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The Effects of Entrepreneurship Education[☆]

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Abstract

Entrepreneurship education ranks high on policy agendas in Europe and the US, but little research is available to assess its impact. To help close this gap we investigate whether entrepreneurship education affects intentions to be entrepreneurial uniformly or whether it leads to greater sorting of students. The latter can reduce the average intention to be entrepreneurial and yet be socially beneficial. This paper provides a model of learning in which entrepreneurship education generates signals to students. Drawing on the signals, students evaluate their aptitude for entrepreneurial tasks. The model is tested using data from a compulsory entrepreneurship course. Using ex ante and ex post survey responses from students, we find that intentions to found decline somewhat although the course has significant positive effects on students' self-assessed entrepreneurial skills. The empirical analysis supports the hypothesis that students receive informative signals and learn about their entrepreneurial aptitude. We outline implications for educators and public policy.

JEL Classification: D83, J24, L26, M13

Keywords: entrepreneurship, entrepreneurship, education, Bayes' Rule, learning, signals

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1. Introduction

Policy-makers generally consider new venture formation to be instrumental for economic growth and technological progress. The academic literature is less unanimous. While many studies find positive effects (Reynolds et al., 1994; Sheshinski et al., 2007; Audretsch and Fritsch, 2002), others caution that entrepreneurship in general may not create growth in industrialized countries. However, many scholars concede that particular forms of entrepreneurship are associated with sizable positive effects (Sternberg and Wennekers, 2005; van Stel et al., 2005; Wong et al., 2005; Acs and Szerb, 2007). There appears to be some agreement on the role of start-ups founded by university graduates and faculty. Academic entrepreneurs are likely to employ more people than their non-academic counterparts (Dietrich, 1999), and founders with university education apparently make higher investments in their business than non-academic entrepreneurs (Reynolds et al., 1994). Moreover, their firms perform disproportionately better (Shane, 2004). University spin-offs also create important spill-over effects for the regional economy (Harhoff, 1999; Shane, 2004). In awareness of these findings, some policy-makers declare the sensitization and advancement of potential founders at tertiary educational institutions a primary goal of innovation policies. As a result, a wide range of entrepreneurship education efforts have been initiated (Fayolle, 2000; Liñán, 2004; Kuratko, 2005).

The effects emanating from entrepreneurship education are still poorly understood. Several previous studies find a positive impact of entrepreneurship education courses or programs at universities on perceived attractiveness and feasibility of new venture initiation or even on actual startup activity (Tkachev and Kolvereid, 1999; Peterman and Kennedy, 2003; Fayolle et al., 2006; Souitaris et al., 2007). Other studies find evidence that the effects are negative (Oosterbeek et al., 2010). There may be methodological reasons why the literature has not generated consistent assessments as of yet. While the studies provide intriguing results, many of them tend to have methodological limitations. For example, few studies employ a pre-post design, and even fewer involve a control group. Most of the studies focus on self-selected participants with some existing predisposition towards entrepreneurship which is likely to bias results in favor of educational interventions (Gorman et al., 1997). But methodological weaknesses may not be the only problem. Currently, there is also no agreement on what would constitute a suitable conceptual model for the analysis of effects of entrepreneurship education. Most studies measure the impact of entrepreneurship education merely by searching for uniform course-induced changes in entrepreneurial intentions. We argue that this approach may be misleading because it masks important sorting effects which can be socially positive even if entrepreneurial intentions decline as a consequence of entrepreneurship training.

Our paper seeks to make three contributions. First, we develop a new conceptual perspective which emphasizes learning and discovery of one's own aptitude for entrepreneurship. In this view, entrepreneurship education allows students to better assess whether they should pursue an entrepreneurial career. This view differs significantly from the implicit notion that entrepreneurship education somehow enhances students' willingness to become entrepreneurs. We cast this new perspective in a formal model where learning follows Bayes' Rule.¹ Using this

¹ Recent research by behavioral economists demonstrates that people do not always update their beliefs according to Bayes' Rule (Rabin and Schrag, 1999; Charness and Levin, 2005; Charness et al., 2007). However, the experiments undertaken by Charness et al. (2007) demonstrate that Bayes' Rule describes learning behavior better if subjects update their beliefs after interaction with people in larger

model of updating and learning, we show that if students differ in their aptitude for entrepreneurship and if entrepreneurship education helps them uncover these differences, entrepreneurship education may not always lead to stronger entrepreneurial intentions on average. Thus, the new conceptual perspective allows us to develop a possible explanation why the results in the literature have been somewhat contradictory.

As a second contribution, we study the effects of a large-scale compulsory entrepreneurship course at a major German university, using a pre-test–post-test design. We explore whether students learned about their own entrepreneurial aptitude from this course. A descriptive analysis of students' intentions to become entrepreneurs shows that the course induces sorting. Especially students who are initially uncertain about their entrepreneurial aptitude are able to determine more clearly whether or not they are suited to entrepreneurship after the course. We test three hypotheses derived from our model. The results confirm that learning about entrepreneurial aptitudes takes place, and that it occurs as the model predicts. We can also show that while average measures of attitudes do not change significantly, these attitudes do change at the individual level. These effects have not found any attention in the extant literature.

In a third contribution we address the welfare implications of our results for future evaluation of entrepreneurship education. Given our conceptual model and the empirical support provided by the data, we argue that a focus on startup propensity alone is misleading. In order to come to a comprehensive assessment of entrepreneurship education, the gains from improved matching between students and career paths need to be considered. Informing non-entrepreneurial individuals that they are not well-suited for startup activities may be as valuable as confirming and strengthening entrepreneurial tendencies in other students. We argue that this is not only the conceptually appropriate approach, it is also ethically the right route to take.

The remainder of the paper contains six sections. Next, we review the literature on entrepreneurship education and its impact on entrepreneurial activity. In Section 3, we discuss a formal model of learning based on Bayesian updating. Section 4 describes the setting of our study and contains a descriptive analysis of the data. Section 5 provides an empirical test of the predictions from our model. Section 6 concludes and discusses future research.

2. Literature Review

2.1. *Entrepreneurship as Intentionally Planned Behavior*

Since much of the literature relates to the theory of entrepreneurship as intentional behavior (or variants of that theory), we summarize this theory briefly. Intentionality is a state of mind directing a person's attention (and therefore experience and action) toward a specific object (goal) or a path in order to achieve something (means) (Bird, 1988). Any planned behavior is best predicted by observing intentions toward that behavior, not by attitudes, beliefs, personality or demographics (Bagozzi et al., 1989). Thus, according to the social psychology literature, intentions are the single best predictor of planned behavior. This holds especially when the target behavior is rare, hard to observe or when it involves unpredictable time lags (Ajzen, 1991). When the target behavior affords a person

groups, which applies to the course setting we investigate here.

complete control over behavioral performance, intentions alone should be sufficient to predict behavior, as explained in the theory of planned behavior (Ajzen, 1991).

Intentions have been found to be an unbiased predictor of action, even where time lags exist, for example in career choices (Lent et al., 1994). Hence, intentions predict behavior, while in turn certain specific attitudes predict intention. Attitudes derive from exogenous influences (Ajzen, 1987). Thus, intentions are indirectly affected by exogenous influences: either they drive attitudes or they moderate the relationship between intentions and behavior (i.e. facilitate or inhibit the realization of intentions). And intentions serve as a mediator or catalyst for action: intention-based models describe how exogenous influences change intentions and, in the end, actual behavior. This is confirmed by meta-analytic studies (Kim and Hunter, 1993). Across a wide variety of target behaviors and related intentions, attitudes explain over 50% of the variance in intentions, intentions in turn explain over 30% of the variance in behavior. This compares to 10% usually explained by trait measures or attitudes alone (Ajzen, 1987).

Many researchers see entrepreneurship as a typical example of planned intentional behavior (Bird, 1988; Katz and Gartner, 1988; Krueger and Brazeal, 1994). Having an entrepreneurial intention means that one is committed to starting a new business (Krueger, 1993). The attitude towards entrepreneurship may be influenced by educational measures. However, despite the recognition that education and prior entrepreneurial experiences may influence people's attitudes towards starting their own business, the impact of entrepreneurship education, as distinct from general education, on intentions towards entrepreneurship has remained largely unexplored (Donckels, 1991; Krueger and Brazeal, 1994).

2.2. *Research on Effects of Entrepreneurship Education*

Research about the effects of entrepreneurship education is still in its infancy (Gorman et al., 1997). Many studies to date simply describe entrepreneurship courses (Vesper and Gartner, 1997), discuss the content of good entrepreneurship education (Fiet, 2001) or evaluate the economic impact of courses by comparing takers and non-takers (Chrisman, 1997). Some researchers have proposed a positive link between entrepreneurship education and entrepreneurial attitudes, intention or action, but the evidence is still not strong (Gibb Dyer, 1994; Robinson et al., 1991; Krueger and Brazeal, 1994).

Some empirical studies do confirm that there is a positive impact of entrepreneurship education courses or programs at universities on perceived attractiveness and perceived feasibility of new venture initiation (Tkachev and Kolvereid, 1999; Fayolle et al., 2006). Reviews of literature on enterprise and entrepreneurship education (Dainow, 1986; Gorman et al., 1997) and of particular entrepreneurship programs (McMullan et al., 2002) give evidence that these programs encourage entrepreneurs to start a business. But usually, there are serious methodological limitations. For example, studies rarely involve control groups or a form of stochastic matching (Block and Stumpf, 1992), basic controls as pre- and post-testing are not employed and most studies survey participants with an existing predisposition towards entrepreneurship, biasing the results in favor of educational interventions (Gorman et al., 1997).

The studies by Peterman and Kennedy (2003), Souitaris et al. (2007) and Oosterbeek et al. (2010) are three

remarkable exceptions, using pre-test-post-test control group designs. Peterman and Kennedy (2003) find that exposure to enterprise education affected entrepreneurial intentions of high-school students. Students from 17 Australian schools participated in this study, with 109 participants in the treatment and 111 students in the control group. Interestingly, the authors detect a differential effect: participants with weak ex ante entrepreneurial propensities experienced a stronger positive treatment effect than participants with strong ex ante entrepreneurial intentions. Souitaris et al. (2007) find that sensitization through a semester-long (January-May) entrepreneurship program led to stronger entrepreneurial intentions. The authors employed a pre-test-post-test control group-design and conducted their survey at two major European universities surveying science and engineering students. They received 124 matched questionnaires from the program group and 126 from the control group. The students of the program group took an entrepreneurship course as an elective module within their curriculum. Hence, the allocation of students to the program group was not fully random, and different classes were taught by different academic instructors so that the treatment might have differed across classes. Oosterbeek et al. (2010) study the impact of entrepreneurship education in a compulsory course, using a difference-in-differences framework. Since students may have self-selected into different school locations, location choice (and thus treatment) is instrumented. Their results show that the effect on students' self-assessed entrepreneurial skills is insignificant. Moreover, the effect of the course on entrepreneurial intentions is significantly negative.

