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ABSTRACT

Peer Creativity and Academic Achievement*

This paper studies the relationship between the creative abilities of study peers and academic achievement. We conduct a novel large scale field experiment at university, where students are randomized into work groups based on their score on a creativity test prior to university entry. We first show that the creative abilities of peers matter for a student's academic achievement. A one standard deviation higher creativity peer group improves study performance by 8.4 to 10 percentage points. Notably, this effect is driven by the average group creativity, there is no special impact of creative superstars. Further analysis suggests that students exposed to creative peers become more creative, but do not adjust their overall study effort. This is in line with the idea that creative approaches and questions of peers help students to master the study material better. Overall, our study highlights the importance of peer effects of creative students in shaping academic outcomes.

JEL Classification: I21, I24, J24

Keywords: peer effects, academic achievement, creativity, field experiment

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1 Introduction

Creativity - defined as the ability to produce novel ideas or solutions that are useful or appropriate in a given situation (Amabile 1996, Bradler et al. 2019) - is seen as an important skill that is essential to problem solving and (for now) mostly resistant to automation. It is important for entrepreneurship and innovation (Erat and Gneezy 2016 and Gross 2020) and a driver of the economy (Charness and Grieco 2019). On an individual level creativity has significant pay offs in terms of educational attainment and labor market outcomes (Gill and Prowse 2021).

There is a by now large literature showing that peer effects are an important driver of educational performance, see e.g. Sacerdote (2011) for a literature review and a discussion at the end of this introduction. While the importance of creativity is by now well studied, the impact of peer creativity has received surprisingly little attention in this literature.

In this paper we study the impact of the creative abilities of randomly assigned study peers on students' academic achievement. In this context, before entering university, students participate in a survey. As part of this research we include two creativity tests to this survey: the Remote Associates Test (RAT) and a domain specific version of the Kaufman Domains of Creativity Scale (K-DOCS). Based on students' score on the RAT we assign them randomly to low, mixed, and high creativity groups.[1] We subsequently estimate how peer creativity impacts academic achievement.

The creative ability of study peers can influence students in at least three ways. First, students who work together with creative peers may learn from the questions that creative peers ask or from discussions with creative peers, and they may learn strategies and techniques that help them increase their

[1]We choose the RAT as our main measure of creativity for several reasons, which are carefully explained in section 3. The most important reasons are that the RAT is specifically developed to measure creativity (see Mednick 1963) and the RAT is shown to strongly correlate with other creativity measures (see e.g. Resout and Nietfeld 2021).

study performance. Second, students may become more motivated and engaged from experiencing creativity from their peers, for instance when creative peers make learning more fun and challenging. This leads students to increase their study effort and as a consequence their performance increases. Finally, there may be a direct effect from creative students who stimulate their peers to 'think outside the box', resulting in improved creative ability and as a consequence improved study performance.

This paper shows that students' creativity is positively associated with their own study performance (GPA). A one standard deviation increase in creativity is associated with an increase of 7 to 8 percentage points in GPA.[2] The key contribution of this paper however, lies in the ability to study the effects of peer creativity on study achievement. We first show that the distribution of creativity of peers matters for students' achievement. A one standard deviation increase in the mean of peer creativity increases a student's GPA by 8.4 to 10 percentage points of a standard deviation. The dispersion of creativity within a work group has a very limited effect conditional on the mean. The result that the creativity peer effect is larger than the individual effect may seem odd at first. However, in all regressions we control for study performance prior to entering university, a large part of the impact of creativity on performance is therefore implicitly controlled for. Hence, note that without controlling for High School grades, the correlation between one's own creativity and GPA would be much larger.

As a robustness test we replicate our main findings using an alternative measure of creativity, a stated-creativity test: the K-DOCS. We find that the results replicate quite well. There is a small positive effect of one's own creativity on study performance and a one standard deviation increase in the score on the K-DOCS leads to a significant and specification robust increase in GPA of 4 to 5 percentage points.

With the aim of shedding light on what mechanisms drive the positive

[2] This finding is in line with the literature, see e.g. Naderi et al. (2009), Naderi et al. (2010), Kaufman (2010), Name et al. (2014), Mourgues et al. (2016), Atwood and Pretz (2016), and Zhang et al (2020) who report either insignificant or small and positive associations between creativity and academic achievement.

impact of creative peers on academic achievement we use a follow-up survey roughly six months later. These data show that students with creative peers become more creative, but report no difference in the amount of hours they studied. This implies that students become more productive per hour, and suggests that students learn from creative peers through the questions that the creatives ask, the discussions, or through adopting their learning strategies. Students do not seem to become more motivated from creative peers which would suggest a change in the number of study hours and/or the allocation of their hours towards studying more often with work group members.

This paper relates to two main strands of literature. The literature studying the relation between creativity and academic achievement and the literature on peer effects in education. Regarding the first strand of literature, there are many paper that study the association between creativity and academic achievement. See Gajda et al. (2017) for a recent literature overview of 120 papers from the 1960s onwards. On average the correlation between creativity and academic achievement is 0.22, which is stable over time, and weaker for GPA measures than for measures using standardized tests. This is in the same direction, though considerably larger, than the correlation that we find.[3] Notably, the correlation is stronger for revealed creativity tests as compared to self-reported measures, which is also in line with our findings.

There is a rich body of research studying peer effects in education, see Sacerdote (2011) for an extensive review of the literature. This literature is concerned with estimating causal effects of social spillovers within groups. It shows that peer test scores affect students.[4] Also gender and race composition of groups impact students.[5] So far there is surprisingly little research

[3] We find a correlation between creativity and a student's GPA of 13.4%, without adding control variables.

[4] See e.g. Carell et al. (2009), Carell et al. (2013), De Giorgi and Pelizzari (2013), Duflo et al. (2011), Feld and Zölitz (2017), Lyle (2009), Whitmore (2005), Zimmerman (2003).

[5] See e.g. Hoxby (2000), Angrist and Lang (2004), Hoxby and Weingarth (2005), Lavy and Schlosser (2011), and Oosterbeek and van Ewijk (2014).

on the peer effects of non-cognitive skills and preferences. There are only a few recent exceptions, e.g. Golsteyn et al. (2021) on the peer effects on persistence and risk preferences, Hancock and Hill (2022) and Shure (2021) on the peer effect of conscientious peers, Zarate (2023) who study the impact of peers' social skills on academic achievement, and Shan and Zoelitz (2022) on the impact of the big five of peers on academic achievement. The contribution of this paper to the literature is twofold. First, we study the effect of peer creativity on academic achievement. Second, by randomizing creativity block based into three groups - low creativity, high creativty, and mixed creativity - we increase the variation of peer creativity between groups.[6] As a consequence this paper avoids the issue that the exogeneous variation between groups is so limited that the estimates become imprecise and amplify bias, see also Angrist (2014) for an extensive discussion on this issue.

