials, squared	0.0003	(0.0004)	-0.0003	(0.0002)	0.0006 ***	(0.0002)
Other study relates activities	0.0076	(0.0050)	0.0180 ***	(0.0061)	0.0116 ***	(0.0043)
Other study relates activities, squared	-0.0003	(0.0002)	-0.0002	(0.0003)	-0.0002	(0.0002)
Student assistant/ tutor	0.0388 ***	(0.0149)	0.0323 **	(0.0155)	0.0216 ***	(0.0078)
Student assistant/ tutor, squared	-0.0022 *	(0.0013)	-0.0016	(0.0011)	-0.0008	(0.0005)
Employment	0.0041	(0.0037)	-0.0001	(0.0041)	-0.0046	(0.0035)
Employment, squared	-0.0002	(0.0002)	0.0000	(0.0002)	0.0003 *	(0.0002)
R^2 adjusted	0.196		0.187		0.230	
N	2,927		2,983		5,387	

Notes: All other variables from Model (3) are included. Robust standard errors in parenthesis. Time use is measured in average hours per week in the current semester. * $p < 0.10$, ** $p < 0.05$,*** $p < 0.01$.
Source: Student survey 1983-2007, AG Hochschulforschung, own calculations.

Translog production function

Each student only has a certain amount of time that they can allocate between the different activities. For this reason, it can be assumed that some activities are substitutes and some are complements. For example, time use for courses and for self-study could be substitutes if the course is of good quality and therefore less time is needed for preparing and revising the lecture. In general, inputs x_1 and x_2 are substitutes if an increase in the use of x_1 causes the marginal product of input x_2 to decline. A functional form that allows for substitutability and complementarity is the translog (transcendental logarithmic) production function.[13] The translog production function for output Y and inputs x_i with $i = 1, ..., K$ is defined as

$$\ln Y = \beta_0 + \sum_i \beta_i \ln x_i + \sum_i \sum_j \beta_{ij} \ln x_i \ln x_j + \varepsilon. \tag{2}$$

β_{ij} is assumed to be symmetric ($\beta_{ij} = \beta_{ji}$).

In Table 8, the estimation results regarding the time use variables are presented using the whole sample.[14] In order to use the translog model, some transformations of the time use variables are necessary. For some activities, the participation of students is low (especially for working as a student assistant, but also for attending student work groups and other

[13] A discussion on translog cost and production functions can be found in e.g. Frondel and Schmidt (2002).
[14] The translog function is not estimated separately for the subgroups. Including all interactions of the time use variables enlarges the model so that the sample size for each of the subgroups is too small.

employment). Because the logarithm of 0 is not defined, there would be a large number of missing values for these activities. To avoid this, firstly, additionally to the continuous variable that measures the amount of time that is spent on a specific activity (t_j), a dummy variable that indicates participation in the activity (dt_j) is included. Secondly, if no time is invested in activity j ($t_j = 0$), the logarithm of the time use is replaced by zero ($\log(t_j) = 0$) and the dummy variable that indicates whether time is invested equals zero ($dt_j = 0$). For the other cases, no replacements are made, i.e., in the case that one hour ($t_j = 1$) is invested, the dummy equals one ($dt_j = 1$) and the logarithm of the time use variable zero ($\log(t_j) = 0$), and in the case that more than one hour ($t_j > 1$) is invested, $dt_j = 1$ and $\log(t_j) = \log(t_j)$.

Attending courses and self-study seem to be substitutes as well as attending courses and other study-related activities. That means if students spend more time on attending lectures the productivity of the time allocated to self-study or to other study-related activities decreases, and vice versa. This results suggests that there exists a selection into activities. For some students it is more productive to attend courses and for some other students self-study is more productive. In contrast, devoting time to attending courses and to working as a student assistant or tutor are found to be complements. More time spent on working as a student assistant or tutor increases the productivity of attending courses, and vice versa.

Table 9 shows the estimated output elasticities $\partial \ln g / \partial \ln t$. The elasticities for attending courses, self-study, and other study-related activities are positive and significantly different from zero, even though the values are small. Increasing the time spent on each of these three activities by 1% increases the grade by 0.01%. In contrast, the output elasticity for attending student work groups or tutorials is significant and negative, indicating a decrease of grades by 0.01% if the amount of hours spent on this activity is increased by 1%.