While this literature has generated interesting insights, the research on effects of entrepreneurship education still has huge gaps. Unsurprisingly, several researchers have called for more research to answer the question if entrepreneurship education can influence entrepreneurial perceptions and intentions (Donckels, 1991; Kantor, 1988; Krueger and Brazeal, 1994; McMullan et al., 2002). Descriptive and retrospective studies are not sufficient to provide convincing evidence for the presumed effects (Alberti, 1999; Gorman et al., 1997; Matthews and Moser, 1996). Peterman and Kennedy (2003) call for the development of credible methods of testing preconceived hypotheses, using large sample sizes and control groups, in order to move this young field of research beyond its exploratory stage (Alberti, 1999).

Our paper is meant to contribute to this agenda. But we note a conceptual gap too - none of the studies discussed here has attempted to investigate the *nature of learning processes* that occur in the course of entrepreneurship education. Students are assumed to face no uncertainty regarding their own skills and interests, while the process of learning itself is hardly modeled.² This is where our study deviates from its predecessors. We explore the possibility that students need to find out above all whether entrepreneurial activity suits them, i.e., whether they have sufficiently high entrepreneurial aptitude to become entrepreneurs. Depending on what they learn students may adjust their entrepreneurial intentions upwards or downwards.

2.3. *Entrepreneurial Aptitude*

Entrepreneurship education may have several distinct effects. First, entrepreneurship education is likely to influence knowledge and skills. Courses at tertiary institutions are usually oriented towards teaching of methods,

² Recent work on learning under certainty notes that this is generally true of the literature on skill formation in economics (Cunha et al., 2006; Cunha and Heckman, 2007).

concepts and facts. We conceive of this component as reducing the cost of becoming an entrepreneur. However, the skills and the knowledge taught will have generic components (e.g., knowing how to write a business plan is also helpful in an established corporation). Therefore, such education may not shift entrepreneurial intentions by much. Nonetheless, where entrepreneurship education also affects the attitudes and perceptions of students it may affect entrepreneurial intentions, and thereby actions.

Finally and most importantly for our paper, entrepreneurship courses may allow students to engage in entrepreneurial activity in an experimental setting, e.g., by supporting founders of startups in their actual day-to-day activities. This experience may also be emulated in the classroom, e.g. in startup simulations. We argue that this latter component will be particularly valuable in helping students reduce uncertainty as to how suitable an entrepreneurial career is for them personally. The most important effect of entrepreneurship education may therefore lie in students adjusting and refining their assessment of their own entrepreneurial aptitude.

This view implies that some students learn that entrepreneurial careers are not well-suited for them while the educational measures lead other participants to come to a more positive assessment of their entrepreneurial aptitude. This perspective is radically different from the one that has dominated the literature. In that view, students face no uncertainty about their own type and therefore do not have to learn about their entrepreneurial aptitude. As a consequence, an important aspect of entrepreneurship education may have been neglected.

3. Learning about Aptitude for Entrepreneurial Tasks

In this section we discuss a formal model of learning about own aptitude for entrepreneurial tasks. The model itself is set out in the appendix (Appendix A). Our starting point is the assertion that most students are unlikely to be very certain about their aptitude for entrepreneurial tasks. We model learning about entrepreneurial aptitude as a process of Bayesian updating of beliefs based on signals generated before and during an entrepreneurship course. By generating these signals the course affects students' discovery of their own aptitude for entrepreneurial tasks.

In the course of learning about entrepreneurship the student may receive conflicting signals and different students will receive signals of different quality. Any course on entrepreneurship can therefore be expected to generate three types of outcome: students who learn nothing and students who either learn and discover that they like or dislike entrepreneurship.

In such a context it is interesting to characterize what effects an informative course on entrepreneurship will have on the distribution of students' beliefs about their own entrepreneurial aptitude. For instance a course that leaves the average belief about entrepreneurial aptitude unchanged but leads to greater polarization of beliefs may be counted a success, because it has more clearly separated those who are suited to entrepreneurship from those who are not.

Our principal interest here is in characterizing the distribution of students' beliefs about own aptitude for entrepreneurial tasks. We show how informative signals about entrepreneurial ability generated before and by entrepreneurship education determine such beliefs, allowing students to learn their type.

In our surveys we elicited the strength of the signals that students have received. In other words we measure how sure a student is that they either are or are not an entrepreneur. A weak signal is equivalent to a signal that leaves

the student unsure about their aptitude. This information allows us to test for learning by exploiting variation in the strength of signals that students receive. The model we develop focuses on the consequences of such variation in signal strength.

Below we provide three formal results that can be tested empirically:

- I We show that students' beliefs about their entrepreneurial aptitude display higher variance after a course, if uncertainty about entrepreneurial aptitude is sufficiently high before the course and if the course provides information.
- II We show that any course which provides students with informative signals about entrepreneurial ability will have two main effects: i) it will leave students who receive consistent signals before and during the course with stronger beliefs about their entrepreneurial aptitude than students who do not receive consistent signals; and ii) it will leave students with stronger pre course signals with stronger beliefs about their entrepreneurial aptitude.
- III We show that an informative entrepreneurship course will change the beliefs of participants less the stronger the pre course signal, if signals are consistent and sufficiently precise.

While none of these predictions is particularly surprising the benefit of a formal model is to provide exact conditions under which these seemingly obvious results obtain. We find below that these conditions matter for the statistical tests we undertake.

The formal setup of the model is relegated to the appendix. For the purposes of what follows here the following assumptions we make should be noted. We assume students are uncertain about their entrepreneurial aptitude but know how this aptitude is distributed in the population around them. Their pre university life and an entrepreneurship course at university provide students with two independent signals of their entrepreneurial ability.

For simplicity we distinguish just between **entrepreneurs** and **employees**. Being (truly) an entrepreneur means that one's own utility from being in an entrepreneurial function is greater than the utility from being in an employee function. Conversely, we label employees all students who are better suited to non-entrepreneurial work. The label "employee" is not intended to be pejorative. An important function of entrepreneurship education is to help students self-select into activities which they are most suited to. Our model shows when this type of sorting is supported by entrepreneurship education.

Beliefs after Entrepreneurship Education

We begin with the most obvious implication of updating of beliefs: If there are entrepreneurs and employees in the population of students, if these all receive informative signals, if entrepreneurs' pre course signals that they are entrepreneurs are not too strong and if students update their beliefs according to Bayes' Rule, then we can show that:

Proposition 1

The distribution of beliefs after the course will have greater variance than the distribution of beliefs before, if signals before are not too strong and if signals are informative.

In the appendix we derive the expectation and the variance of students' beliefs that they are entrepreneurs before and after the course. A comparison of these variances shows that the variance of beliefs after the course is greater than the variance of beliefs before, if the strength of the pre course signal is low and if the course generates an informative signal.

A course that provides informative signals will raise the number of students who have learned something about their aptitude for entrepreneurial tasks. If students also received informative signals before a course, then the signal provided by the course will increase sorting of students into two groups that are increasingly sure that they are or are not entrepreneurs. However, this will be less likely if students already know a lot about their entrepreneurial ability or if the signal generated by the course is very noisy.

In Section 5 below we test the following hypothesis:

Hypothesis 1

The variance of beliefs after the course is greater than the variance of beliefs before the course.

Now consider the effects of pre course signals on the post course beliefs of entrepreneurs and employees. Consistency of signals will lead to stronger beliefs. Also, greater strength of signals received before the course will make beliefs after the course stronger.

Proposition 2

If the two signals received by students are consistent, then beliefs after the course will be stronger, than if signals are inconsistent.

Stronger pre course signals lead to stronger beliefs after the course.

We prove this Proposition in Appendix Appendix A.2. While this proposition may look trivial it is important to note that beliefs after the course will also be stronger for those students who receive conflicting signals. The hypothesis corresponding to Proposition 2 is:

Hypothesis 2

i) If signals are consistent then beliefs after the course are stronger.

ii) Stronger pre course signals lead to stronger beliefs after the course.

To test the hypothesis we regress a measure of strong pre course signals (*SFPS*) and of consistent signals (*CS*) on the variance of beliefs after the course (\bar{B}) around their mean. The dependent variable is defined such that stronger beliefs increase the level of the dependent variable. It does not matter whether the belief that one is an entrepreneur is close to one or close to zero. In both cases students have strong beliefs and in both cases the level of the dependent variable is high.

Hypothesis 2 implies that the coefficients on the measure of extreme signals, the measure of consistent signals and their interaction are all positive. Our empirical model is:

$$\bar{B} = \beta_0 + \beta_1 CS + \beta_2 SFPS + \beta_3 CSX + \beta_4' X + \epsilon \quad , \quad (1)$$

where $\bar{B} \equiv (B[2] - \mu(B[2]))^2$ captures the squared deviation of students' beliefs after the course ($B[2]$) from the mean, *CS* is a measure of consistent signals, *SFPS* is a measure of the strength of the pre course signal and *CSX*

is the interaction of the latter two variables. X represents a vector of control variables. Hypothesis 2 predicts that $\beta_1 > 0, \beta_2 > 0$ and $\beta_3 > 0$.

The Change in Beliefs after Entrepreneurship Education

Finally, consider changes in students' beliefs resulting from an entrepreneurship course. We find that it is quite difficult to characterize the relationship between the size of the change in students' beliefs about their aptitude for entrepreneurial tasks and the strength of pre course signals they receive. This is due to the fact that for any given pre course signal the student can receive several different kinds of signals after the course and we have to characterize all of these different cases.

If we assume that the signaling process is informative and also reliable, then we can derive an additional prediction. We have already assumed that signals are informative above. Here we define a reliable signal such that students have a probability greater than 1/2 of receiving the correct signal for their type. In such a setting there will be more students with correct and consistent signals than students with misleading and consistent signals. Given these assumptions we prove the following additional result:

Proposition 3

If students receive sufficiently precise and reliable pre course signals then those who receive consistent signals will change their beliefs less as pre course signals become stronger.

We prove this result in Appendix Appendix A.2. Proposition 3 is tested with the following hypothesis:

Hypothesis 3

If students receive consistent signals, then those among them who have received stronger signals before the course will change their beliefs less.

To test this hypothesis we regress the square of the change in beliefs due to the course on a measure of the strength of pre course signals and of consistent signals. We predict a negative coefficient on the interaction of strong and consistent signals. The dependent variable is squared, since our model makes predictions about the extent of a change in beliefs, not about their direction.

The empirical model in this case is:

$$\bar{\Delta} = \gamma_0 + \gamma_1 CS + \gamma_2 SFPS + \gamma_3 CSX + \gamma_4' X + \epsilon \quad (2)$$

where $\bar{\Delta} \equiv \Delta^2$ captures the squared change in students' beliefs. The remaining variables are defined as above. Hypothesis 3 predicts that $\gamma_3 < 0$.

Proposition 3 is weaker than Proposition 2. It relies on the additional assumption that the signaling process is reliable. Additionally, it is weaker because our model predicts that in the counterfactual case in which students receive inconsistent signals there are two groups with different reactions to more precise pre course signals. Our model predicts that these two groups will be of equal size, in which case these reactions cancel out in aggregate. In smaller populations we may see deviations from this prediction.