A challenge when estimating the impact of peer creativity - or any other personality trait or characteristic - on academic achievement is the fact that peer creativity can be related to other characteristics of peers that impact academic achievement directly. Therefore as a robustness check, we include the risk preference and persistence of students and of their peers as additional controls (since these personality traits have shown to impact study performance, see Golstyen et al. 2021) and peers' study performance prior to entering university. We find that our results are robust for including these peer effects. In addition - using a sample of students who are in the same study programs, but were not part of this experiment - we test to what extend creativity correlates with measures of the big five personality traits and measures of IQ. We find that the relation between creativity and the big five is insignificant with an exception of a small and marginally significant correlation between creativity and openness to experience. Creativity and IQ on the other hand are correlated, however this relation disappears once we control for study grades prior to joining university. These findings combined suggest that it is actually peer creativity that affects students' performance, and not primarily a correlate of creativity.

[6] This approach is in line with Booij et al. (2017) and Zarate (2023).

Our key findings - of positive creativity peer effects - have at least three implications. First, since creative students create positive spillovers, creativity can (and perhaps should) be used as a selection criteria into selective schools. Second, the positive peer effects imply that the value of creativity extends beyond the individual, this suggests that courses that stimulate creativity are more valuable that previously thought and should therefore be part of study curricula. Third, the positive spillovers that come from creative peers depend on the exposure of students to their peers. This implies that information provision to students, about the benefits of creative peers may help them to reap the benefits from peer creativity.

This paper proceeds as follows. In the next section we discuss the institutional setting. Section 3 describes the data, which includes both survey and administrative data and descriptive statistics. Section 4 explains the experimental design, Section 5 the empirical methodology, and section 6 the results. The final section provides a discussion of the results and concludes.

2 Setting

This experiment took place in all full time undergraduate study programs of a large Law School in the Netherlands. Law school is consistently among the top 10 largest and most popular studies and is not selective. Students from all pre-university tracks can enter Law school. This particular Law School has an influx of around 1,200 students per year who study Law or Criminology.

All students are assigned to small work groups of 25 to 30 students, before the start of the academic year.[7] Students spend their first days at university within these groups learning about each other, the study program, and the information and communication systems they will be using during their studies. After these introduction days they participate in these same small groups for most of their study time for the rest of their first year of studies.

[7]The cohort 2020-2021 started during the COVID-19 pandemic. As a consequence work group were made smaller and hosted most of the time online.

Most courses consist of one or two main lecturers, who teach all students at once, and work groups where students learn with each other and work through cases, cooperate on group assignments, and solve problem sets. In the first year students take 10 courses, dependent on their study specialization.[8] Roughly 30% of their scheduled classes are lectures with all students of one or more of the study specializations, the remaining 70% percent of their contact hours is in the smaller work groups. These work groups are designed with the purpose of studying together and learning from each other, as well as for the social aspect of studying at this university. For instance, students occasionally have social activities with these groups. In other words, this work group system is designed with the purpose of students getting (positively) affected by each other.

In all study programs that are part of the analysis, students are graded on an absolute - instead of relative - grading scale. On top of that, work group teachers typically don't grade their own students. Instead, all teachers grade part of the exams of all students. These characteristics of the program avoid the potential issue that if all students in a work group perform better - for instance because of peer creativity - the grades are adjusted downwards, because of grading on a curve. In addition, since exams are mostly graded by other teachers - and/or graded anonymously - there is no room for favoritism or other forms of biases.

Students are allowed to initially fail a few courses in their first year of studies. They can progress to the second year when they complete at least 40 of the 60 course credits in the first year. In the second year students need to finish at least the remaining credits from the first year. Students who fail to obtain at least 40 course credits at the end of the first year have to drop out of the program.

[8] These seven specializations are: Dutch Law, Fiscal Law, Notarial Law, Law and Economics, Law and Entrepreneurship, International Business Law, and Criminology. In the first year all but one course are the same of the first six specializations. The criminology track is more different.

3 Data

We use data on all full time first year students of the cohorts 2019-2020, 2020-2021, and 2021-2022 of a Law School at a Dutch University from two different sources. Administrative data on all students that start in these undergraduate study programs. These data include gender, High School grades, study track specialization, and study grades obtained at university. Second, we have data from two surveys. One that was administered before students entered university and were assigned to work groups, and a second survey that was administered during the second semester (i.e. nearly six months later). These surveys were matched with the administrative data. Both surveys contain questions on students' creativity. Specifically we conduct two well known creativity tests, the RAT and the K-DOCS. In addition, the second survey is supplemented with questions on study behaviors and work group dynamics.

3.1 Remote Associates Test

There are many different tests used in the literature to measure creativity, without a consensus on what the best way to measure creativity is, see e.g. Freund and Holling (2008) and Kaufman et al. (2008) for such discussions. In this paper the main measure of students' creative abilities comes from the Remote Associates Test (RAT).

The RAT (developed by Mednick 1962) is a type of cognitive task that measures a person's ability to generate creative solutions by making connections between seemingly unrelated words. During the RAT, participants are presented three words, and are instructed to find a fourth word that is most strongly associated with all three words. The three words may seem unrelated at first, but there is a hidden link that can be discovered through creative thinking (Backman and Tuckman 1972). The RAT is often used as a measure of creativity and problem-solving ability because it requires people to provide novel solutions, 'think outside the box', and make connections between concepts that seem unrelated. Several of these three word problems together form a measure of someone's creative abilities.[9]

We chose the Remote Associates Test (RAT) as our main creativity measure for several reasons. The test is developed with the intention to measure creativity specifically (Mednick 1963) and validated by Chermahini et al. (2012) in the Dutch language. It's a language based creativity test, that can be easily incorporated in a survey. As Gajda et al. (2017) point out, linguistic creativity tests are more strongly associated with academic achievement as compared to figurative tests. Further, the test is a convergent thinking test, which correlates more strongly with academic performance (as compared to a divergent thinking test), see Yang and Zhao (2021). Finally the RAT has a significant correlation with many other creativity measures. For instance, Resout and Nietfeld (2021) show in a large sample of college students a significant correlation between the RAT and the product improvement test (PIT, as part of the Torrance Test of Creative Thinking, Torrance 1974) and the Similarities Test (Walach and Kogan 1965).