5 Conclusion

Plenty of research has been conducted in the field of the input factors of the educational production function to explain the determinants of educational achievement. Most studies focus on institutional inputs, e.g., student-teacher ratio, class size or school or university quality. Only little attention is paid to student-related inputs like the students' time allocation. In this paper, some light is shed on the productivity of different time uses with respect to academic achievement. Using data on students at German universities between 1986 and 2006, the results suggest that time spent on courses is positively correlated with average grades for female and high-ability students. Distinguishing between the fields of study Arts/

Table 8: Average university grade, translog-estimation results

	(11)	
Courses (yes/no)	-0.0003	(0.0353)
Self-study (yes/no)	0.0160	(0.0195)
Student work groups/ tutorials (yes/no)	0.0076	(0.0047)
Other study relates activities (yes/no)	0.0119 ***	(0.0034)
Student assistant/ tutor (yes/no)	0.0079	(0.0165)
Employment (yes/no)	-0.0059	(0.0097)
Ln(Courses)	0.0082	(0.0204)
Ln(Self-study)	0.0177	(0.0108)
Ln(Student work groups/ tutorials)	-0.0128	(0.0126)
Ln(Other study relates activities)	0.0246 **	(0.0095)
Ln(Student assistant/ tutor)	0.0040	(0.0269)
Ln(Employment)	-0.0008	(0.0134)
Ln(Courses)^2	0.0033	(0.0036)
Ln(Self-study)^2	0.0008	(0.0015)
Ln(Student work groups/ tutorials)^2	0.0037	(0.0035)
Ln(Other study relates activities)^2	-0.0011	(0.0024)
Ln(Student assistant/ tutor)^2	-0.0064	(0.0070)
Ln(Employment)^2	0.0017	(0.0029)
Ln(Courses) X Ln(Self-study)	-0.0049 **	(0.0024)
Ln(Courses) X Ln(Student work groups/ tutorials)	-0.0005	(0.0032)
Ln(Courses) X Ln(Other study relates activities)	-0.0065 **	(0.0028)
Ln(Courses) X Ln(Student assistant/ tutor)	0.0085 **	(0.0041)
Ln(Courses) X Ln(Employment)	0.0016	(0.0024)
Ln(Self-study) X Ln(Student work groups/ tutorials)	0.0005	(0.0019)
Ln(Self-study) X Ln(Other study relates activities)	0.0014	(0.0021)
Ln(Self-study) X Ln(Student assistant/ tutor)	-0.0031	(0.0030)
Ln(Self-study) X Ln(Employment)	-0.0023	(0.0015)
Ln(Student work groups/ tutorials) X Ln(Other study relates activities)	-0.0020	(0.0025)
Ln(Student work groups/ tutorials) X Ln(Student assistant/ tutor)	0.0023	(0.0036)
Ln(Student work groups/ tutorials) X Ln(Employment)	0.0004	(0.0014)
Ln(Other study relates activities) X Ln(Student assistant/ tutor)	-0.0004	(0.0030)
Ln(Other study relates activities) X Ln(Employment)	-0.0009	(0.0014)
Ln(Student assistant/ tutor) X Ln(Employment)	0.0006	(0.0024)
R^2 adjusted	0.265	
N	11,297	

Notes: In the regressions are also all other variables from model (3) included. Clustered standard errors in parenthesis. The time use variables are measured in average hours per week in the current semester. *$p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Source: Student survey 1983-2007, AG Hochschulforschung, own calculations.

Table 9: Calculated outout elasticities and standard errors, translog-estimation: whole sample

	$Y = \ln$(average grade)	
Courses	0.0137 ***	(0.0032)
Self study	0.0062 ***	(0.0017)
Student work groups/ tutorials	-0.0088 **	(0.0040)
Other study related activities	0.0055 **	(0.0023)
Student assistant/ tutor	0.0219	(0.0211)
Employment	0.0013	(0.0057)

Notes: Elasticities calculated at the mean. Clustered standard errors in parentheses. *$p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Source: Student survey 1983-2007, AG Hochschulforschung, own calculations.