4. Data Description

Before we test the hypotheses introduced in the previous section, this section focuses on the data generated by our surveys. First, we discuss data collection in the context of an entrepreneurship course. In particular, we focus on the problem of sample selection. Next, we characterize the effects of the entrepreneurship course on students' attitudes to entrepreneurship. It can be shown that the course we study is comparable in its effects to other courses studied in the literature, e.g. Oosterbeek et al. (2010). Finally, we provide descriptive evidence consistent with the hypothesis that these students learned about their entrepreneurial aptitude during the course.

4.1. Data Collection and Sample Selection

The setting for data collection is the Department of Business Administration, in the Munich School of Management, at Ludwig-Maximilians-Universität (LMU) Munich, one of Germany's largest universities. The Bachelor curriculum at the Munich School of Management is somewhat untypical due to its obligatory entrepreneurship education course "Business Planning". Every business administration student in the Bachelor of Science curriculum at LMU has to enroll in this course in the third semester of their study program.

The objectives of the "Business Planning" course are threefold: i) to teach students basic capabilities needed in the planning and management of a startup enterprise, in particular to convey the necessary knowledge and skills for crafting a complete business plan; ii) to sensitize students for entrepreneurship according to the classification by Liñán (2004): students are supposed to acquire knowledge about small enterprises, self-employment and entrepreneurship so that they can make rational career decisions; iii) to allow students to gain practical experience by interaction with real-world entrepreneurs. The objectives of this course do not encompass any notion of convincing students to become entrepreneurs or to describe entrepreneurship as a particularly desirable option. While the economic importance of entrepreneurship is clearly signaled, students are not meant to be indoctrinated.

The students we survey took the course between October 2008 and February 2009. They took part in eight lectures conveying the principles of business planning. These lectures held by LMU faculty were augmented with input from experts on financial planning, entrepreneurial marketing, experienced entrepreneurs and investors. Thus students obtained first-hand insight into their businesses. The students also attended small group tutorials. In these tutorials they practiced application of business planning concepts and developed their own business plan. Feedback was given by fellow students, a teaching assistant and a tutor.

Students were surveyed (either using a written or an online survey) directly before the kickoff session of the course and immediately before the time when the students received their grades at the end of the semester. The survey instruments used had been reviewed by three academics and 12 non-participating students to ensure clarity of wording and face validity of the constructs. Due to ethical concerns, we did not enforce participation in the two surveys. The two survey instruments were largely identical. However, the second survey also contained items used in the course evaluation.³ The survey forms were anonymized in both rounds, and matching was achieved by

³ The survey forms are available upon request.

employing a voluntary structured identification code.⁴

Participation in the Surveys and Possible Selection Biases. The setting of this course presents a particularly suitable framework for our study since business studies students do not self-select into the “Business Planning” course. Moreover, given that students interact with real-world entrepreneurs we believe that they receive informative and important signals of their own ability as entrepreneurs.

While this setting allows us to eliminate the sample selection issues that affect most previous work on entrepreneurship education we cannot avoid sample selection due to self selection into business studies. Therefore, it is desirable to repeat the survey we present here in entrepreneurship courses that include a more diverse set of participants in the future.

We proceed to investigate whether the pattern of responses and non-responses to our survey suggests any additional sources of sample selection bias. In total we received responses from 357 students. They represent 97.8 percent of total enrollment in the “Business Planning” course. 265 students participated in the first and 274 in the second survey. For 196 students we were able to match two survey responses. While our research design has the advantage that students cannot self-select into the course itself, we may still face selection issues due to differential propensities to respond to our surveys.

A first indication that we do not face major (or possibly any) selection bias due to non-response can be taken from Table 1. This provides demographic variables for three sets of respondents: those who only responded to the first survey, those who responded to both surveys, and those who only responded to the *ex post* survey. Participants to both surveys were significantly younger than those who responded to only one survey round. This may reflect students’ behavior - older students are likely to feel more pressure to focus on their studies and may therefore be less willing to “waste” time on surveys. Moreover, students not participating in both surveys were more likely to have self-employed parents (in the pre- and post-survey group) and had higher intentions to found (in the pre- and post-survey group). However, it is important to note that while the intention to found declines significantly within the group answering the survey *ex ante* and *ex post*, the intention to found is not significantly different, *ex ante* or *ex post*, for those who only responded once and those who responded both times.

Table 1: Demographic Characteristics and Sample Composition

subgroup	age (years)	female (%)	protestant (%)	non- German (%)	parents self-employed (%)	intention <i>ex ante</i> (%)	intention <i>ex post</i> (%)
pre-survey only (N=69)	22.3*	52.8	30.1	29.2*	47.8	76.8	-
both surveys (N=196)	21.7	55.1	22.2	18.4	40.3	71.4	63.8
post-survey only (N=78)	22.9*	48.8	24.4	22.5	50.0	-	70.5

Note: *- $p < 0.10$, **- $p < 0.05$

Differences significant between students who participated in both surveys and pre- or post-group only.

Post-survey age was corrected by 0.30 years to correct for calendar time of survey.

⁴ The code consisted of the first letter of the first name of the student’s mother, the last letter of the student’s name, the first digit of the student’s month of birth, and the first letter of the student’s place of birth.

Given that we have some information about non-respondents for both of the two surveys, we can use a multivariate test to establish whether the likelihood of responding in the *ex ante* (*ex post*) survey is systematically related to characteristics revealed in the second (first) data collection. We ran two probit regressions in which we predict response behavior as a function of sex, age, religion, nationality and the employment status of parents and friends. Additionally, we included scale variables for the students' attitude towards entrepreneurship, the perceived social norms in favor of entrepreneurship, the perceived entrepreneurial self-efficacy, and the perceived feasibility of a startup project. Both probit regressions contained 11 regressors and were either largely or totally uninformative ($p=0.089$, $n=251$ in the case of participation in the post-survey as a function of *ex ante* data, and $p=0.267$, $n=263$ in the case of *ex ante* participation as a function of data collected in the second round). The marginal explanatory power in the *ex post* survey participation is due to non-German participants and students with self-employed parents. The non-participation of these students is likely to introduce a conservative (if any) bias in our results.⁵ The subsequent discussion focuses on the matched sample with *ex ante* and *ex post* information from 196 students.

4.2. Overall Course Assessment and Impact on Attitudes and Skills

Previous work on entrepreneurship education has shown that entrepreneurship courses may reduce the number of students who intend to found (Oosterbeek et al., 2010). We confirm this finding here. The following section provides an interesting perspective on it: entrepreneurship education helps students learn about their entrepreneurial aptitude.

Table 2: Attitudinal Measures and Assessments

	Ex ante	S.E.	Ex post	S.E.	Difference	p-value
Attitude towards entrepreneurship (scale, 5 items)	4.319	(0.100)	4.389	(0.110)	0.070	$p = 0.357$
Risk preference (scale, 6 items)	4.774	(0.111)	4.841	0.114	0.068	$p = 0.452$
Entrepreneurial self-efficacy (scale, 20 items)	6.466	(0.094)	6.513	(0.096)	0.047	$p = 0.617$
Feasibility of start-up project (scale, 6 items)	1.551	(0.060)	1.656	(0.065)	0.106	$p = 0.028$
Perceived social norms (weighted sum of 4 items)	-2.413	(2.178)	-4.163	(2.057)	1.75	$p = 0.261$

Note: N=196. Responses from matched surveys of LMU students.

First we explore the impact of our entrepreneurship course. Table 2 summarizes evidence on *ex ante* and *ex post* assessments of several classical attitudinal measures. First, we use a scale comprised of five items to measure students' attitude towards entrepreneurship.⁶ We test the scale using inter-item correlation. Scale reliability is high for both surveys (Cronbach's $\alpha=0.886$ and 0.924 in the first and the second survey, respectively). To

⁵ The detailed results of these probit regressions are available upon request.

⁶ These items are taken from Gundry and Welsch (2001) and have been used in Kolvareid and Isaksen (2006).

maintain the scale's information, we do not standardize the two measures. We also obtain a scale measure of risk preference⁷ based on 6 items (Cronbach's alpha 0.767 and 0.798), entrepreneurial self-efficacy⁸ based on 20 items (Cronbach's alpha 0.935 and 0.942), an assessment of the perceived feasibility⁹ of handling a startup project (six items, Cronbach's alpha 0.750 and 0.747) and finally a measure of perceived social norms.¹⁰ The latter is based on four items asking for an assessment whether family members, friends, fellow students or other important persons thought that the respondents ought to become entrepreneurs. These were transformed to yield a symmetric scale, which was then multiplied by a weight obtained in a survey item in which respondents indicated to which extent they cared about the particular opinion. This measure is best considered a formative variable since the social influence of family members, friends, fellow students or other important persons may be additive.

Table 2 summarizes the mean values of these measures and their differences. Only the perceived feasibility of handling a startup project displays a statistically significant change of about 7 percent of its ex ante value as a result of the course.

An larger change is apparent in a confidence measure summarized in Table 3 below. Ex post, students agree less to the statement "I can always conclude my projects successfully" than ex ante, and the change is marginally significant ($p=0.087$). The confrontation with a real-world problem may have led to an adjustment of assessments. A large and significant improvement is apparent in the response to the statement "I know everything that is needed to start a new enterprise." The ex ante average response to that statement was between "do not agree" and "rather not agree" (mean value 2.50) and shifts to a mean value of 3.87 (between "rather not agree" and "neither agree nor disagree").

Table 3: Confidence Assessments

	Ex ante	Ex post	Difference	<i>p</i> -value
1. I can always conclude my projects successfully.	5.43	5.31	-0.12	$p = 0.087$
2. I know everything that is needed to start a new enterprise.	2.5	3.87	1.37	$p < 0.001$
3. I am very self-confident	4.88	4.98	0.1	$p = 0.028$

Note: N=196. Responses measured on rating scales from 1 to 7 in matched surveys of LMU students.

Moreover, the measure of general self-confidence has risen significantly, but much less than the response to the entrepreneurship-specific question. We conclude from these answers that the course has had a significant positive effect on students' skills and self-confidence, and that it may have led to a reduced, and possibly more realistic assessment of project success.

⁷ This scale is based on items first used in the 2004 wave of the Socio-economic Panel (SOEP) and employed by Dohmen et al. (2008) and Caliendo et al. (2009).

⁸ This scale is based on 20 items derived from the work of Chen et al. (1998); De Noble et al. (1999); Anna et al. (2000). The items are used together by Kolvereid and Isaksen (2006).

⁹ This scale is derived from Kolvereid (1996a) and subsequently used by Tkachev and Kolvereid (1999); Souitaris et al. (2007).

¹⁰ This measure is derived from Kolvereid (1996b) and has found use in Tkachev and Kolvereid (1999); Kolvereid and Isaksen (2006); Souitaris et al. (2007).

In Appendix Appendix B we provide further evidence that shows that students gave a positive evaluation of various aspects of the entrepreneurship course they took. We conclude from this evidence that students' evaluation of entrepreneurship is not the result of a poor course.