Creativity, and measures of it like the RAT, are also correlated with both cognitive and non-cognitive traits. For instance there is a moderately positive correlation between scores on an RAT and scores on an IQ test. Further the RAT is positively correlated to the big five personality trait openness to experience, see e.g. Taft and Rossiter (1966), Chermahini et al. (2012), and Lee et al. (2014).

Our paper focuses on the impact of peer creativity (as measured by the RAT) on study performance. Since traits like IQ and the big five are (weakly) correlated with the RAT we take a convenience sample of students consisting of 95 students of the cohort 2023-2024 of the same study programs for which we obtain high school grades, RAT scores, IQ test scores, and measures of the big five. We find that for this sample the scores on the RAT correlate positively with IQ and with openness to experience. But once we control for high school grades in a regression using both IQ and the big five, the effect on RAT diminishes. This suggests that using high school grades is sufficient to pick up the impact of traits correlated with creativity. For the full sample of students we study in this paper we have high school

[9] A whole question bank can be found at: https://www.remote-associates-test.com/.

grades (that we use as controls for both the individual and its peers), but no measures of IQ or the big five personality traits.

3.2 K-DOCS

Supplementary to the RAT, we conducted a stated creativity test. One benefit of using this additional test of creativity is that the stated test can be made domain specific. Secondly, for creativity spillovers someone's own perceived creativity may matter in particular, because it may affect the way in which students choose to interact with their peers more. For instance students who believe they are creative may be more outspoken in group discussions. We use the Kaufman Domains of Creativity Scale (K-DOCS) as a starting point (see Kaufman 2012) and adjust some of these questions to be specific of the academic study domain. In the end we developed and used the following introduction question and statements: *Compared to others, how creative would you rate yourself for each of the following acts?* 1=much less creative, 2=less creative, 3=neither more or less creative, 4=more creative, 5=much more creative.

1. Choosing the best solution to a study problem.
2. Helping other people cope with a difficult situation.
3. Thinking of many different solution to a study problem.
4. Helping other students during a difficult problem or assignment.
5. Thinking of new ways to help people with their studies.
6. Being able to offer constructive feedback based on my own reading of a paper.
7. Coming up with a new way to think about an old debate.
8. Debating a controversial topic from my own perspective.

In order to get an impression about the quality of the answers to these questions, we added a question in the end where the respondent is asked to rate how difficult they found it to answer the series of statements about their own creativity. A large majority (nearly 70%) of respondents state that they did not find it difficult (at all) to answer these questions.

3.3 Descriptive Statistics

This paper uses data of three cohorts of students who have subscribed to a full time undergraduate degree at a large Dutch Law School. The students are enrolled in one of the following seven programs: Dutch Law, Fiscal Law, Notarial Law, Law and Economics, Law and Entrepreneurship, International Business Law, or criminology. Dutch law is the largest with around 750 students a year. The other programs vary yearly between 50 and 125 students. The target group of students in this paper are 3,787 students, 1,103 in the 19-20 cohort, 1,381 in the 20-21 cohort, and 1,303 in the 21-22 cohort. These 3,787 students are divided over 120 work groups in total. The sample of students who start with the first survey consists of 2,444 students of which 1,973 students progress until the RAT. The non-responding students are subsequently allocated randomly and equally to each group. More details about the assignment procedure will be provided in the next section.

In the Netherlands, Law schools typically have a majority of female students, in this setting 65% of the students enrolled is female. Students get enrolled to a study program after completing one of the pre-university high school tracks. The university keeps track of students' high school grades for Dutch language and Mathematics. Grades vary between 1 and 10, where 5.5 is the threshold of passing a course. Students score on average slightly below 7 for both courses. This pattern turns out to be essentially the same for all cohorts and is compared to the average national scores a bit higher for the Dutch language and a bit lower for Mathematics.

On the RAT students could score 0 - 12 points, 1 point per question. In the end the average score is 5.82 which is similar to the score in Lee et al. (2014). Across the cohorts the difficulty of questions was the same, and consequently their scores were also similar. Female students receive higher scores on the RAT which is in line with earlier studies.

The self-reported creativity test (K-DOCS) consisted of eight questions, where 1 indicated the lowest and 5 the highest score. Therefore the scores vary between 8 and 40. With an average of 29.58 students believe they are slightly more creative than their peers (a score of 24 would mean that students believe they are at the average of creativity in their groups). Males score higher on the K-DOCS.

The last panel of Table 1 shows students' study performance at university. It is important to note that students are graded on an absolute scale, not relative to other students in their working group or cohort. GPA is the students' grade point average (between 1 and 10, where 5.5 is the threshold for passing a course). The next row gives the number of courses passed from the total of 10 courses. The GPA and number of courses completed is relatively low, because the group of students that drops out of the program is relatively large. In addition, students need to pass at least two thirds of their courses in order to proceed to the second year of their study program. We see that, one out of five students drops out of their study program during the first year. All these study performance patterns are similar across cohorts.

Table 1: Descriptive Statistics

	Full sample	Males	Females
Male (%)	35.48	X	X
HS Grade Dutch language	6.72	6.58	6.79
	(0.68)	(0.73)	0(.64)
HS Grade Mathematics	6.65	6.63	6.65
	(1.02)	(0.94)	(1.06)
Creativity	5.82	5.61	5.94
	(2.12)	(2.07)	(2.14)
Stated Creativity	29.58	30.16	29.26
	(3.55)	(3.61)	(3.47)
GPA	5.15	4.84	5.32
	(1.95)	(2.03)	(1.89)
Course credits	5.46	4.81	5.81
	(3.55)	(3.52)	(3.52)
Drop out (%)	20.1	23.7	18.1
Observations	1,973	700	1,273

The full sample refers to the sample of students how participated in the RAT (creativity test). this respons is needed in order to estimate our individual measure of creativity. The standard deviations are in parentheses.

4 Experimental Design

The aim of this study is to measure the impact of the creative ability of work group peers on students' academic achievement. In order to study how the distribution of peer creativity affects students' performance, we cannot rely on natural variation stemming from a full randomization of students into work groups. This is the case because natural variation is limited and as a consequence the difference between high and low creativity groups stemming from only natural variation would be too limited. This is especially the case if one wants to draw conclusions about matching the most and least creative students. Such a recommendation cannot follow from a fully randomized design, because groups of only high or only low creativity are expected to be underrepresented in such designs, see e.g. Angrist et al. (2014) and Booij et al. (2017) for a thorough discussion. We therefore create additional variation using the experimental design. We do this in two steps. First, we assign students a type based on their creativity score. Second, based on this type we randomly allocate students to different group types with low, high, or mixed creativity peers.