Humanities, Social Sciences, and Sciences/ Engineering, for all fields except Arts/ Humanities the correlation is found to be significant and positive. Devoting time to self-study is positively associated with grades and there are neither differences by gender nor by ability. Regarding the field of study, the positive association is significant only for Arts/ Humanities and Social Sciences. For male and female students, spending time on self-study and on attending courses seems to be of similar productivity. Time devoted to student work groups or tutorials is negatively correlated with grades if the students have an ability that is below average or if they study Sciences/ Engineering. Spending time for other study-related activities seems to be positively associated with grades. The only exception are students of Arts/ Humanities. For working as a student assistant or tutor, a positive correlation can be found for all students. Working in other employment seems to be uncorrelated with grades.

Using a translog production function facilitates controlling for substitutability and complementarity of several time use variables. Applying this model to the data reveals that time devoted to attending courses and time devoted to self-study are substitutes as well as time devoted to courses and time devoted to other study-related activities. However, time spent on attending courses and time spent on working as a student assistant or tutor are substitutes. Regarding the concrete output elasticities, increasing the time spent on courses, self-study, and other study-related activities by 1% increases the grade by 0.01%. In contrast, raising the amount of hours spent on attending student work groups or tutorials by 1% decreases the grade by 0.01%.

Despite the problem of endogeneity and the descriptive nature of the results, there are reasons to believe that a causal association exists between the students' time allocation and academic achievement. The positive association between grades and time for self-study should be kept in mind, especially against the background of the restructuring of the educational system to Bachelor and Master degrees. A curriculum should provide the students some time

for self-study. The results further induce that an introduction of mandatory course attendance would not lead to higher academic achievement in general. There exist significant and positive correlations only for some subgroups. Spending a great amount of the revenues from tuition fees for increasing the supply of tutorials can also not be supported by the results, neglecting the selection issues.