4.3. Changes in Entrepreneurial Intentions

This final section shows that students' entrepreneurial intentions have become more pronounced as a result of the course. Entrepreneurial intentions were surveyed with two items in the questionnaires. First, we asked a direct question "Would you like to found your own enterprise at some point?" requesting a yes or no-response. Second, we asked for an indication of agreement regarding the statement "I intend to found my own enterprise within the next five to ten years" with responses on a seven-point rating scale. The results are presented in Tables 4 below and B.13 in Appendix Appendix B.

Table 4: Ex ante and ex post Entrepreneurial Intentions

I intend to start my own enterprise within the next five to ten years.

	Ex post response							Total		
	1	2	3	4	5	6	7			
Ex ante response	strongly disagree	8	4	3	0	0	1	0	16	8.2%
	disagree	10	13	3	1	0	0	0	27	13.8%
	somewhat disagree	4	8	12	3	6	2	1	36	18.4%
	neutral	2	3	10	11	8	4	0	38	19.4%
	somewhat agree	1	1	0	7	14	5	1	29	14.8%
	agree	0	2	0	3	5	12	4	26	13.3%
	strongly agree	1	0	2	1	2	6	12	24	12.2%
Total	26	31	30	26	35	30	18	196	100.0%	
	13.3%	15.8%	15.3%	13.3%	17.9%	15.3%	9.2%			

Note: N=196. Responses from matched surveys of LMU students.

Table 4 provides results for the more detailed measure of entrepreneurial intentions. Consistent with the less detailed measure, the average score (interpreting the scale as metric) has decreased from 4.08 to 3.89 ($p=0.069$ in a two-tailed test, $N=196$). Additionally, the distribution itself is informative. The share of neutral responses declined from 19.4% to 13.3%. The neutral overall balance in the ex ante survey (40.4% vs. 40.2% with negative vs. positive assessments) gave way to a slightly more negative result (44.4% vs. 42.3%). These changes are small, but they indicate that the course helps students to develop more precise plans for their future. The number of students with neutral assessments declines, opinions grow stronger.

This result is also apparent in Table 5 where we cross-tabulate a discrete measure of changes in entrepreneurial intentions with ex ante intentions. The table shows that students with strong ex ante opinions were less likely to change their intentions than indifferent students. Changes in intentions occur mostly amongst the undecided, as one would expect in a world with Bayesian updating during the course.

Table 5: Changes in Entrepreneurial Intention by ex ante Intention

I intend to start my own enterprise within the next five to ten years.

	Change in ex post response				Total	
		Change	No change			
Ex ante response	strongly disagree	8	50.0%	8	50.0%	16
	disagree	14	51.9%	13	48.1%	27
	somewhat disagree	24	66.7%	12	33.3%	36
	neutral	27	71.1%	11	28.9%	38
	somewhat agree	15	51.7%	14	48.3%	29
	agree	14	53.8%	12	46.2%	26
	strongly agree	12	50.0%	12	50.0%	24
	Total	114	58.2%	82	41.8%	196

Note: N=196. Responses from matched surveys of LMU students.

However, it would be misleading to believe that only the undecided learned something from the course. Table 6 provides evidence to this regard. In the upper panel of the table, we display which percentage of students who indicate a particular level of entrepreneurial intentions have parents or friends who are self-employed. For example, while only 12.5% of those who disagree strongly with the statement "I intend to found my own enterprise within the next five to ten years" have self-employed parents, the share of students with self-employed parents is 58.3% for those in the highest response category. There is a clear bivariate relationship between parental self-employment and students' intentions. This is even more clearly visible once we condition parental self-employment on positive experience. The relationship is less pronounced for self-employment of friends, but again clearer once one requires self-employment to have been a positive experience.

Table 6: Ex ante and ex post Entrepreneurial Intentions

Ex ante statement: "I intend to found my own enterprise within the next five to ten years."

Level of agreement	parent self-employed	... and positive experience	friends self-employed	... and positive experience	N
strongly disagree	12.5%	6.3%	68.6%	31.3%	16
disagree	29.6%	22.2%	66.7%	55.6%	27
somewhat disagree	36.1%	30.6%	77.8%	58.3%	36
neutral	43.2%	35.1%	83.8%	75.7%	37
somewhat agree	41.4%	34.5%	82.8%	65.5%	29
agree	53.8%	53.8%	69.2%	65.4%	26
strongly agree	58.3%	54.2%	91.7%	87.5%	24
Total	40.5%	54.2%	77.9%	64.6%	195

Ex post statement: "I intend to found my own enterprise within the next five to ten years."

Level of agreement	parent self-employed	... and positive experience	friends self-employed	... and positive experience	N
strongly disagree	23.1%	15.4%	69.2%	46.2%	26
disagree	32.3%	29.0%	71.0%	51.6%	31
somewhat disagree	40.0%	36.7%	86.7%	70.0%	30
neutral	53.8%	34.6%	84.6%	73.1%	26
somewhat agree	29.4%	26.5%	76.5%	64.7%	34
agree	50.0%	46.7%	73.3%	66.7%	30
strongly agree	66.7%	66.7%	88.9%	88.9%	18
Total	40.5%	54.2%	77.9%	64.6%	195

Note: parental and friends' self-employment is taken from the ex-ante survey in both panels.

Note: N=195. Responses from matched surveys of LMU students.

While these results are not surprising, the second panel of Table 6 shows how the course affected students' intentions. Here we find that the share of students with self-employed parents or friends has become much higher in the lower *ex post* response categories. The share of students with self-employed parents has almost doubled now in the lower response category, and it has increased somewhat in the upper one. This shows that the course detached some participants from their *ex ante* entrepreneurial intentions.

At the end of this section we are left with an interesting puzzle. The course has apparently reduced the entrepreneurial intentions of participating students.¹¹ However, it has also led students to develop firmer future plans. Students state that they feel more assured regarding the capabilities needed to found a new enterprise (see Table 3 and Table B.12). Moreover, we find interesting evidence that students reshape their intentions and opinions regarding entrepreneurship during the course. "Weak" opinions become more defined, and students become detached from previous convictions as determined by parental background and former personal environment. We consider these descriptive results to be important since they shed new light on the learning process itself. In the next section we test the predictions of the theoretical model to see whether Bayesian updating provides an explanation of what we observe.

5. Testing the Learning Model

In this section we test the learning model discussed in Section 3 above. We begin by presenting the variables which enter our regressions. Then we present results of a differences of variances test and two regressions. We provide evidence to support all three of our hypotheses.

5.1. Description of Variables

Table 7 below sets out descriptive statistics. At the top of the table we present the dependent variables, below that we present the explanatory variables. The statistics are presented for the sample of 189 students whose responses to pre and post questionnaires we are able to match.

We elicit students' beliefs about their own entrepreneurial aptitude by asking them about their intention to found their own company. A set of questions related to the feasibility of founding a company is used to measure what signals the students have received about their entrepreneurial aptitude before and during the course.

The dependent variables. We test Hypothesis 1 using detailed measures of students' intentions to found an enterprise within the next five to ten years. We analyze the variance of the intention to found before and after the course.

¹¹ We have to sound a warning here - the sentiment of students regarding entrepreneurship may also have been affected by the financial crises that began to impact the economy at the end of 2009 - exactly the time when students enrolled in this class.

Hypothesis 2 focuses on the strength of students' beliefs that they are (are not) entrepreneurs after the course. We take the squared deviation from the mean of students' intentions to found after the course (\bar{B}) as our measure of the strength of students' beliefs after the course.¹²

Hypothesis 3 is based on the change in students' intentions resulting from entrepreneurship education. The dependent measure here is the squared *change* of intentions to found ($\bar{\Delta}$). Here the change refers to the difference between intentions measured before and after the course.¹³

Table 7: Descriptive Statistics

Variable	Mean	Median	Std. Deviation	Minimum	Maximum
Intention to found afterwards	4.111	4	1.799	1	7
\bar{B} ¹⁴	3.595	3.771	3.260	0.003	9.351
$\bar{\Delta}$ ¹⁵	2.021	1	4.401	0	36
Perceived social norms	-4.016	-1	29.266	-78	84
Scale: entrepreneurial self efficacy	6.486	6.450	1.301	0.550	9.950
Scale: risk preference	4.846	4.857	1.561	0.571	8.286
Scale: feasibility assessment before course	4.220	4.167	0.826	2.333	7
Change in feasibility assessment scales	0.090	0.167	0.646	-2	1.500
Strength of signals before	0.727	0.250	1.171	0	9
Strength of signals afterwards	0.424	0.111	0.620	0	4
Consistent signals	0.312	0	-	0	1
Parents self-employed	0.402	0	-	0	1
Friends self-employed	0.783	1	-	0	1
non- German	0.185	0	-	0	1
Female	0.556	1	-	0	1
Protestant	0.236	0	-	0	1

Note N = 189. Responses from matched surveys of LMU students responding to a full set of questions.

¹² In unreported results we find that the precise definition of strong beliefs does not affect our findings. Regressions in which we take the squared difference between students' intentions and the median of the seven point Likert scale on which intentions to found were reported are qualitatively similar to the results we report below.

¹³ This variable is clearly skewed. Regressions in which we use its logarithm as the dependent variable produce qualitatively identical results to those reported below.

¹⁴ This variable is defined in Section 3.

¹⁵ This variable is defined in Section 3.

Signals and their strength. We measure the level of students' pre course signals of their type using the questions on students' assessment of the feasibility of founding and running their own company. We construct a scale from six questions on feasibility to capture the signals students receive before the course. The values of this scale lie on the interval [1, 7] for each individual. As Table 7 shows the realized values are above 2.332.

The level of the signal students receive during the course is measured as the difference between two scales aggregating ex-ante and ex-post responses to the feasibility questions. The values of this measure could lie on the interval [-6, 6]. Table 7 shows the realized values are restricted to the interval [-2, 1.5].

The strength of signals is measured by comparing each individual signal to the point on each scale indicating indecision between being an entrepreneur and not being an entrepreneur. In case of the ex ante signal indecision is indicated by a value of 4 and in the case of the ex post signal by a value of 0, these being the median values of these scales. We define the strength of each signal as the squared deviation from these points of indecision. The resulting variables capture the strength but not the direction of a signal.¹⁶

Consistency of signals. We define a sequence of signals as consistent if signals received before and during the course were both high or both low. More particularly we define signals as consistently high if the first signal is above the median of the seven point Likert scale (i.e. > 4) and if the realization of the second signal is slightly above the median (0) of the scale for that signal. We define the signal received during the course as high if its realization is greater than 0.2. By choosing a value above the median of the signal received during the course we exclude those students from being classified as having strong signals who do not have very strong beliefs of their entrepreneurial ability after the course. On this definition just under one third of students in our sample received consistent signals. Consistently weak signals of entrepreneurial ability are defined symmetrically to consistently strong signals.¹⁷

Control variables. We employ a number of control variables such as gender, nationality and confession as well the scales for social norms regarding entrepreneurship, self efficacy and risk which were discussed previously.