4.1 Step 1: assign students a type

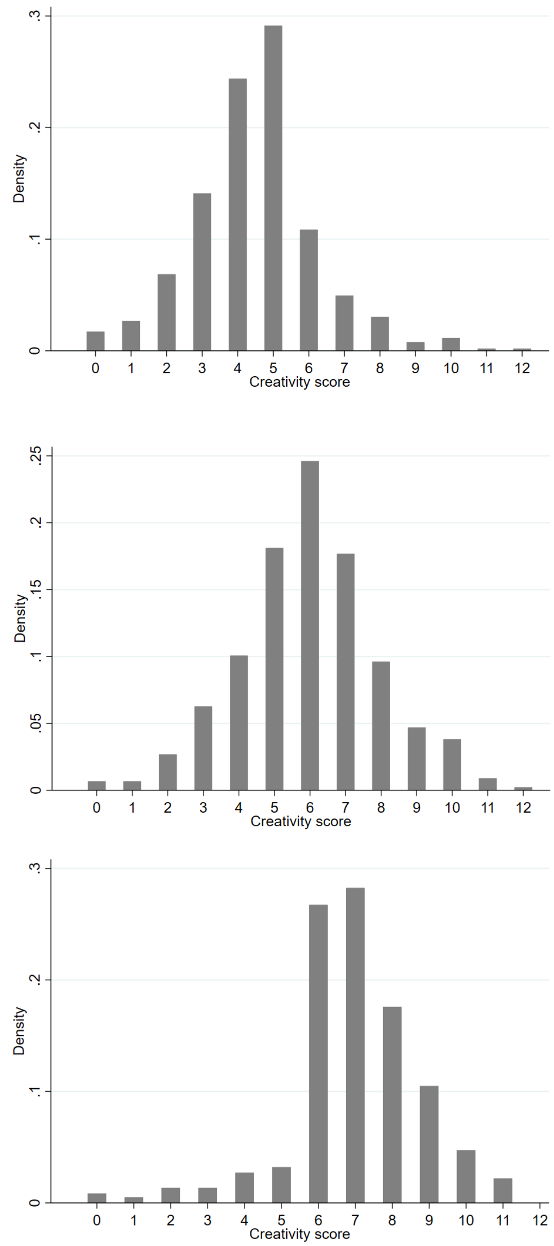
We assign students to one of three types based on their RAT score: high creativity, low creativity, or non-participant. The non-participant type consists of all students who hadn't participated in the survey at the moment of randomization. Some of those students still participate in the survey after the randomization but before the start of the academic year (when they first meet their work group mates), these students still receive a creativity score. Those students who have completed the survey before randomization have a creativity score - a discrete score between 0 and 12 - and are allocated a type based on their score. The mean scores of participants were in each year between 5 and 6. Therefore students with a creativity score of 5 or lower are assigned the low creativity type, and those with a score of 6 or higher are assigned the high creativity type.

4.2 Step 2: randomize students into work groups conditional in their type

Based on the classification of students into three creativity types, we assign each student to work groups that are of three possibly types: low creativity groups consisting of students who score low on creativity; high creativity consisting of student who score high on creativity, and mixed creativity groups; consisting of a mix between low and high creativity students. All the students that didn't complete the survey before the time of work group assignment are randomly and equally divided over all groups. We divided these non-responding students equally across the groups for two reasons. Practically, when the assignment was conducted it was unsure whether students in the end choose to start an education program in this Law School. Those students who fill in the survey almost always attend a study program, while this is not the case for the non-responding students. Therefore spreading them equally avoids the issue of reallocating students afterwards because some groups would contain much more students than others. Secondly, since non-responding students may differ from responding students in non-observable ways in their peer effect, it is important to divide them equally across groups in order to avoid this bias.

There are two other restrictions with regard to group assignment, which followed from university policy. First, all students within a work group need to be subscribed to the same study specialization. Second, between work groups of the same specialization the gender balance should be the same. Therefore the randomization into the groups: high, mixed, and low creativity is based on the creativity type classification, study specialization, and gender of the student. Figure 1 shows the final creativity distribution per group. Distributional tests show that the distribution clearly differs across each group type, be it low, mixed, and high creativity groups.

Figure 1: Creativity distribution for low, mixed, and high creativity groups respectively. Creativity is measured on a scale from 0 to 12.



4.3 Non-Participation

Since the aim of this paper is to study the impact of peer creativity on study performance, students only enter our main sample when they obtain a creativity score through survey participation. The participation rates range from 60% to 70% per cohort. We find some selection into survey participation. Female students and students with better high school grades are somewhat more likely to participate in the survey, and there are some differences between study programs. As discussed before, the distribution of non-participating students across work groups is by design the same. Therefore, even if non-participating students differ in dimensions important for other students' productivity in work groups, this non-participation does not lead to a bias in our estimate of peer effects.

4.4 Randomization Test

In order to study whether the randomization has worked properly, we regress the group type (low, mixed or high creativity work group) while controlling for the creativity type (low or high type) and exact creativity score, on students' individual characteristics (i.e. gender and High School grades in Dutch and Mathematics). When the randomization has worked,we expect no significant relation between the group type (while flexibly controlling for the creativity type) and students' individual characteristics. Table 2 shows that indeed there is no significant relationship between the group allocation (A_i) and students' characteristics.

Table 2: Randomization test

Dep. var.:	Gender	Dutch grade	Math grade
A_i	-0.024	-0.011	0.018
	(0.021)	(0.017)	(0.019)
Creativity type	0.038	-0.022	-0.035
	(0.042)	(0.045)	(0.046)
C_i	-0.038	0.009	0.003
	(0.024)	(0.027)	(0.027)
Observations	1,973	1,973	1,973

This table shows the results of an OLS regression where I regress the allocation to a group A_i, the creativity type, and the exact creativity score on students' individual characteristics. The standard errors are clustered by work group and in parentheses. *, **, *** indicate significance levels at the 0.10, 0.05, 0.01 level respectively.

