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Heterogene Arbeit: Positive und Normative
Aspekte der Qualifikationsstruktur der Arbeit

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Learning and Peer Effects

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Zusammenfassung:

The paper documents the results from an experiment on peer effects in learning processes. The experimental approach eliminates endogeneity and selection problems which typically restrict the measurement of peer effects with administrative or survey data. The results provide evidence on the mechanisms of peer interaction and on optimal learning group composition. Learning with a partner is more successful than learning without one, though differences between gender and age groups are observable. High ability students provide benefits to other high ability students. Subjects who are member in a club provide a benefit to partners who are not.

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Learning and Peer Effects

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Abstract:

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Keywords: Learning – Peer Effects – Experiment – Economics of Education

JEL Codes: I21, C90

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1 Introduction

Rothschild and White (1995) describe education as a customer-input-technology. The educational performance of a student depends on the characteristics and behaviour of his fellow students, the peer effect. If this statement is true it is not irrelevant for a single student with whom he or she is studying. Hence, the (self-)selection of students into different types of schools and peer groups is a policy topic in many countries. Yet one of the biggest obstacles for a reasonable debate about selection policies is the measurement of peer effects. This paper approaches the measurement problem with a classroom experiment. It documents a learning experiment with “clean” peer effects derived from interaction among randomly assigned learning partners. The results offer an insight into the optimal composition of learning groups.

A large econometric literature has been devoted to the identification of peer effects. This literature offers a great variety with respect to identification strategies and results. Yet most econometric studies actually look on a peer group *composition* effect. Gould et al. (2005) for Israel, Hoxby (2000) for the United States and Ammermüller and Pischke (2006) for primary schools in six European countries rely on differences in the compositions of individual class rooms within a school. These authors estimate what would happen if a student was in a different class. Hanushek et al. (2003) and McEwan (2003) use variation within schools to identify peer effects. Stinebrickner and Stinebrickner (2006), Foster (2006), Zimmerman (2003) and Sacerdote (2001) investigate peer effects in universities in a different way. They use the random assignment of students into university dormitories as indicators for social tie formation and its subsequent impact on educational performance.

The econometric studies invest a great deal in getting around three key problems. Firstly, measures for peer effects have to be exogenous. Take ability of fellow class members as an example. If positive peer effects exist, the performance of any student should improve with the performance of his class members. However, the left hand variable has an impact on the peer effect measure, as any observed student also has an impact on his fellow students. This reflection problem (Manski, 1993) could be ignored if an independent ability measure for any student was available which lacks in many datasets.

Secondly, students are not randomly assigned to their peer groups. Parents, schools or any other party decide where students enrol. Such a selection process precludes the identification of a plausible counter-factual result: i.e. how would a student have performed in a different peer group or as a single learner?

Thirdly, teacher behaviour and other environmental characteristics can change with the peer group composition. The same teacher may teach the same topic in a different way, if the average ability or the ability distribution changes in a class (Meier, 2004). Arguably, such an effect is part of a peer effect. One could distinguish between a direct peer effect, where students directly influence each other, and an indirect one, where students influence each other via the teacher.

Behind these methodological problems a more fundamental one is looming. The observation of a peer group composition effect in survey or administrative data does not explain *how* peers influence each other. Peers can provide an external effect in different ways. Falk and Ichino (2006) find experimental evidence for positive peer effects in a "real task" production environment. In their case the peer effect stems from the mere presence of another person in the room.[1] A large psychological literature emphasizes the role of peers as benchmark for the development of academic self-concepts. An academic self concept captures the self-assessment of individual capabilities for a specific academic subject[2].

Yet, mere presence, social comparison and social tie formation are hardly the only ways in which students influence each other. Lazear (2001) provides a theoretical model with an explicit peer effect mechanism. Students provide a negative external effect by interrupting the instruction in a classroom. Lazear's approach provides a connection between peer group composition and peer group size. In his model educational output is maximized if each student is alone with a teacher. Lazear's approach neglects potential positive contributions from fellow students through cooperation.

An experimental approach allows controlling for the econometric problems and gives a better insight into the interaction between peers. In this paper I document an experiment in which subjects learn the logic of a puzzle. The participants learn either alone or with another, randomly assigned subject. A pretest provides an independent ability measure, a final test a performance measure.