5.2. Test of Hypothesis 1

Our model of learning shows that Bayesian updating has the effect that students' beliefs about their entrepreneurial aptitude will have greater variance if students receive an informative signal of their aptitude from the course and if the first signal of entrepreneurial ability is not too strong. Table 8 sets out the standard deviations of students' beliefs about their entrepreneurial ability for the pre- and post-course samples. We provide these for the full set of students who responded to at least one survey and for the restricted sample of students that took part in both surveys. We also consider the latter sample excluding all those students whose pre course intentions to become entrepreneurs were in a range indicating indecision (neutral or somewhat agree / disagree) and whose intentions had not changed after the course. This indicates that these students did not receive sufficiently strong signals from the course or that they do

¹⁶ In a previous version of this paper we construct the strength measure relative to the mean of the empirical distribution of students' signals. It remains for future research to establish whether students' beliefs are based on a relative assessment of their ability or on an absolute standard. The results we present below indicate that for this group of students we can confirm our hypotheses based on relative or absolute measures of signal strength.

¹⁷ We have found that our results are robust to slight alterations in the cutoff points for what constitutes a strong signal.

not update beliefs as predicted by Bayes' Rule. Finally, we show results when we also exclude those students who received very strong signals before the course.

Table 8 shows that the variance of beliefs about entrepreneurial ability increases in all four samples: beliefs after entrepreneurship education have greater variance than beliefs before. However, we are unable to reject the hypothesis that the variances are statistically identical in the first three samples. The fourth sample excludes students who do not update at all and students who received strong signals before the course. Here we find a statistically significant increase in the variance of beliefs, once we allow for non-normality of the distributions by using Levene's robust test or Brown and Forsythe's median test.

Table 8: Comparing the Variances of ex ante and ex post Beliefs

		Standard Deviation of Beliefs by Sample			
		Full	Estimation	Restricted - Estimation	Most Restricted
N		541	392	318	234
Response time	ex ante	1.821	1.806	1.965	1.456
	ex post	1.873	1.898	2.068	1.576
Test statistic		p-value			
	F-test	0.323	0.243	0.260	0.197
	Levene's robust test	0.455	0.357	0.117	0.081
	Brown and Forsythe's median test	0.394	0.365	0.113	0.067

This result shows that the formal model provides important conditions for the test - that we exclude those students who have strong pre course signals and those who have not received sufficiently strong signals during the course. Note that this condition significantly reduces the size of the sample which makes it harder to obtain a statistically significant result. We conclude that our results confirm Hypothesis 1.

5.3. Test of Hypothesis 2

Table 9 below sets out results from regressions performed to test Hypothesis 2. Note that the dependent variable in this regression is a continuous variable, so that we use OLS. There are 189 observations as we do not have responses on all questions contained in the feasibility scale from all those students who took part in the first and second round surveys. We set out four regressions. The first contains only control variables and shows that none of these is able to explain the strength of students' intentions to become entrepreneurs or to avoid entre-

Table 9: Regressions for Strength of Intentions after the Course

Dependent Variable:	(1) \bar{B}	(2) \bar{B}	(3) \bar{B}	(4) \bar{B}
Strength of signals before		0.509** (0.246)	0.541* (0.277)	0.567** (0.273)
Consistent signals		1.949*** (0.546)	1.995*** (0.575)	2.043*** (0.564)
Consistent and strong signals		1.475*** (0.518)	1.442*** (0.535)	1.317** (0.524)
Strength of signals afterwards			-0.107 (0.414)	0.025 (0.398)
non - German	0.343 (0.660)	0.536 (0.599)	0.523 (0.602)	
Female	-0.031 (0.533)	0.166 (0.480)	0.166 (0.481)	
Protestant	0.699 (0.600)	0.667 (0.539)	0.669 (0.540)	0.493 (0.526)
Parents self-employed	0.264 (0.520)	0.252 (0.468)	0.267 (0.473)	
Friends self-employed	-0.351 (0.613)	-0.495 (0.553)	-0.495 (0.555)	
Scale: feasibility assessment before	-0.497 (0.461)	-1.270*** (0.449)	-1.296*** (0.461)	-1.049*** (0.324)
Scale: feasibility assessment afterwards	-0.123 (0.450)	-0.517 (0.418)	-0.508 (0.421)	-0.214 (0.367)
Scale: entrepreneurial self efficacy	0.294 (0.250)	0.284 (0.225)	0.293 (0.228)	
Scale: risk preference	-0.301* (0.177)	-0.222 (0.161)	-0.227 (0.162)	
Perceived social norm	0.003 (0.011)	0.007 (0.010)	0.007 (0.010)	
Constant	5.244*** (1.943)	7.026*** (1.815)	7.107*** (1.846)	6.683*** (1.316)
Adjusted R-squared	-0.016	0.181	0.176	0.184
N	189	189	189	189

Standard errors are shown in parentheses: *** (**, *) denotes a 1% (5%,10%) level of significance.

preneurship after the course. This is interesting because several of these variables do provide information about the level of students' intentions before and after the course.¹⁸

Next we include the three measures suggested by Hypothesis 2: a measure of the strength of pre course beliefs, a measure of consistent beliefs and the interaction of these two measures. Our results show that all three measures have positive sign and are generally significant at the 1% and 5% levels. In the regressions reported in columns 2 and 3 of Table 9 we use the same large set of control variables as in column 1. We find that apart from the feasibility assessment scale non of these variables is significant. In the regression reported in column 4 we drop all those controls that are insignificant above the 20% level. We arrived at the specification reported there by iteratively removing the least significant controls one by one. While the adjusted R-squared measure of this last regression is highest we find that the coefficients estimated are not much affected by the procedure. We conclude that the effects we identify are robust.

¹⁸ We do not report regressions on the intentions ex ante and ex post here as our model makes no predictions about these. The regressions are available from the authors upon request.

These results indicate that the strength and consistency of students' signals affect intentions to become entrepreneurs as predicted by Hypothesis 2.

5.4. Test of Hypothesis 3

Here we investigate how students who have received consistent signals and who have a stronger pre course signal adjust their beliefs during the course.

Table 10 shows that we are unable to reject Hypothesis 3. The table provides coefficients of four ordered probit regressions.¹⁹ In column (1) we regress the main variables of interest on the dependent variable. We find that the strength of signals received during the course significantly affects changes in intentions as does the interaction of consistent and strong pre course signals. The interaction term has the sign predicted in Proposition 3. In column (2) we introduce a large set of control variables. This does not affect the significance of the main variable of interest, nor is the coefficient significantly altered. Columns (3) and (4) provides the starting point and the results of testing down, iteratively removing the least significant regressors. Once more this has no significant effect on the signs or coefficients of the interaction effect.

Table 10: Coefficients From Ordered Probit Regressions for Extent of Changes in Intentions

Dependent Variable:	(1) $\bar{\Delta}$	(2) $\bar{\Delta}$	(3) $\bar{\Delta}$	(4) $\bar{\Delta}$
Strong pre course signals	-0.083 (0.083)	-0.064 (0.084)	-0.089 (0.087)	-0.088 (0.086)
Consistent signals	0.172 (0.224)	0.168 (0.226)	0.143 (0.228)	0.131 (0.226)
Consistent and strong pre course signals	-1.035** (0.417)	-1.004** (0.416)	-0.975** (0.427)	-0.960** (0.419)
Strong course signals	0.360** (0.143)	0.354** (0.146)	0.394*** (0.149)	0.399*** (0.148)
non - German		-0.054 (0.214)	-0.162 (0.226)	
Female			0.132 (0.179)	
Protestant			0.065 (0.203)	
Parents self-employed			-0.368** (0.177)	-0.329* (0.172)
Friends self-employed			0.126 (0.206)	
Scale: entrepreneurial self efficacy		-0.052 (0.076)	-0.049 (0.077)	-0.063 (0.076)
Scale: risk preference		-0.050 (0.058)	-0.058 (0.061)	-0.059 (0.060)
Perceived social norm			0.003 (0.003)	0.003 (0.003)
Log-Likelihood	-232.15	-231.08	-228.36	-229.06
N	189	189	189	189

Standard errors are shown in parentheses: *** (**, *) denotes a 1% (5%, 10%) level of significance.

¹⁹ As noted above the dependent variable here is defined as the square of the change in intentions to found. this variable has seven discrete values, so that we use ordered probit here.

We also calculate the average marginal effects (AME) for the interaction term (Bartus, 2005; Cameron and Trivedi, 2005). Table 11 below provides these estimates for the models reported in columns (1) and (4) of Table 10 above. We find that the marginal effect is generally highly significant and negative for all groups of students who change their beliefs.

Table 11: Selected Marginal Effects From Ordered Probit Regressions for Extent of Changes in Intentions

Dependent Variable:	Outcome:	(1)	(4)
Consistent and strong pre course signals	$\bar{\Delta} = 0$	0.380*** (0.078)	0.345*** (0.077)
Consistent and strong pre course signals	$\bar{\Delta} = 1$	-0.097*** (0.023)	-0.088*** (0.022)
Consistent and strong pre course signals	$\bar{\Delta} = 4$	-0.144*** (0.033)	-0.131*** (0.032)
Consistent and strong pre course signals	$\bar{\Delta} = 9$	-0.050*** (0.015)	-0.045*** (0.014)
Consistent and strong pre course signals	$\bar{\Delta} = 16$	-0.063*** (0.018)	-0.056*** (0.017)
Consistent and strong pre course signals	$\bar{\Delta} = 25$	-0.013* (0.007)	-0.012* (0.007)
Consistent and strong pre course signals	$\bar{\Delta} = 36$	-0.014* (0.007)	-0.013* (0.007)

Standard errors are shown in parentheses: *** (**, *) denotes a 1% (5%, 10%) level of significance.

As a further robustness check we investigate whether the boundedness of the dependent variable affects our findings. In particular one may wonder whether students who already have an extreme signal of their entrepreneurial ability before the course will find their initial belief confirmed and further strengthened. Our scale would not allow them to indicate if this were the case. To test this we predict students' second stage beliefs using ordered probit and adjust those students' beliefs for whom even more extreme beliefs are predicted. We then rerun the regressions reported above. We find that our results are robust to this test.²⁰

These findings indicate that the strength and consistency of signals students receive affect changes in students' intentions to become entrepreneurs as predicted by Hypothesis 3.

6. Conclusion

This paper provides an analysis of learning processes in entrepreneurship education. While entrepreneurship education has been introduced and promoted in many countries and at many institutions of tertiary education, little is known at this point about the effect of these courses. In particular, it is largely unknown how the courses impact students' willingness to engage in entrepreneurial activity and what kind of learning processes are responsible for these effects. Instead, the literature has focused on a simplified "up and down" analysis which studies outcomes, but does not consider the causes or the path of learning.

²⁰ The results of this test are available upon request.

In the context of funding of entrepreneurial ventures it has been argued that subsidizing finance for new entrepreneurs could be socially wasteful (De Meza and Southey, 1996; De Meza, 2002; Shane, 2009). By analogy, one might expect that entrepreneurship education could have negative effects if it succeeded in convincing those not suited to entrepreneurship that they should become entrepreneurs. Alternatively, and more positively, it could be that such education actually informs students and allows them to discover their specific abilities. In this case, even a decline in entrepreneurial intentions could be socially valuable, since it may indicate that subsequent matches in the labor market will be improved.