5 Empirical Methodology

In order to estimate peer effects we use a flexible specification that allows a peer group to affect students in various ways. We use the student's own creativity, the leave-out-mean (i.e. the mean of creativity of the work group, excluding the individual), the leave-out-standard deviation (i.e. the standard deviation of peer creativity within the group, excluding the individual), and in some specifications their interactions. This estimation strategy closely follows Booij et al. (2017). To be precise we estimate:

$$Y_i = \alpha C_i + \beta \overline{C_{-i}} + \gamma SD(C_{-i}) + \nu \overline{C_{-i}} * SD(C_{-i}) + \xi X_i + \epsilon_i \quad (1)$$

where Y_i is academic achievement measured in various ways, by grade point average (GPA), by number of courses completed, and by whether the student drops out of the first year. C_i is the creativity score of individual i,

$\overline{C_{-i}}$ the leave-out-mean of the work group's creativity score, and $SD(C_{-i})$ the standard deviation of the creativity score of the students in the work group excluding student i. This implies that $\overline{C_{-i}}$ and $SD(C_{-i})$ vary not only between work groups but also within work groups for students with different creativity scores. Note that Y_i, C_i, C_{-i}, and $\overline{C_{-i}}$ are all mean standardized, implying that for each variable the mean equals 0 and the standard deviation equals 1. Finally, our vector of control variables includes the individual characteristics gender and high school grades, and the group variables that determine assignment to work groups, which are: study specialization fixed effects, and creativity type (either, high or low).[10] Creativity type is added as a control variable to allow the effect of creativity to vary non-linearly. Specifically, because of the fact that those students with a high creativity label have by definition in expectation higher creativity peers than students with a low creativity label. The standard errors are clustered at the work group level.[11]

In addition to the OLS of equation one, we use the random assignment to the student's own type or mixed type creativity groups as an instrument for the leave-out-mean of group creativity. For this we use the following two-stage-least-squares estimation:

$$\overline{C_{-i}} = \pi A_i + \delta C_i + \mu X_i + \eta_i \qquad (2)$$

$$Y_i = \theta \hat{C}_{-i} + \sigma C_i + \chi X_i + \psi i, \qquad (3)$$

where equation 2 is the first stage regression where the leave-out-mean of group creativity, $\overline{C_{-i}}$, is instrumented for by A_i, the instrument, which is the assignment to the own creativity group of mixed creativity group. Equation 3 is the second stage regression where Y_i are the same outcomes described

[10]In addition, for institutional reasons there had to be a gender balance between work groups within the same study specialization. Therefore controlling for the gender composition of work groups leads to an insignificant coefficient and no change in the estimates of the variables of interest.

[11]The full sample consists of 159 work groups.

above. The vector of control variables in equation 2 and 3 are also the same as those described below equation 1.

6 Results

6.1 Main results

We estimate the effect of peer creativity on students' grade point average (GPA) in Table 3. The main creativity measure we use is the RAT (for a description see section 3.1). We build up equation 1 by first estimating only the effect of one's own creativity (column 1), than the mean of peer creativity (column 2), and then both (column 3). The results show that a one standard deviation increase in creativity is associated with a 8.3 percentage point increase in GPA. A one standard deviation increase in the mean creativity of peers leads to an increase in GPA of 8.7 percentage points of a standard deviation. Column 3 shows that when we include both students own creativity and the mean of peer creativity the impact of individual creativity drops to 7.1 percentage points while the mean of peer creativity remains a strongly significant 8.4 percentage points.

Perhaps surprising at first, the mean peer effect of creativity is larger than the impact of the student's own creativity. However, this can be explained by the fact that the impact of creative peers does not need to come from an increase in a student's own creativity. For example, creative peers may ask questions and approach problems in different ways, which may directly improve other students' understanding of the study material, impact the way that the student studies, and their study motivation and effort. In addition, we control for high school grades which already pick up part of the impact of an student's creativity on study performance.

In columns 4 and 5 we include the standard deviation of peer creativity in order to allow the effect of peer creativity to depend on the extremes. Specifically, these specifications allow us to learn whether the positive impact of more creative peers is driven by a few highly creative (and more low creativity) peers, or that the impact of these high creativity peers is less pronounced. Overall we see evidence that the creativity of peers matter for students performance. In all columns we see based on joint F-tests that the peer creativity variables are jointly strongly significant in explaining students' GPA. The impact of the standard deviation is negative but far from significant. This implies that the dispersion of creativity within a group is not important, given the mean creativity.[12]

Table 3: The effect of peer creativity on GPA

Dep. var.: GPA	(1)	(2)	(3)	(4)	(5)
C_i	0.083*		0.071*	0.073*	0.076*
	(0.043)		(0.042)	(0.042)	(0.043)
$\overline{C_{-i}}$		0.087***	0.084***	0.089**	0.100**
		(0.029)	(0.029)	(0.039)	(0.039)
$SD(C_{-i})$				-0.009	-0.022
				(0.041)	(0.041)
$\overline{C_{-i}} * SD(C_{-i})$					-0.034
					(0.030)
Controls	Y	Y	Y	Y	Y
F-test (p-value)					
peer variables = 0		0.003	0.005	0.019	0.025
Observations	1,973	1,973	1,973	1,973	1,973

This table shows the results of an OLS regression where I control for creativity type, gender, studyprogram, and High School study grades in Dutch and Math. The standard errors are clustered by work group and in parentheses. *, **, *** indicate significance levels at the 0.10, 0.05, 0.01 level respectively.

As alternative measures of study performance we use the number of completed course and drop out of the study program as outcome variables, see Tables A1 and A2. The pattern of results is remarkably similar to the effect on GPA. The mean creativity of the peer group positively affects the

[12]In addition - in order to test whether the most creative student affects the group - we estimate the impact of the student with the highest creativity score for each group on peers. This also shows no particular impact of the top creative student.

number of courses completed. A one standard deviation increase in peer creativity leads to an increase of 0.345 courses completed. For drop out we find a qualitatively similar pattern, although mostly insignificant, with lower drop out rates for students with on average higher creativity peers.

6.2 Robustness: Correlates of Creativity

So far we have shown that students who are randomly assigned to more creative work group peers perform better at university. Creativity may be correlated with cognitive and/or non-cognitive skills that result in peer effects. It could therefore be the case that peer creativity impacts study performance through a trait or skill that is correlated with creativity (instead of creativity itself).

Earlier literature found peer effects in the higher education classroom based on students' high school GPA (see Booij et al. 2017) and personality (see Golsteyn et al. 2020). It may be that highly creative students also have better grades prior to university entry and/or have a personality that creates positive peer effects. Than we may falsely attribute peer effects in creativity to creativity while the effects are actually driven by these students having higher GPA or certain personality traits. In order to test these particular channels we use peers' high school grades and peers' persistence and risk preferences (those personality traits that showed the strongest peer effects in Golsteyn et al. 2020) as additional controls in Table A3 and A4.