The results show that subjects benefit from active cooperation with another person in the learning period. Two results stand out with respect to optimal group composition. Firstly, only high ability students benefit from increasing ability of the partner. Secondly, subjects who are member in a club (e.g. sports team or orchestra) provide a positive effect for non associated

1 Falk and Ichino relate their approach to the "social facilitation paradigm", a research topic in the psychological literature (e.g., Zajonc, 1965, Cottrell et al., 1968, or more recently Feinberg and Aiello, 2006).

2 Festinger (1954) initiated this literature, and Marsh (1987) captured it as the Big-Fish-Little-Pond-Effect. A student thinks he is good in, say, math, just because all others are rather bad. Köller (2004) provides a summary of this psychological literature.

subjects (i.e. those who are not in a club). The performance of club members is independent of the membership status of their partners.

The paper is structured as follows. The following section describes the experimental design. Section 3 documents the results and section 4 concludes.

2 The Experiment

The objective of the experiment is to provide evidence on the existence of peer effects from cooperation in learning processes as well as on the optimal composition of learning groups. In the experiment the participants can learn a solution strategy for a logical puzzle called Kakurasu.[3] To solve a Kakurasu puzzle the correct boxes in the following matrix have to be marked:

Figure 1: Exemplary Kakurasu puzzle

	5	6	1	2	
3					1
7					2
1					3
2					4
	1	2	3	4	

Each box in the matrix has two values depending on its column and row (see numbers below and on the right hand side). The sum of the marked boxes has to add up to the values on the top (column values) and the left hand side (row values). Figure 2 provides the correct solution.

Figure 2: Solution for the example

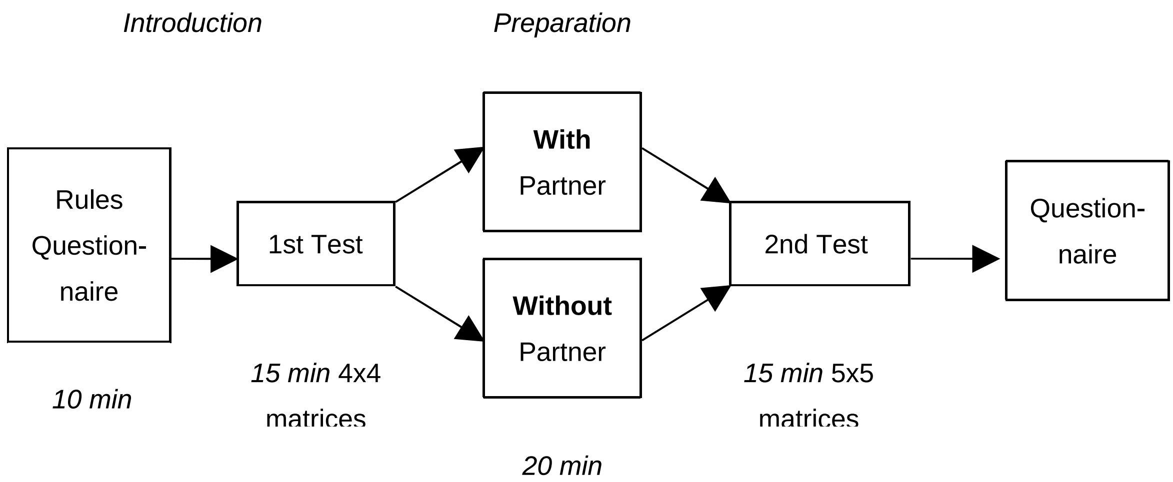
	5	6	1	2	
3			X		1
7	X	X		X	2
1	X				3
2		X			4
	1	2	3	4	

The students got the rules in written form but no hints how to solve the puzzles. A first test with a set of these puzzles measured how much the students did understand. 4x4 matrices like in Figures 1 and 2 were used for this test. The test score of this test serves as an ability

3 A detailed description of the puzzle can be found at www.janko.at (in German).

measure in the analysis. After this first test the students could prepare for a final test. In this preparation period the experimental treatment took place. In the single treatment group the subjects prepared alone. In the pair treatment group they could cooperate with a partner. A final test concluded the experiment. This final test contained 5x5 matrices. All subjects had to solve it alone. The number of correctly solved puzzles provides the test score in both tests. Questionnaires collecting data on control variables were handed out at the beginning and at the end of the experiment. All tests and questionnaires are available on request from the author.