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Appendix

Table 10: Summary Statistics, whole sample and by gender

	Whole sample		Male		Female	
	Mean	SD	Mean	SD	Mean	SD
Average grade at university	4.362	0.606	4.303	0.617	4.440	0.582
Age	22.265	2.495	22.589	2.379	21.835	2.579
Male	0.570	0.495	1.000	0.000	0.000	0.000
Courses	18.864	7.754	18.651	7.817	19.148	7.662
Self-study	12.333	9.001	12.509	9.081	12.100	8.890
Student work groups/ tutorials	2.534	3.428	2.802	3.567	2.178	3.201
Other study relates activities	2.445	2.920	2.269	3.011	2.679	2.777
Student assistant/ tutor	0.367	1.882	0.387	1.954	0.341	1.781
Employment	4.253	6.490	4.043	6.532	4.532	6.425
Final high school grade	4.695	0.654	4.648	0.662	4.757	0.638
Less than vocational degree, father	0.047	0.213	0.049	0.215	0.046	0.209
Vocational degree, father	0.430	0.495	0.439	0.496	0.418	0.493
Tertiary degree, father	0.522	0.500	0.512	0.500	0.536	0.499
High occupational status, father	0.494	0.500	0.503	0.500	0.482	0.500
Middle occupational status, father	0.310	0.463	0.311	0.463	0.310	0.462
Low occupational status father	0.164	0.371	0.160	0.367	0.170	0.375
Other occupational status, father	0.032	0.175	0.027	0.161	0.039	0.193
Less than vocational degree, mother	0.117	0.322	0.133	0.340	0.096	0.295
Vocational degree, mother	0.531	0.499	0.546	0.498	0.510	0.500
Tertiary degree, mother	0.352	0.478	0.321	0.467	0.394	0.489
High occupational status, mother	0.198	0.398	0.182	0.386	0.219	0.413
Middle occupational status, mother	0.503	0.500	0.488	0.500	0.522	0.500
Low occupational status, mother	0.081	0.273	0.082	0.274	0.080	0.271
Other occupational status, mother	0.054	0.227	0.058	0.233	0.050	0.219
Has never worked/homemaker, mother	0.164	0.371	0.190	0.393	0.130	0.336
Relevance of career for choice of study	0.204	0.403	0.235	0.424	0.163	0.369
Relevance of interest for choice of study	0.533	0.499	0.501	0.500	0.576	0.494
Quality of mentoring at university	1.186	0.513	1.165	0.480	1.214	0.553
Quality of courses at university	1.802	0.895	1.776	0.895	1.836	0.894
Quality of courses' procedure at university	1.300	0.628	1.277	0.612	1.330	0.647
Completed vocational training	0.127	0.333	0.115	0.319	0.143	0.351
Duration of study (semesters)	3.186	2.215	3.244	2.242	3.110	2.177
Change of university or major	0.193	0.395	0.181	0.385	0.209	0.407
Field of study - Cultural sciences, others	0.213	0.409	0.142	0.349	0.306	0.461
Field of study - Social sciences	0.097	0.295	0.053	0.225	0.154	0.361
Field of study - Law	0.050	0.218	0.050	0.218	0.050	0.218
Field of study - Economics	0.172	0.378	0.205	0.404	0.129	0.335
Field of study - Medicine	0.087	0.282	0.070	0.255	0.109	0.312
Field of study - Natural sciences	0.223	0.416	0.252	0.434	0.185	0.388
Field of study - Engineering	0.158	0.365	0.228	0.419	0.067	0.250
TU Berlin	0.094	0.292	0.112	0.315	0.070	0.255
University of Bochum	0.092	0.289	0.098	0.297	0.084	0.277
TU Dresden	0.070	0.255	0.067	0.250	0.074	0.262
University of (Duisburg-)Essen	0.067	0.250	0.073	0.260	0.060	0.237
University of Frankfurt	0.079	0.270	0.069	0.254	0.092	0.289
University of Freiburg	0.086	0.280	0.085	0.279	0.087	0.281
University of Hamburg	0.087	0.283	0.084	0.278	0.092	0.289
TU Kaiserslautern	0.011	0.104	0.011	0.104	0.011	0.103
University of (TH) Karlsruhe	0.113	0.316	0.157	0.364	0.053	0.224
University of Kassel	0.011	0.104	0.009	0.094	0.014	0.117
University of Leipzig	0.061	0.240	0.041	0.199	0.088	0.284

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... Table 10 continued

	Whole sample		Male		Female	
	Mean	SD	Mean	SD	Mean	SD
University of Magdeburg	0.031	0.174	0.031	0.172	0.032	0.176
University of Munich	0.118	0.323	0.102	0.302	0.141	0.348
University of Oldenburg	0.009	0.093	0.006	0.080	0.012	0.109
University of Potsdam	0.028	0.166	0.021	0.143	0.038	0.192
University of Regensburg	0.008	0.087	0.006	0.076	0.010	0.100
University of Rostock	0.034	0.182	0.028	0.164	0.043	0.204
Semester 1986/87	0.139	0.346	0.171	0.376	0.097	0.297
Semester 1989/90	0.129	0.335	0.143	0.351	0.109	0.312
Semester 1992/93	0.156	0.363	0.172	0.377	0.134	0.341
Semester 1994/95	0.104	0.305	0.111	0.314	0.095	0.293
Semester 1997/98	0.094	0.292	0.088	0.283	0.102	0.303
Semester 2000/01	0.121	0.326	0.104	0.305	0.144	0.351
Semester 2003/04	0.148	0.355	0.118	0.323	0.187	0.390
Semester 2006/07	0.110	0.313	0.094	0.292	0.132	0.338
	11,297		6,443		4,854	

Notes: The grades are transformed such that 6.0 is the best and 2.0 the worst. The time use variables are measured in average hours per week in the current semester. For the classification of parents' occupational status see Table 4.
Source: Student survey 1983-2007, AG Hochschulforschung, own computations.