Table A3 shows that the impact of creativity peers is virtually unaffected by the inclusion of peer grades in high school Mathematics and Dutch. Furthermore, the impact of the mean of peer high school grades are significant and positive, with the impact of high grades in Dutch being slightly larger than the impact of grades in Math. Table A4 - which includes the mean of peers in risk preferences and persistence - shows that the impact of peer creativity also survives.[13] These results imply that high creativity peers do not impact other students via their cognitive ability as measured by their

[13]We measure risk preferences using the response to the question: "In general, how willing are you to take risks?" For persistence we took six questions from the CP-SRLI. See VandeVelde et al. (2013) for a description of the CP-SRLI.

prior study grades nor by the personality characteristics persistence and risk preferences.

Other cognitive and non-cognitive skills that are known to be correlated with creativity are intelligence (see e.g. Lee and Therriault 2013) and the big five personality traits (mainly openness to experience), see e.g. Pesout and Nietfeld (2021). We don't have measures of these skills for our subjects. However we take a 'convenience sample' of 95 students - who were willing to participate in a survey - from the same university programs that started in the academic year 2022 - 2023 for which we measure IQ, the big five personality traits, and creativity using the RAT. For this sample we establish three facts. First, there is only a weak and insignificant correlation between the big five personality traits and creativity, where openness to experience is marginally significant, and the other traits aren't. Second, there is a significant correlation between IQ and creativity. Third, this positive correlation disappears once we control for High school grades. In the baseline specification we control for High school grades and as a robustness check we control for spillovers in High school grades by including the mean of peers' High school grades. Therefore we believe there are no strong correlates with creativity that drive the peer effect. Taken together our findings mirror the statement in Gill and Prowse (2021) that creativity is a unique trait that affects educational attainment besides the standard cognitive and non-cognitive traits.

6.3 Stated creativity

Research has found that the correlation between stated creativity and academic achievement is positive but weaker than the correlation between revealed creativity and academic achievement, see e.g. Gadja et al. (2017). However, when studying peer effects of creativity it is crucial that students show their creativity, e.g. through asking questions, participating in class, or in group assignments. Hence, some creative students - as measured by the RAT - may not believe they are creative and hence contribute less to discussions leading to less positive spillovers to their peers. Therefore we also study the peer effects of a stated creativity measure, the K-DOCS which we adjust to fit the academic context, see section 3.2 for more the questions and their scales. We estimate the impact that the stated creativity of peers has on students using equation 1. We mean standardize the stated creativity variable, in the same way as the revealed creativity measure. Note that the randomization is based on the RAT, not on the K-DOCS, hence the between group variation in K-DOCS creativity is less pronounced. Figure A1 shows the distribution of the domain specific K-DOCS scores across the different type of work groups.

Table 4 shows that the impact of stated creativity on students' own study performance is small, positive, and insignificant. The peer effects are positive, borderline significant, and relatively smaller than for the RAT measure of creativity. Across the different specifications, an increase of one standard deviation in peer creativity (as measured by the K-DOCS) leads to an increase in GPA of roughly 5 percentage points. The fact that our results using the alternative K-DOCS measure are weaker than with the RAT measure is in line with the practice that students are assigned to a work group based on their RAT score, not based on their K-DOCS score.

Combined with our findings in Table 3 this shows that the peer effect of creativity is robust across two different creativity measures. Meanwhile, as the literature predicts, the link between GPA and (peer) creativity measured by revealed creativity is stronger than by self-stated creativity.

Table 4: The effect of peer stated creativity on GPA

Dep. var.: GPA	(1)	(2)	(3)	(4)	(5)
C_i	0.024		0.014	0.015	0.015
	(0.021)		(0.021)	(0.021)	(0.021)
$\overline{C_{-i}}$		0.045	0.051*	0.045	0.039
		(0.031)	(0.029)	(0.035)	(0.036)
$SD(C_{-i})$				0.023	0.107
				(0.060)	(0.105)
$\overline{C_{-i}}$ * $SD(C_{-i})$					-0.032
					(0.025)
Controls	Y	Y	Y	Y	Y
F-test (p-value)					
peer variables = 0		0.147	0.098	0.201	0.265
Observations	1,973	1,973	1,973	1,973	1,973

This table shows the results of an OLS regression where I control for creativity type, gender, studyprogram, and High School study grades in Dutch and Math. The standard errors are clustered by work group and in parentheses. *, **, *** indicate significance levels at the 0.10, 0.05, 0.01 level respectively.

6.4 Instrumental Variable estimates

Close to 30% of the students hasn't participated in the survey at the time of randomization, but participated later. These students are part of the study (and part of the main sample we use for estimation in section 6.1) but are not randomized to a group based on their creativity type. Instead, they are randomly distributed across all groups (see also section 5 for the randomization procedure of the experiment). As a consequence these 30% are not part of the two-stage-least-squares estimation.

Table 5 shows the results of the estimation of equations 2 and 3. The first stage regressions show that - following from the experimental design - assignment to the own creativity type groups is associated with a lower mean peer creativity for low creativity peers and for an increase in the mean peer creativity for high creativity peers. Since the instrument is relevant and based on random assignment we conclude that the instrument is valid, and interpret the second stage estimates of the impact of the mean of peer creativity as causal. The second stage regressions show that the instrumented mean of peer creativity ($\hat{C_{-i}}$) impacts students' study performance. A one standard deviation increase in peer creativity - due to the randomization - leads to an increase in 11.1 percentage points in students' GPA. Columns two and 2 and 3 show a positive but insignificant impact (p=0.173 and p=0.119) of high creativity peers, with no clear difference in the impact for high creativity as compared to low creativity students. This lack of significance plausibly stems from lower statistical power.

Table 5: TSLS regression with assignment to group type as an instrument for peer creativity

Sample	all	low creativity	high creativity
First stage:	$\overline{C_{-i}}$	$\overline{C_{-i}}$	$\overline{C_{-i}}$
A_i	0.810***	1.014***	0.735***
	(0.060)	(0.112)	(0.115)
Second stage:	GPA	GPA	GPA
C_i	0.081**	0.043	0.099*
	(0.038)	(0.058)	(0.051)
$\hat{C_{-i}}$	0.111**	0.073	0.105
	(0.048)	(0.053)	(0.068)
Controls	Y	Y	Y
Observations	1,393	586	807

Notes: We estimate a linear two-stage least-squares model. In the first stage we use the assignment to group type (own group of mixed) as an instrument for the mean of peer creativity. In the second stage we estimate the impact of the mean of peer creativity on students' GPA. This regression includes the gender, study specialization, and high school grades as control variables. Standard errors are clustered at the work group level and shown in parentheses, *,**,*** indicate significance at 10%, 5%, and 1% levels.