Figure 3: The design of the experiment



The first experiment was conducted on December the 5th in 2006 with 85 Swiss students which we recruited at a high school (Kantonsschule) in Kreuzlingen in the canton of Thurgau in Switzerland. The students applied with their name and their class level and got 20 Swiss Francs (about 12.40 € or 16.25 US$ at that day) for their participation. A replication is scheduled for February at a similar school in the same canton.

29 participants were assigned to the single treatment and 56 to the pair treatment group. The subjects were assigned randomly to the different groups. Each subject in the pair treatment group got a randomly assigned partner, though only from the same class level and sex. Due to missing partners, two pairs were formed with subjects from different class level. Table 1 shows the composition of single treatment and pair treatment groups. All subjects did the experiment at the same time to ensure that students could not communicate solution hints to following students. Due to capacity constraints the subjects did the experiment in five

different rooms in the Kantonsschule. Two rooms were filled with single learners, three rooms (including a large one) with the pair treatment group. Since the differences across rooms within a specific treatment group are insignificant, it is assumed that differences in rooms do not matter between the treatment groups, too.

The student received their instructions in oral and written form from the author of this paper. In each room an overseer was in charge of the technical details. These overseers received instructions about the procedure of the experiment but not about the puzzle. The participants were explicitly told that the overseer could not answer questions with respect to the puzzle.

Table 1: The distribution of the subjects into single treatment and pair treatment groups

	Single treatment group			Pair treatment group		
Classlevel	Male	Female	Sum	Male	Female	Sum
Level 2	6	5	11	11	17	28
Level 3	4	6	10	5	11	16
Level 4	6	2	8	4	8	12
Sum	16	13	29	20	36	56

3 Results

3.1 The Existence of Peer Effects

The descriptive statistics show (significant) differences between single treatment group and pair treatment group in the second test score (label: *secondtest*). The results in the first test (*firsttest*) also differ, but not significantly. Further research may reveal if this difference is caused by the fact that the participants knew at the beginning of the first test about the enrolment in the pair treatment and about their prospective partner.

Table 2: Descriptive Statistics

	Single treatment		Pair treatment	
	Mean	St.dev	Mean	St.dev
secondtest (5x5 matrices)	2.069	1.981	3.125	2.001
firsttest (4x4 matrices)	3.207	3.109	4.018	2.526

Negative binomial regressions show the treatment effect, i.e. the existence of peer effects (Table 3). Learning with a partner provides a benefit even if one controls for differences in the first test and heterogeneity in class levels and sex. Count data like in our case the number of correctly solved puzzles require either negative binomial or Poisson regressions, depending on the dispersion. Throughout the paper, only the results from negative binomial regressions are reported. The results from the different approaches do not differ very much anyway.

The first test score is a good ability measure. It is a highly significant predictor of the final test score. A great number of control variables have been collected, e.g. performance in school, marks in math, membership in clubs, etc. The subjects could also evaluate how they liked the partner, the assigned task, the cooperation and much more. Only one of them was significant, club membership (*Club*), i.e. if the subject was member in any type of club like a sports team or an orchestra. Controlling for club membership of the subjects implies that the treatment effect is significant only on a 10% level. The share of club members was greater in the pair treatment group and club membership boosts performance. The club membership issue will be addressed in greater detail later in the paper.

Table 3: Estimation of the Peer Treatment Effect

Negative binomial regression; N =85, *Indep.Var: Secondtest;* coefficients (St.err)					
Treatment	.412** (.179)	.322* (.150)	.343* (.152)	.463** (.176)	.257^ (.155)
Firsttest		.195*** (.026)	.191*** (.026)		.174*** (.027)
Classlevel			.093 (.081)	.175 (.158)	.084 (.082)
Sex			.039 (.134)	.157 (.095)	-.025 (.136)
Club					.420*** (.159)
Constant	.727*** (.152)	-.084 (.185)	-.360 (.300)	.171 (.331)	-.451 (.303)
Pseudo R^2	.0149	.1678	.1717	.0254	.1923
*Significance levels: ***=.001,**=.01,*=.05, ^=0.1*					

The treatment effect differs with the subsamples. Only male subjects and students from higher class levels (3rd and 4th level) benefit from a partner (Tables 4 and 5). The peer effect among men may be explained by results from Gneezy, and Rustichini (2004) who find that men, but not women perform much better in competitions than if acting alone. If this explanation holds, cooperation in the preparation induces competition.