In this paper we analyze the effects of entrepreneurship education on a group of students who are not selected for their interest in entrepreneurship. We postulate that student behavior is largely driven by Bayesian updating - students enter entrepreneurship courses with prior beliefs about their own "type", but update their beliefs in the course of entrepreneurship training. Based on a theoretical model we derived three hypotheses that link ex post intentions as well as changes in intentions to the strength and consistency of signals received by students prior to and during the entrepreneurship course. Data were collected in a compulsory entrepreneurship class at a large German university.

In a descriptive analysis, we find evidence that students update their beliefs about their entrepreneurial aptitude. In particular, initially undecided students are most likely to change their beliefs most readily. More formally we show that the variance of beliefs about entrepreneurial aptitude increased significantly during the course if we focus on students who learn during the course. Two further hypotheses derived from our model cannot be rejected either. We show that strong ex ante beliefs and consistency of signals lead to stronger ex post intentions to found or not to found, and that changes in intentions due to the course tend to be smaller if ex ante signals are strong and if the signals received by students are consistent.

A number of caveats apply. The current study does not employ data from a control group.²¹ Hence, we cannot exclude the possibility that students updated their beliefs based on information that was extraneous to the course. We consider this unlikely, since the course contents were very specific and not duplicated in other courses. Nor do we know if particular content characteristics of this course have led to the described outcomes.

In our overall assessment, the results can be read as confirmation for educational policies that view entrepreneurship training as a way of informing students about career options, and of creating learning opportunities for calibrating and refining their assessments of which career is most suitable. We have no means to assess how costly the mistakes of choosing the "wrong" career would be to the students and to society at large. Hence, we cannot quantify the true economic and societal impact of entrepreneurship training. But it seems worthwhile to consider that a simple increase in entrepreneurial activity may neither be a good objective, nor the most likely outcome for including entrepreneurship in the curriculum.

Our results also have implications for public policy, and in particular for the evaluation of entrepreneurship

²¹ In addition to the data collection for the course studied, we also obtained data on a small sample of students at another Munich university. However, with 44 observations the sample is too small for setting up a fully developed pre-post control group design. Entrepreneurial intentions declined in the control group as well and more strongly than in our treatment group.

education. Currently, evaluation is based on estimating positive outcomes (increases in the actual or anticipated startup rate) and trading that benefit off against program costs. In our view this approach misses the sorting benefits highlighted in our paper. Consider a student who has learned that she would probably not be a good entrepreneur or would not enjoy being an entrepreneur. Rather than performing a possibly very costly real-world experiment of starting a firm and failing at the task, this student may now decide to enter a managerial career. This should be considered to be a positive outcome of entrepreneurship education, while most of the current literature (and many policy-makers) would proclaim it a case of failure. We believe that this kind of welfare accounting needs to be rethought.

The framework we outline in this paper opens up several avenues for future work. First and foremost we intend to further test our theoretical framework. We intend to reapply the framework to other entrepreneurship courses and seek to establish whether the framework also describes effects of other types of education, which are intended to help students discover their proclivity for a specific type of work. Secondly, an integration of the framework with the theory of planned behaviour is likely to be helpful in further identifying exactly which benefits and costs that entrepreneurship education can affect. Finally, the integration of uncertainty into models of skill formation over the life cycle (Cunha et al., 2006; Cunha and Heckman, 2007) holds out the promise of a theory of learning about own aptitude.

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Appendix A. A Model of Learning About Own Entrepreneurial Ability

This appendix provides the analytical results from which we derive the hypotheses provided in Section 3 above. The appendix consists of two sections: the first sets out our assumptions and definitions, the second contains proofs of Propositions 1- 3.

Appendix A.1. Assumptions and Definitions

We assume that there are two types of student: **entrepreneurs (n)** and **employees (m)**. Students know that these two types exist and have information about the proportion of entrepreneurs in the population ϕ , but they do not know their own type.

In our model students receive information about their ability as entrepreneurs and as employees in two successive periods: periods one and two. Period one takes place before students go to university. Here students receive a signal σ_1 of their entrepreneurial ability. Period two takes place once students go to university. Here students receive a signal σ_2 of entrepreneurial ability from formal entrepreneurship education. We distinguish between signals that entrepreneurs (σ^n) and employees (σ^m) receive about entrepreneurial ability.

Students' beliefs about their own entrepreneurial ability are distributed on the interval $[0, 1]$. A belief of 0 implies that the student believes absolutely that they are an employee, a belief of 1 implies that they believe they are certainly an entrepreneur. Each type of student will receive a positive signal of high entrepreneurial aptitude in each period with probability ψ^k where $\psi \in [0, 1]$ and $k \in \{n, m\}$. Define the precision of these positive signals as ζ_i where $i \in \{1, 2\}$.

We make a number of assumptions about the signals that students receive:

- a) We assume that students are either entrepreneurs or employees.
- b) Further, we assume that the signaling process is informative - call this Assumption (I).²² This assumption has three components:

$$(i) \quad 1 \geq \psi^n > \psi^m \geq 0 \qquad (ii) \quad 1 \geq \zeta_i > \frac{\psi^m}{\psi^m + \psi^n}.$$

Part (i) implies that the probability that an entrepreneur-type receives a positive signal that they are an entrepreneur is greater than the probability that an employee-type receives such a signal. Part (ii) implies that signals always contain some information. Now define the strength of signals of entrepreneurial aptitude that a student receives as:

$$(iii) \quad \sigma_i^n \equiv \psi^n \cdot \zeta_i \qquad \sigma_i^m \equiv \psi^m \cdot (1 - \zeta_i)$$

Then signals will be informative ($\sigma_i^n > \sigma_i^m$) if $\zeta_i > \frac{\psi^m}{\psi^m + \psi^n}$.

- c) Finally, we assume that students update their beliefs about their own type according to Bayes' Rule.

²² We would like to thank Lotta Väänänen for her comments regarding this part of the model.

Assumption (I) implies that the belief of an entrepreneur-type student that she is an entrepreneur will not decline if she receives a positive signal of entrepreneurial aptitude (σ_i^n).

Note that greater precision of signals simultaneously improves the strength of the signal of entrepreneurial aptitude received by an entrepreneur-type and reduces the strength of this signal as received by the employee-type. This means that students receiving the correct signal about their type will revise their beliefs more as the precision of the signal increases.²³

Definitions

Initially students only know that a proportion ϕ of people in the population around them are entrepreneurs. Hence their prior of the probability that they are an entrepreneur is ϕ . Then, in the course of their pre university life they receive the first signal about their own entrepreneurial ability. This signal will generally differ depending on their type.

Beliefs after Period One. By Bayes' rule the strength of the beliefs of entrepreneurs that they are entrepreneurs after period one is:

$$B_n^n \equiv \frac{\sigma_1^n \phi}{\sigma_1^n \phi + \sigma_1^m (1 - \phi)} \quad \text{and} \quad B_m^n \equiv \frac{(1 - \sigma_1^n) \phi}{(1 - \sigma_1^n) \phi + (1 - \sigma_1^m) (1 - \phi)}, \quad (\text{A.1})$$

where B_n^n is the strength of the pre course belief of an entrepreneur n that they are an entrepreneur n if they receive a positive signal, while B_m^n is the strength of the entrepreneur's pre course belief that they are an entrepreneur if they receive a negative signal. The expressions in (A.1) show that the first period signal divides the group of entrepreneurs into two sets, one of which believes more firmly that they are entrepreneurs (B_n^n) and one of whom no longer believes very strongly that they are entrepreneurs (B_m^n).

Given these definitions the strength of the beliefs of the employees that they are employees after period one can be expressed as:

$$B_n^m \equiv 1 - B_n^n \quad \text{and} \quad B_m^m \equiv 1 - B_m^n. \quad (\text{A.2})$$

Beliefs after Period Two. Applying Bayes' rule once more the strength of beliefs of the entrepreneurs that they are entrepreneurs after period two is given by:

$$\begin{aligned} B_{n|n}^n &= \frac{\sigma_2^n B_n^n}{\sigma_2^n B_n^n + \sigma_2^m B_m^n} & \text{and} & & B_{n|m}^n &= \frac{\sigma_2^n B_m^n}{\sigma_2^n B_m^n + \sigma_2^m B_m^m} \\ B_{m|n}^n &= \frac{(1 - \sigma_2^n) B_n^n}{(1 - \sigma_2^n) B_n^n + (1 - \sigma_2^m) B_m^n} & \text{and} & & B_{m|m}^n &= \frac{(1 - \sigma_2^n) B_m^n}{(1 - \sigma_2^n) B_m^n + (1 - \sigma_2^m) B_m^m} \end{aligned} \quad (\text{A.3})$$

where $B_{n|n}^n$ is the strength of the entrepreneur-type student's belief that she is an *entrepreneur* after receiving a second period signal that she is an entrepreneur and a pre course signal that she is an entrepreneur ($_{n|n}$). $B_{m|n}^n$ is the student's

²³ This corresponds to a simultaneous increase in the sensitivity and specificity of the signals.

second period belief that she is an entrepreneur if she received a second period signal that she is an *employee* and a pre course signal that she is an entrepreneur ($B_{n|n}^n$) given that she is an entrepreneur (B_n^n).

After period two there are four groups of students each with a distinct level of belief about their entrepreneurial ability. These beliefs are a function of the history of signals that students have received. Two groups of students have received signals going in the same direction and they now have the strongest ($B_{n|n}^n$) and the weakest ($B_{m|m}^n$) beliefs that they are entrepreneurs. In contrast the other two groups have received countervailing signals. These groups revise their belief about being entrepreneurs upwards ($B_{n|m}^n$) and downwards ($B_{m|n}^n$) after period two.

Analogously there are four groups of employees with different levels of beliefs that they are employees after period two:

$$B_{n|n}^m = 1 - B_{n|n}^n \quad , \quad B_{n|m}^m = 1 - B_{n|m}^n \quad , \quad B_{m|n}^m = 1 - B_{m|n}^n \quad \text{and} \quad B_{m|m}^m = 1 - B_{m|m}^n .$$

There are those employees who are truly employee-types and have received a series of consistent signals, leading them to believe quite strongly that they are employees ($B_{m|m}^m$) or quite strongly that they are not ($B_{n|n}^m$). Also, those employees who receive inconsistent signals will revise their beliefs that they are entrepreneurs upwards ($B_{n|m}^m$) and downwards ($B_{m|n}^m$).

Appendix A.2. Proofs of Propositions

In this section we prove the propositions discussed in Section 3 of the paper.

Proof of Proposition 1

To complete the proof we derive the expectations of first and second period beliefs. Then we derive the variances of first and second stage beliefs. Finally, we derive conditions under which the variance of second stage beliefs exceeds that of first stage beliefs.