6.5 Mechanisms

So far we have established that there are positive peer effects from creativity on students' academic performance. In this section we try to distinguish between some of the mechanisms that may drive these results. We distinguish between three main channels. First, creative students may ask different (novel) questions, contribute with creative arguments to discussions, and change other students' perspectives on how to approach problem sets. These approaches may increase students' understanding of the study material, without increasing their study effort, leading to a higher productivity per study hour, which improves performance. Second, the before mentioned behaviors of creative peers may make studying more fun and motivate students, this may increase effort, which improves performance. Finally, students may become more creative from their interactions with creative students, this may improve their study performance.[14]

In the second semester - roughly six months after the start of their study program - of each year we administered a survey containing questions that help us distinguish between the three mechanisms described above. We ask about work group dynamics in order to learn whether students believe groups with more creative peers are more productive. In order to measure these group dynamics we ask respondents to rate the following two statements on a five-point-scale, ranging from 1=never to 5=always: *I think I learn a lot from studying together with students from my work group*, and *I spend time with students from my work group outside university.* If students experience that creative peers contribute to work groups in a way that their productivity per hour increases, we would expect them to respond more positive to the statement about whether they learn a lot from students in their work group. In order to distinguish whether increased productivity comes from an increase in productivity per hour or from increased effort, we also ask students about the amount of hours that they study, both with their work group peers as well as the total number of hours. Finally, the second survey contains another RAT (but with different questions). From this we obtain a new measure of creativity that we can use to analyze whether students with more creative peers become more creative. We analyze whether the mean peer creativity (as measured by the RAT) impacts the student's survey responses while also controlling for initial creativity as well as creativity type using OLS regressions.

The response rate to this second survey is (with roughly 20%) rather

[14]This last hypothesis - that creativity improves after exposure to creative student - is in line with Shan and Zolitz (2022) who find peer effects in the big five personality traits. Students with peers who are more conscientious and have a higher openness to experience improve these traits over time, but not the other traits. Shan and Zolitz argue that students adopt the productive traits, but not the non-productive traits.

low. We therefore test for selection into survey participation in Table 6. Specifically, we want to rule out that the outcome of the randomized group allocation is indicative of survey participation. If only or mainly those assigned to a certain work group participate in the survey our results would be biased. We find no indication of selection into survey participation based on the allocation of students into groups. Neither the allocation (to same type of mixed type creativity peers), nor (group) creativity measured before randomization are significantly correlated with the decision to participate in the second survey.[15] However, some of the control variables - specifically gender, study specialization, and work group - are correlated with survey two participation. Therefore, when testing for mechanisms using the responses to the second survey we use inverse probability weighting based on these variables, in order to correct for participation differences.

[15] As an alternative way to get a feel of whether second survey participants are different from the full sample is by reproducing the main results using only the second survey participants. We do this in Table A5, and find qualitatively similar effects.

Table 6: Selection into follow-up survey

Dep.var. participation in survey 2			
A_i	-0.014	0.017	-0.022
	(0.031)	(0.045)	(0.040)
Creativity type	0.000		
	(0.053)		
C_i	-0.006	0.084**	-0.062**
	(0.026)	(0.040)	(0.031)
$\overline{C_{-i}}$	0.007	0.030	-0.006
	(0.018)	(0.032)	(0.023)
Controls	Y	Y	Y
Observations	1,393	586	807

This table shows the results of an OLS regression where I control for gender, study specialization, and High School grades in Dutch and Mathematics. The standard errors are clustered by year and study specialization and in parentheses. *, **, *** indicate significance levels at the 0.10, 0.05, 0.01 level respectively.

Table 7 shows how (the mean of) peer creativity relates to students responses to the second survey. In column 1 we regress (peer) creativity on students' response to the questions whether they 'believe they learn a lot from other students in their work group. We find a very small and insignificant (but positive) effect. Similarly, in column 2 we see that peer creativity appears unrelated to students' response to the question whether they spent time with work group members outside the classroom. These responses suggest that students are unaware of the positive impact that creative peers have on their study performance. Columns 3 and 4 show the impact of peer creativity on the time that students spent studying. These results show that there is no impact on the total number of hours students nor on the allocation of these study hours. This suggests that students do not adjust their effort (measured in study hours) based on the creativity of their peers. Finally, in column 5 we see that students with one standard deviation higher creativity peers, score 36.1 percentage points higher on the RAT in the second survey. This suggests that students who are exposed to high creativity peers become more creative.

Table 7: Exploration of possible mechanisms

Dep. var:	(1)	(2)	(3)	(4)	(5)
C_i	0.164	0.050	0.637	-0.701	0.624***
	(0.207)	(0.183)	(2.824)	(0.748)	(0.211)
$\overline{C_{-i}}$	0.160	-0.007	-2.145	-0.724	0.361***
	(0.122)	(0.102)	(2.201)	(0.489)	(0.111)
Controls	Y	Y	Y	Y	Y
Observations	384	384	384	384	384

This table shows the results of an OLS regression where I control for gender, studyprogram ,year, and creativity type. The standard errors are clustered by work group and in parentheses. *, **, *** indicate significance levels at the 0.10, 0.05, 0.01 level respectively. The dependent variable is: (1) whether the student believes he learns a lot from other work group members, (2) whether the student spends time outside university with work group members, (3) the number of hours studied‘with workgroup student, and (4) the total number of hours studied, and (5) creativity measured in the follow up survey.

7 Discussion and Conclusion

In this paper we studied the impact of peer creativity on academic achievement. We find that the distribution of peer creativity is important for study performance. Students with a one standard deviation more creative peer group obtain a 8.4 to 10 percentage point higher GPA. The variation within the group (as measured by the standard deviation) turns out to be unimportant, given the mean. We subsequently explore what drives these creativity peer effects. Our findings suggest that students do not increase the number of hours that they study, and hence become more productive per hour. Surprisingly, students seem to be naive about these positive effects given that they don't believe they learn more from their creative peer group. In addition, creative peers seem to help students improve their creative ability half a year later.