Table 4: Estimation of the Treatment Effect, separate for men and women

NBReg; Male subjects; N = 36		*NBReg; Female subjects;* N = 49	
Treatment	.487* (.215)	*Treatment*	.177 (.211)
Firsttest	.173*** (.040)	*Firsttest*	.208*** (.035)
Constant	-.060 (.266)	*Constant*	-.043 (.258)
Pseudo R^2	.1803	*Pseudo R^2*	.1637

Table 5 : Estimation of the Treatment Effect, separate for younger and older subjects

NBReg; Class level 2; N = 39		*NBReg; Class level 3 & 4; N = 46*	
Treatment	.131 (.241)	*Treatment*	.504** (.192)
Firsttest	.118** (.0385)	*Firsttest*	.262*** (.038)
Constant	.334 (.256)	*Constant*	-.516 (.279)
Pseudo R^2	.0712	*Pseudo R^2*	.2623

3.2 Providers of and Beneficiaries of Peer Effects

The literature about peer effects typically focuses on the ability of learning partners. The score in the first test provides the ability measure in this experiment. Of course, the analysis is restricted to those 56 subjects who studied with a partner. Again club membership is the only significant control variable and remains in the analysis. Table 6 documents the results. Regarding the whole sample the ability of the partner does not have a significant impact on the performance of a subject. However, the impact of a good partner depends on the subject itself. Only good subjects (who solved four or more puzzles in the first test) benefit from an increasing ability of the partner. The negative coefficient for low ability students becomes even significant if club membership as a control variable is dropped.

Table 6: The impact of the partner's ability on performance in the second test

Negative binomial regression, Independent Variable: *Secondtest;* coefficients (robust St.err)			
	N = 56	Firsttest<4; N=23	Firsttest≥4; N=33
Partnerscore (firsttest of partner)	.022 (.022)	-.110 (.068)	.057* (.022)
Firsttest	.171*** (.027)	.152 (.120)	.173*** (.031)
Club	.378* (.146)	.343 (.282)	.340* (.145)
Constant	-.009 (.201)	.536 (.356)	-.131 (.249)
Pseudo R^2	.1644	.0890	.1041
*Significance levels: ***=.001,**=.01,*=.05, ^=0.1*			

However, promoters of "soft skills" trainings claim that the benefits of cooperation do not depend only on the ability of the partners but on some sort of social competence. The membership in a club suggests that a subject has more experience in interaction with others than a non-associated subject. Hence, the next analysis focuses on the impact of club membership of a subject and his partner on performance in the second test. I repeat the analysis from above and control also for club membership of the learning partner. Table 7 documents the results. In general, the club membership of a partner does not provide a benefit for a subject. But an asymmetric effect exists again. For club members (*Club* = 1) the membership of the partner does not matter. However, non-associated subjects (*Club* = 0) benefit from learning together with a club member. The sample size for this analysis is quite small but the effect is still highly significant.

Table 7: The impact of club membership on performance in the second test

Nbreg, Independent Variable: Secondtest; coefficients (robust St.err)			
	N = 56	Club = 0, N = 19	Club = 1, N = 37
firsttest	.168*** (.027)	.155*** (.054)	.168*** (.029)
Clubpeer (membership of partner)	.089 (.109)	.850*** (.202)	-.065 (.118)
Club	.385** (.142)		
Constant	.029 (.188)	-.512* (.255)	.513** (.189)
Pseudo R^2	.1634	.1569	.1351

4 Summary and Discussion of the Results

This first experiment has shown that cooperation in learning processes is associated with positve peer effects. Furthermore it revealed that, for the given task and difficulty, good students benefit from increasing ability of their partners. Club members provide a positive effect for subjects who are not in a club.

The existence of peer effects suggests that single learners face some deficits which have to be compensated elsewhere. The evidence from this experiment suggests that pairing good students with other good students maximizes peer effects. Yet this argument is qualified by the club membership issue. Club members perform, on average, better but they produce a positive effect for their non-associated partners. This evidence supports rather comprehensive learning groups.

The experimental design described in this paper allows to control for key problems which restrict the analysis of peer effects with survey or administrative data. The experimental approach also provides a better insight into the mechanisms of peer interaction. Further experiments can improve the external validity of the results by testing for group size and composition effects, using a different subject pool, changing the task etc. Replications of the study at the University of Konstanz and at another Swiss school are in preparation at the moment.

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