Table 11: Summary Statistics, by ability and field of study

	Below average ability		Above average ability		Arts/ Humanities		Social Sciences		Sciences/ Engineering	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Average grade at university	4.221	0.577	4.497	0.603	4.616	0.523	4.174	0.584	4.328	0.614
Age	22.873	2.617	21.682	2.221	22.425	2.797	22.415	2.445	22.095	2.332
Male	0.603	0.489	0.539	0.498	0.338	0.473	0.622	0.485	0.668	0.471
Courses	17.871	7.566	19.816	7.814	17.041	6.351	17.489	6.877	20.616	8.491
Self-study	11.689	8.734	12.951	9.209	10.984	7.979	10.919	7.849	13.850	9.841
Student work groups/ tutorials	2.554	3.418	2.516	3.438	1.594	2.269	3.309	3.674	2.616	3.682
Other study relates activities	2.426	2.873	2.463	2.965	3.102	3.132	2.319	2.788	2.157	2.815
Student assistant/ tutor	0.288	1.712	0.444	2.028	0.305	1.619	0.255	1.595	0.463	2.139
Employment	5.317	7.099	3.232	5.663	5.475	6.872	5.171	7.105	3.080	5.665
Final high school grade	4.142	0.360	5.225	0.373	4.625	0.639	4.619	0.648	4.775	0.656
Less than vocational degree, father	0.055	0.227	0.041	0.197	0.048	0.214	0.054	0.226	0.043	0.204
Vocational degree, father	0.482	0.500	0.381	0.486	0.443	0.497	0.449	0.497	0.413	0.492
Tertiary degree, father	0.463	0.499	0.578	0.494	0.509	0.500	0.497	0.500	0.544	0.498
High occupational status, father	0.466	0.499	0.520	0.500	0.474	0.499	0.488	0.500	0.508	0.500
Middle occupational status, father	0.327	0.469	0.294	0.456	0.318	0.466	0.312	0.463	0.305	0.461
Low occupational status father	0.172	0.377	0.157	0.364	0.168	0.374	0.169	0.375	0.159	0.366
Other occupational status, father	0.035	0.183	0.029	0.168	0.040	0.197	0.031	0.174	0.027	0.163
Less than vocational degree, mother	0.133	0.340	0.102	0.302	0.101	0.302	0.123	0.329	0.123	0.328
Vocational degree, mother	0.596	0.491	0.468	0.499	0.526	0.499	0.557	0.497	0.518	0.500
Tertiary degree, mother	0.271	0.444	0.430	0.495	0.373	0.484	0.319	0.466	0.359	0.480
High occupational status, mother	0.163	0.369	0.231	0.422	0.209	0.407	0.184	0.388	0.199	0.399
Middle occupational status, mother	0.510	0.500	0.496	0.500	0.519	0.500	0.513	0.500	0.488	0.500
Low occupational status, mother	0.094	0.292	0.068	0.252	0.073	0.261	0.078	0.268	0.086	0.281
Other occupational status, mother	0.060	0.237	0.049	0.217	0.054	0.226	0.051	0.219	0.057	0.231