This research has several implications. First, the fact that peer creativity positively impacts other students' academic achievement implies that creativity can be part of selection criteria into selective schools. This holds especially since creativity is only weakly correlated with the variables that schools mostly use for selection such as prior study grades. Second, the fact that there are positive spillovers from creative students to their peers, strengthens the case to have creativity training as part of an academic curriculum. See for instance Fleith et al. (2010) and Morin et al. (2018) for suggestions about creativity training programs, and their impact on students' creative abilities. Third, since students seem unaware of the advantages that studying with more creative peers has, it is useful to reveal this information to students. This may trigger students to reallocate effort towards studying together with creative peers.

While this paper finds robust peer effects of creativity and can shed some light on reasons for the increased performance of students with more creative peers, additional research is desired. First, different creativity measures (such as divergent thinking tests) may bolster the robustness of our creativity measure for our results. Second, observed study behavior from test preparations and exam taking (in addition to stated behavior from the survey) would give more reliability to the claim that students become more productive per hour. Third, while our peer effects are based on the entire work group, students generally don't interact with all students to the same extent. Information on students' social network and/or randomization of students' desk assignment (such as in Harmon et al. 2019 and Wu et al. 2023) within class may provide addition insight in what drives the peer effects. Finally, it is interesting to learn to what extend our findings generalize to a labor market setting where people produce in teams.

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Appendix Tables

Table A1: The effect of peer creativity on the number of courses completed

Dep. var.: GPA	(1)	(2)	(3)	(4)	(5)
C_i	0.165		0.117	0.152	0.171
	(0.158)		(0.156)	(0.157)	(0.156)
$\overline{C_{-i}}$		0.345***	0.339***	0.430***	0.490***
		(0.163)	(0.116)	(0.162)	(0.159)
$SD(C_{-i})$				-0.150	-0.222
				(0.162)	(0.160)
$\overline{C_{-i}} * SD(C_{-i})$					-0.188
					(0.121)
Controls	Y	Y	Y	Y	Y
F-test (p-value)					
peer variables = 0		0.003	0.004	0.014	0.011
Observations	1,973	1,973	1,973	1,973	1,973

This table shows the results of an OLS regression where I control for creativity type, gender, studyprogram, and High School study grades in Dutch and Math. The standard errors are clustered by work group and in parentheses. *, **, *** indicate significance levels at the 0.10, 0.05, 0.01 level respectively.

Table A2: The effect of peer creativity on dropping out of the program

Dep. var.: GPA	(1)	(2)	(3)	(4)	(5)
C_i	0.002		0.004	0.001	-0.001
	(0.017)		(0.018)	(0.018)	(0.018)
$\overline{C_{-i}}$		-0.017	-0.018	-0.026	-0.032**
		(0.012)	(0.012)	(0.016)	(0.016)
$SD(C_{-i})$				0.013	0.021
				(0.016)	(0.018)
$\overline{C_{-i}}$ * $SD(C_{-i})$					0.022*
					(0.013)
Controls	Y	Y	Y	Y	Y
F-test (p-value)					
peer variables = 0		0.148	0.146	0.251	0.160
Observations	1,973	1,973	1,973	1,973	1,973

This table shows the results of an OLS regression where I control for creativity type, gender, studyprogram, and High School study grades in Dutch and Math. The standard errors are clustered by work group and in parentheses. *, **, *** indicate significance levels at the 0.10, 0.05, 0.01 level respectively.

Table A3: The effect of peer creativity when controlling for peers' High School grades in Dutch and Mathematics

Dep. var.: GPA	(1)	(2)	(3)	(4)	(5)
C_i	0.081*		0.071*	0.073*	0.077*
	(0.042)		(0.042)	(0.042)	(0.042)
$\overline{C_{-i}}$		0.078***	0.075**	0.080**	0.091**
		(0.025)	(0.029)	(0.038)	(0.038)
$SD(C_{-i})$				-0.010	-0.022
				(0.040)	(0.041)
$\overline{C_{-i}} * SD(C_{-i})$					-0.033
					(0.030)
Controls	Y	Y	Y	Y	Y
F-test (p-value)					
peer variables = 0	0.014	0.001	0.002	0.004	0.006
Observations	1,973	1,973	1,973	1,973	1,973

This table shows the results of an OLS regression where I control for creativity type, gender, studyprogram, and High School study grades in Dutch and Math, and the mean peer grade in High School Dutch and Math. The standard errors are clustered by work group and in parentheses.
*, **, *** indicate significance levels at the 0.10, 0.05, 0.01 level respectively.

Table A4: The effect of peer creativity while controlling for peers's persistence and risk preferences

Dep. var.: GPA	(1)	(2)	(3)	(4)	(5)
C_i	0.082*		0.070*	0.073*	0.076*
	(0.043)		(0.028)	(0.043)	(0.043)
$\overline{C_{-i}}$		0.086***	0.083***	0.089**	0.101***
		(0.029)	(0.029)	(0.038)	(0.039)
$SD(C_{-i})$				-0.009	-0.023
				(0.040)	(0.041)
$\overline{C_{-i}}$ * $SD(C_{-i})$					-0.036
					(0.030)
Controls	Y	Y	Y	Y	Y
F-test (p-value)					
peer variables = 0	0.719	0.029	0.040	0.078	0.089
Observations	1,973	1,973	1,973	1,973	1,973

This table shows the results of an OLS regression where I control for creativity type, gender, studyprogram, and High School study grades in Dutch and Math, and the mean peer level of persistence and risk preferences. The standard errors are clustered by work group and in parentheses. *, **, *** indicate significance levels at the 0.10, 0.05, 0.01 level respectively.

Table A5: The effect of peer creativity for the sample that participated in the second survey

Dep. var.: GPA	(1)	(2)	(3)	(4)	(5)
C_i	0.111*		0.108*	0.097	0.097
	(0.059)		(0.058)	(0.059)	(0.059)
$\overline{C_{-i}}$		0.039	0.035	0.012	0.013
		(0.034)	(0.034)	(0.043)	(0.043)
$SD(C_{-i})$				0.039	0.038
				(0.048)	(0.048)
$\overline{C_{-i}}$ * $SD(C_{-i})$					-0.003
					(0.033)
Controls	Y	Y	Y	Y	Y
F-test (p-value)					
peer variables = 0		0.264	0.116	0.437	0.646
Observations	384	384	384	384	384

This table shows the results of an OLS regression where I control for creativity type, gender, studyprogram, and High School study grades in Dutch and Math. The standard errors are clustered by work group and in parentheses. *, **, *** indicate significance levels at the 0.10, 0.05, 0.01 level respectively.

Appendix Figures

Figure A1: Stated creativity distribution for low, mixed, and high creativity groups respectively.