The Expectation of First Period Beliefs.

$$\mu_1 = \phi(\psi^n B_n^n + (1 - \psi^n)B_m^n) + (1 - \phi)(\psi^m(1 - B_n^m) + (1 - \psi^m)(1 - B_m^m)) \quad . \quad (\text{A.4})$$

Given that $B_n^n = 1 - B_n^m$ and $B_m^m = 1 - B_m^n$ we can show that:

$$\mu_1 = (B_n^n - B_m^n)(\phi\psi^n + \psi^m(1 - \phi)) + B_m^n \quad . \quad (\text{A.5})$$

We define $\lambda \equiv (\phi\psi^n + \psi^m(1 - \phi))$ to simplify calculations further below. Note that it must be true that $1 \geq \lambda \geq 0$. Now we reexpress the expectation of first stage beliefs as:

$$\mu_1 = \lambda B_n^n + (1 - \lambda)B_m^n \quad . \quad (\text{A.6})$$

The Variance of First Period Beliefs. Given the definition of the expectation of first stage beliefs the variance of first stage beliefs may be written as:

$$V_1 = \lambda(B_n^n - \mu_1)^2 + (1 - \lambda)(B_m^n - \mu_1)^2 \quad . \quad (\text{A.7})$$

Substituting out the expectation and simplifying we obtain:

$$V_1 = \lambda(1 - \lambda)(B_n^n - B_m^m)^2 \quad . \quad (\text{A.8})$$

The Expectation of Second Period Beliefs.

$$\begin{aligned} \mu_2 = B_{n|n}^n (\phi(\psi^n)^2 + (1 - \phi)(\psi^m)^2) + [B_{n|m}^n + B_{m|n}^n] (\phi(1 - \psi^n)\psi^n + (1 - \phi)\psi^m(1 - \psi^m)) \\ + B_{m|m}^n (\phi(1 - \psi^n)^2 + (1 - \phi)(1 - \psi^m)^2), \end{aligned} \quad (\text{A.9})$$

where we have already taken into account that $B_{ik}^n = 1 - B_{ik}^m$ for $k \wedge i \in \{m, n\}$. Now define $\Lambda = \phi(\psi^n)^2 + (1 - \phi)(\psi^m)^2$.

We can then simplify the above expression to:

$$\mu_2 = (B_{n|n}^n - B_{m|m}^n)\Lambda + (B_{n|m}^n + B_{m|n}^n)[\lambda - \Lambda] + B_{m|m}^n[1 - 2\lambda] \quad . \quad (\text{A.10})$$

This leads us to:

$$\mu_2 = (B_{n|n}^n + B_{m|m}^n - (B_{m|n}^n + B_{n|m}^n))[\Lambda - \lambda] + (B_{n|n}^n\lambda + B_{m|m}^n(1 - \lambda)) \quad . \quad (\text{A.11})$$

To simplify further calculations we define $R \equiv (B_{n|n}^n + B_{m|m}^n - (B_{m|n}^n + B_{n|m}^n))$ and $S \equiv (B_{n|n}^n - B_{m|m}^n)$. Then we can express the expectation of second stage beliefs as: $\mu_2 = R[\Lambda - \lambda] + S\lambda + B_{m|m}^n$.

The Variance of Second Period Beliefs.

$$\begin{aligned} V_2 = ((B_{n|m}^n - \mu_2)^2 + (B_{m|n}^n - \mu_2)^2 - ((B_{n|n}^n - \mu_2)^2 + (B_{m|m}^n - \mu_2)^2))[\lambda - \Lambda] \\ + (B_{n|n}^n - \mu_2)^2 \lambda + (B_{m|m}^n - \mu_2)^2 [1 - \lambda] \end{aligned} \quad (\text{A.12})$$

where as above we take into account that $B_{ik}^n = 1 - B_{ik}^m$ for $k \wedge i \in \{m, n\}$. If we substitute out the expected value of second period beliefs using the definitions given above we have:

$$\begin{aligned} V_2 = \left[(R[\lambda - \Lambda] - S\lambda + B_{n|m}^n - B_{m|m}^n)^2 + (R[\lambda - \Lambda] - S\lambda + B_{m|n}^n - B_{m|m}^n)^2 \right] [\lambda - \Lambda] \\ - \left[(R[\lambda - \Lambda] + S(1 - \lambda))^2 + (R[\lambda - \Lambda] - S\lambda)^2 \right] [\lambda - \Lambda] \\ + R^2[\lambda - \Lambda]^2 + S^2(1 - \lambda)\lambda \end{aligned} \quad (\text{A.13})$$

Defining $Z \equiv R[\lambda - \Lambda] - S\lambda$ this may be further simplified to:

$$\begin{aligned} V_2 = \left[(Z + (B_{n|m}^n - B_{m|m}^n))^2 + (Z + (B_{m|n}^n - B_{m|m}^n))^2 - (Z + S)^2 - Z^2 \right] [\lambda - \Lambda] \\ + R^2[\lambda - \Lambda]^2 + S^2(1 - \lambda)\lambda \quad (\text{A.14}) \\ = \left[(B_{n|m}^n - B_{m|m}^n)^2 + (B_{m|n}^n - B_{m|m}^n)^2 - S^2 - 2ZR \right] [\lambda - \Lambda] + R^2[\lambda - \Lambda]^2 + S^2(1 - \lambda)\lambda \end{aligned}$$

$$= \left[(B_{n|n}^n - B_{m|m}^n)^2 + (B_{m|n}^n - B_{n|m}^n)^2 + R^2\Lambda + R\lambda(2S - R) \right] [\lambda - \Lambda] + S^2 (\Lambda - \lambda^2)$$

The Difference of First and Second Period Variance of Beliefs. Here we show that the variance of second stage beliefs (V_2) is greater than the variance of first stage beliefs (V_1).

Note that:

$$V_2 - V_1 = \left[\overbrace{(B_{n|n}^n - B_{m|m}^n)^2 + (B_{m|n}^n - B_{n|m}^n)^2}^Z - (B_n^n - B_m^n)^2 + R^2\Lambda + R\lambda(2S - R) \right] [\lambda - \Lambda] + \left[S^2 - (B_n^n - B_m^n)^2 \right] (\Lambda - \lambda^2). \quad (\text{A.15})$$

Given that $S = B_{n|n}^n - B_{m|m}^n$ it is easily shown that $S = (B_{n|n}^n - B_n^n) + (B_n^n - B_m^n) + (B_m^n - B_{m|m}^n)$. Each of the differences in this sum is non-negative if Assumption (I) holds. Therefore, it must be the case that $S > (B_n^n - B_m^n)$. Note also that $(\lambda - \Lambda)$ and $(\Lambda - \lambda^2)$ are always non-negative if Assumption (I) holds.

It remains to show that $Z = (B_{n|n}^n - B_{m|m}^n)^2 + (B_{m|n}^n - B_{n|m}^n)^2 - (B_n^n - B_m^n)^2 > 0$. A change of variables will simplify the argument here. Define $a \equiv (B_{n|n}^n - B_n^n)$, $b \equiv (B_n^n - B_{m|m}^n)$ and $c \equiv (B_m^n - B_{m|m}^n)$. Then we can reexpress the problem as:

$$\begin{aligned} Z &= (a + b)^2 + (c + (B_n^n - B_m^n) + b)^2 - (B_n^n - B_m^n)^2 > 0 \\ &= a^2 + 2b^2 + 2ab + c^2 + 2bc + 2b(B_n^n - B_m^n) + 2c(B_n^n - B_m^n) > 0 \\ &= a^2 + c^2 + 2ab + 2(B_n^n - B_{m|m}^n)(b + c) \quad . \end{aligned} \quad (\text{A.16})$$

This expression is positive as long as $b + c > 0$. We show below that this corresponds to the requirement that $-\Delta_{m|m}^n > -\Delta_{m|n}^n$ which is the case if $1/2 \geq \sigma_1^n$ and if Assumption (I) holds.

Proof of Proposition 2

To complete the proof we derive results on levels and changes in second period beliefs as first period beliefs change. We focus on beliefs of entrepreneurs as those of employees can be derived by relabeling. We comment on this below.

Consistent and Inconsistent Signals. Here we show that beliefs of students that they are entrepreneurs if they receive consistent signals that they are entrepreneurs are higher than beliefs of all other students. We also show that beliefs of students that they are entrepreneurs if they receive consistent signals that they are not entrepreneurs are lower than beliefs of all other students. This is the first part of Proposition 2.

We show that: $B_{n|n}^n > B_{m|n}^n, B_{n|n}^n > B_{n|m}^n$. We also show that: $B_{m|n}^n < B_{m|n}^n, B_{m|m}^n < B_{n|m}^n$. The corresponding relationships for employees hold by symmetry: $B_{n|n}^m < B_{m|n}^m, B_{n|n}^m < B_{n|m}^m$ and $B_{m|m}^m > B_{m|n}^m, B_{m|m}^m > B_{n|m}^m$.

It is easily shown that:

$$B_{n|n}^n - B_{n|m}^n = \frac{\sigma_2^n B_n^n}{\sigma_2^n B_n^n + \sigma_2^m B_m^n} - \frac{\sigma_2^n B_m^n}{\sigma_2^n B_m^n + \sigma_2^m B_n^n} =$$

$$\frac{\sigma_2^n \sigma_2^m \phi (1 - \phi) (\sigma_1^n - \sigma_1^m)}{\left[\sigma_2^n \sigma_1^n \phi + \sigma_2^m \sigma_1^m (1 - \phi) \right] \left[\sigma_2^n (1 - \sigma_1^n) \phi + \sigma_2^m (1 - \sigma_1^m) (1 - \phi) \right]} > 0 \quad (\text{A.17})$$

$$B_{n|n}^n - B_{m|n}^n = \frac{\sigma_2^n B_n^n}{\sigma_2^n B_n^n + \sigma_2^m B_n^m} - \frac{(1 - \sigma_2^n) B_n^n}{(1 - \sigma_2^n) B_n^n + (1 - \sigma_2^m) B_n^m} = \frac{(\sigma_2^n - \sigma_2^m) B_n^n B_n^m}{\left[\sigma_2^n B_n^n + \sigma_2^m B_n^m \right] \left[(1 - \sigma_2^n) B_n^n + (1 - \sigma_2^m) B_n^m \right]} > 0 \quad (\text{A.18})$$

$$B_{m|m}^n - B_{n|m}^n = \frac{(1 - \sigma_2^n) B_m^n}{(1 - \sigma_2^n) B_m^n + (1 - \sigma_2^m) B_m^m} - \frac{\sigma_2^n B_m^n}{\sigma_2^n B_m^n + \sigma_2^m B_m^m} = \frac{(\sigma_2^m - \sigma_2^n) B_m^n B_m^m}{\left[\sigma_2^n B_m^n + \sigma_2^m B_m^m \right] \left[(1 - \sigma_2^n) B_m^n + (1 - \sigma_2^m) B_m^m \right]} < 0 \quad (\text{A.19})$$

$$B_{m|m}^n - B_{n|m}^n = \frac{(1 - \sigma_2^n) B_m^n}{(1 - \sigma_2^n) B_m^n + (1 - \sigma_2^m) B_m^m} - \frac{\sigma_2^n B_m^n}{\sigma_2^n B_m^n + \sigma_2^m B_m^m} = \frac{(1 - \sigma_1^n)(1 - \sigma_1^m)(1 - \phi) \phi [\sigma_2^m - \sigma_2^n]}{\left[(1 - \sigma_2^n)(1 - \sigma_1^n) \phi + (1 - \sigma_2^m)(1 - \sigma_1^m) (1 - \phi) \right] \left[\sigma_2^n (1 - \sigma_1^n) \phi + \sigma_2^m (1 - \sigma_1^m) (1 - \phi) \right]} < 0 \quad (\text{A.20})$$

These expressions imply that students receiving consistent signals hold stronger second period beliefs than students receiving inconsistent signals.