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... Table 11 continued

	Below average ability		Above average ability		Arts/ Humanities		Social Sciences		Sciences/ Engineering	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Has never worked/homemaker, mother	0.174	0.379	0.155	0.362	0.145	0.352	0.174	0.379	0.170	0.376
Relevance of career for choice of study	0.216	0.412	0.192	0.394	0.076	0.265	0.379	0.485	0.177	0.381
Relevance of interest for choice of study	0.504	0.500	0.561	0.496	0.640	0.480	0.365	0.482	0.568	0.495
Quality of mentoring at university	1.178	0.501	1.194	0.524	1.284	0.620	1.099	0.372	1.181	0.507
Quality of courses at university	1.744	0.884	1.857	0.901	1.873	0.901	1.652	0.842	1.846	0.910
Quality of courses' procedure at university	1.287	0.619	1.312	0.636	1.364	0.681	1.226	0.551	1.306	0.634
Completed vocational training	0.168	0.374	0.088	0.283	0.128	0.334	0.188	0.391	0.093	0.290
Duration of study (semesters)	3.505	2.495	2.881	1.858	3.182	2.323	3.311	2.320	3.120	2.089
Change of university or major	0.219	0.414	0.169	0.375	0.296	0.457	0.190	0.392	0.139	0.346
Field of study - Cultural sciences, others	0.234	0.424	0.192	0.394	0.770	0.421	0.018	0.132	0.017	0.131
Field of study - Social sciences	0.107	0.309	0.087	0.281	0.230	0.421	0.140	0.347	0.000	0.000
Field of study - Law	0.047	0.212	0.053	0.223	0.000	0.000	0.189	0.392	0.000	0.000
Field of study - Economics	0.194	0.395	0.152	0.359	0.000	0.000	0.653	0.476	0.000	0.000
Field of study - Medicine	0.057	0.232	0.115	0.319	0.000	0.000	0.000	0.000	0.182	0.386
Field of study - Natural sciences	0.192	0.394	0.253	0.435	0.000	0.000	0.000	0.000	0.468	0.499
Field of study - Engineering	0.169	0.375	0.148	0.356	0.000	0.000	0.000	0.000	0.332	0.471
TU Berlin	0.105	0.307	0.083	0.276	0.047	0.213	0.077	0.267	0.128	0.335
University of Bochum	0.127	0.333	0.058	0.234	0.093	0.290	0.097	0.296	0.089	0.284
TU Dresden	0.056	0.230	0.083	0.277	0.054	0.225	0.069	0.254	0.079	0.270
University of (Duisburg-)Essen	0.103	0.303	0.033	0.179	0.076	0.265	0.075	0.264	0.058	0.234
University of Frankfurt	0.089	0.285	0.070	0.254	0.096	0.295	0.102	0.302	0.057	0.233
University of Freiburg	0.053	0.223	0.118	0.323	0.102	0.303	0.068	0.251	0.087	0.282
University of Hamburg	0.096	0.294	0.080	0.271	0.097	0.296	0.095	0.293	0.078	0.268
TU Kaiserslautern	0.013	0.113	0.009	0.095	0.000	0.000	0.008	0.091	0.018	0.134
University of (TH) Karlsruhe	0.085	0.279	0.139	0.346	0.025	0.157	0.076	0.265	0.180	0.384
University of Kassel	0.016	0.124	0.006	0.080	0.015	0.122	0.012	0.111	0.008	0.089
University of Leipzig	0.041	0.197	0.081	0.274	0.107	0.309	0.052	0.222	0.042	0.201
University of Magdeburg	0.024	0.152	0.038	0.192	0.022	0.147	0.044	0.206	0.029	0.167
University of Munich	0.121	0.326	0.116	0.320	0.165	0.371	0.127	0.333	0.089	0.284
University of Oldenburg	0.012	0.110	0.005	0.073	0.014	0.116	0.011	0.103	0.005	0.071
University of Potsdam	0.026	0.160	0.031	0.172	0.040	0.196	0.040	0.197	0.016	0.124
University of Regensburg	0.007	0.084	0.008	0.090	0.014	0.119	0.006	0.075	0.005	0.071
University of Rostock	0.028	0.165	0.041	0.197	0.032	0.177	0.041	0.197	0.032	0.176
Semester 1986/87	0.146	0.353	0.133	0.339	0.099	0.299	0.148	0.355	0.156	0.363
Semester 1989/90	0.129	0.335	0.129	0.335	0.110	0.313	0.128	0.335	0.139	0.346
Semester 1992/93	0.152	0.359	0.159	0.366	0.149	0.356	0.160	0.367	0.157	0.364
Semester 1994/95	0.105	0.307	0.102	0.303	0.096	0.294	0.113	0.317	0.103	0.304
Semester 1997/98	0.093	0.290	0.095	0.294	0.101	0.302	0.095	0.293	0.090	0.286
Semester 2000/01	0.119	0.324	0.122	0.328	0.133	0.339	0.120	0.325	0.115	0.319
Semester 2003/04	0.148	0.355	0.148	0.355	0.183	0.387	0.144	0.351	0.130	0.337
Semester 2006/07	0.108	0.311	0.112	0.315	0.129	0.336	0.092	0.288	0.110	0.313
	5,530		5,767		2,927		2,983		5,387	

Notes: The grades are transformed such that 6.0 is the best and 2.0 the worst. The time use variables are measured in average hours per week in the current semester. For the classification of parents' occupational status see Table 4.

Source: Student survey 1983-2007, AG Hochschulforschung, own computations.