Comparative Statics of Consistent Signals. We investigate how the strength of first period signals affects the strength of second period beliefs.

$$\frac{\partial B_{n|n}^n}{\partial \sigma_1^n} = \frac{\partial}{\partial \sigma_1^n} \frac{\sigma_2^n \sigma_1^n \phi}{\sigma_2^n \sigma_1^n \phi + \sigma_2^m \sigma_1^m (1 - \phi)} = \frac{\sigma_2^n \sigma_2^m \sigma_1^m \phi (1 - \phi)}{(\sigma_2^n \sigma_1^n \phi + \sigma_2^m \sigma_1^m (1 - \phi))^2} > 0 \quad (\text{A.21})$$

$$\frac{\partial B_{n|n}^n}{\partial \sigma_1^m} = \frac{\partial}{\partial \sigma_1^m} \frac{\sigma_2^n \sigma_1^n \phi}{\sigma_2^n \sigma_1^n \phi + \sigma_2^m \sigma_1^m (1 - \phi)} = -\frac{\sigma_2^n \sigma_1^n \sigma_2^m \phi (1 - \phi)}{(\sigma_2^n \sigma_1^n \phi + \sigma_2^m \sigma_1^m (1 - \phi))^2} < 0 \quad (\text{A.22})$$

These derivatives demonstrate that second period beliefs of entrepreneurs who receive consistent signals that they are entrepreneurs increase as first period signals for entrepreneurs and for employees become stronger. Note that signals are stronger if $(\sigma_1^n \rightarrow 1)$ or $(\sigma_1^m \rightarrow 0)$.

$$\frac{\partial B_{m|m}^n}{\partial \sigma_1^n} = \frac{\partial}{\partial \sigma_1^n} \frac{(1 - \sigma_2^n)(1 - \sigma_1^n) \phi}{(1 - \sigma_2^n)(1 - \sigma_1^n) \phi + (1 - \sigma_2^m)(1 - \sigma_1^m) (1 - \phi)} = -\frac{(1 - \sigma_2^n)(1 - \sigma_2^m)(1 - \sigma_1^m) \phi (1 - \phi)}{\left((1 - \sigma_2^n)(1 - \sigma_1^n) \phi + (1 - \sigma_2^m)(1 - \sigma_1^m) (1 - \phi) \right)^2} < 0 \quad (\text{A.23})$$

$$\frac{\partial B_{m|m}^n}{\partial \sigma_1^m} = \frac{\partial}{\partial \sigma_1^m} \frac{(1 - \sigma_2^n)(1 - \sigma_1^n) \phi}{(1 - \sigma_2^n)(1 - \sigma_1^n) \phi + (1 - \sigma_2^m)(1 - \sigma_1^m) (1 - \phi)} = \frac{(1 - \sigma_2^n)(1 - \sigma_1^n)(1 - \sigma_2^m) \phi (1 - \phi)}{\left((1 - \sigma_2^n)(1 - \sigma_1^n) \phi + (1 - \sigma_2^m)(1 - \sigma_1^m) (1 - \phi) \right)^2} > 0 \quad (\text{A.24})$$

These derivatives demonstrate that second period beliefs of entrepreneurs who receive consistent signals that they are employees decrease as first period signals for entrepreneurs and for employees become more precise.

Comparative Statics of Inconsistent Signals.

$$\frac{\partial B_{m|n}^n}{\partial \sigma_1^n} = \frac{\partial}{\partial \sigma_1^n} \frac{(1 - \sigma_2^n) \sigma_1^n \phi}{(1 - \sigma_2^n) \sigma_1^n \phi + (1 - \sigma_2^m) \sigma_1^m (1 - \phi)} = \frac{(1 - \sigma_2^n)(1 - \sigma_2^m) \sigma_1^m \phi (1 - \phi)}{\left((1 - \sigma_2^n) \sigma_1^n \phi + (1 - \sigma_2^m) \sigma_1^m (1 - \phi) \right)^2} > 0 \quad (\text{A.25})$$

$$\frac{\partial B_{m|n}^n}{\partial \sigma_1^m} = \frac{\partial}{\partial \sigma_1^m} \frac{(1 - \sigma_2^n) \sigma_1^n \phi}{(1 - \sigma_2^n) \sigma_1^n \phi + (1 - \sigma_2^m) \sigma_1^m (1 - \phi)} = - \frac{(1 - \sigma_2^n) \sigma_1^n (1 - \sigma_2^m) \phi (1 - \phi)}{((1 - \sigma_2^n) \sigma_1^n \phi + (1 - \sigma_2^m) \sigma_1^m (1 - \phi))^2} < 0 \quad (\text{A.26})$$

These derivatives demonstrate that second period beliefs of entrepreneurs who receive first a correct and then an incorrect signal will tend to be closer to entrepreneurship ($B_{m|n}^n \rightarrow 1$) as first period signals for entrepreneurs and employees become more precise.

$$\begin{aligned} \frac{\partial B_{n|lm}^n}{\partial \sigma_1^n} &= \frac{\partial}{\partial \sigma_1^n} \frac{\sigma_2^n (1 - \sigma_1^n) \phi}{\sigma_2^n (1 - \sigma_1^n) \phi + \sigma_2^m (1 - \sigma_1^m) (1 - \phi)} \\ &= - \frac{\sigma_2^n \sigma_2^m (1 - \sigma_1^m) \phi (1 - \phi)}{(\sigma_2^n (1 - \sigma_1^n) \phi + \sigma_2^m (1 - \sigma_1^m) (1 - \phi))^2} < 0 \end{aligned} \quad (\text{A.27})$$

$$\begin{aligned} \frac{\partial B_{n|lm}^n}{\partial \sigma_1^m} &= \frac{\partial}{\partial \sigma_1^m} \frac{(1 - \sigma_2^n) (1 - \sigma_1^n) \phi}{(1 - \sigma_2^n) (1 - \sigma_1^n) \phi + \sigma_2^m (1 - \sigma_1^m) (1 - \phi)} \\ &= \frac{\sigma_2^n (1 - \sigma_1^n) \sigma_2^m \phi (1 - \phi)}{(\sigma_2^n (1 - \sigma_1^n) \phi + \sigma_2^m (1 - \sigma_1^m) (1 - \phi))^2} > 0 \end{aligned} \quad (\text{A.28})$$

These derivatives demonstrate that second period beliefs of entrepreneurs who receive first an incorrect and then a correct signal will tend to be further from entrepreneurship ($B_{n|lm}^n \rightarrow 0$) as first period signals for entrepreneurs and employees become more precise.

Proof of Proposition 3

This section sets out the proof of Proposition 3. We define changes in beliefs as follows:

$$\Delta_{n,n}^n = B_{n|n}^n - B_n^n \quad \Delta_{m,m}^n = B_{m|lm}^n - B_m^n \quad \Delta_{n,n}^m = B_{n|n}^m - B_n^m \quad \Delta_{m,m}^m = B_{m|lm}^m - B_m^m \quad (\text{A.29})$$

$$\Delta_{n,m}^n = B_{n|lm}^n - B_m^n \quad \Delta_{m,n}^n = B_{m|n}^n - B_n^n \quad \Delta_{n,m}^m = B_{n|lm}^m - B_m^m \quad \Delta_{m,n}^m = B_{m|n}^m - B_n^m \quad (\text{A.30})$$

Here the first set of changes in beliefs describes students receiving consistent signals and the second describes students receiving inconsistent signals.

To simplify the following analysis we introduce a change of variables:

$$\zeta \equiv (1 - \sigma_1^n) \phi \quad \nu = (1 - \sigma_1^m) (1 - \phi) \quad \nu = \sigma_1^n \phi \quad \omega = \sigma_1^m (1 - \phi) \quad (\text{A.31})$$

Then we can simplify the expressions for changes in beliefs to:

$$\begin{aligned} \Delta_{n,n}^n &= \frac{\nu \omega (\sigma_2^n - \sigma_2^m)}{[\nu + \omega] [\sigma_2^n \nu + \sigma_2^m \omega]} & \Delta_{m,m}^n &= \frac{\zeta \nu (\sigma_2^m - \sigma_2^n)}{[\zeta + \nu] [\zeta (1 - \sigma_2^n) + \nu (1 - \sigma_2^m)]} \\ \Delta_{n,n}^m &= \frac{\nu \omega (\sigma_2^m - \sigma_2^n)}{[\nu + \omega] [\sigma_2^n \nu + \sigma_2^m \omega]} & \Delta_{m,m}^m &= \frac{\zeta \nu (\sigma_2^n - \sigma_2^m)}{[\zeta + \nu] [\zeta (1 - \sigma_2^n) + \nu (1 - \sigma_2^m)]} \\ \Delta_{n,m}^n &= \frac{\zeta \nu (\sigma_2^n - \sigma_2^m)}{[\zeta + \nu] [\sigma_2^n \zeta + \sigma_2^m \nu]} & \Delta_{m,n}^n &= \frac{\nu \omega (\sigma_2^m - \sigma_2^n)}{[\nu + \omega] [\nu (1 - \sigma_2^n) + \omega (1 - \sigma_2^m)]} \\ \Delta_{n,m}^m &= \frac{\zeta \nu (\sigma_2^m - \sigma_2^n)}{[\zeta + \nu] [\sigma_2^n \zeta + \sigma_2^m \nu]} & \Delta_{m,n}^m &= \frac{\nu \omega (\sigma_2^m - \sigma_2^n)}{[\nu + \omega] [\nu (1 - \sigma_2^n) + \omega (1 - \sigma_2^m)]} \end{aligned} \quad (\text{A.32})$$

Consistent Signals. Begin first with changes in the beliefs of those receiving consistent signals. There are two groups here: those receiving correct and those receiving incorrect signals.

Correct signals:

$$\frac{\partial \Delta_{n,n}^n}{\partial \sigma_1^n} = \frac{\omega(\sigma_2^n - \sigma_2^m) \left[\sigma_2^m \omega^2 - \sigma_2^n v^2 \right] \overbrace{\frac{\partial v}{\partial \sigma_1^n}}^+}{[\nu + \omega]^2 [\sigma_2^n \nu + \sigma_2^m \omega]^2} \quad (\text{A.33})$$

$$\frac{\partial \Delta_{m,m}^m}{\partial \sigma_1^n} = \frac{\nu(\sigma_2^n - \sigma_2^m) \left[(1 - \sigma_2^m) v^2 - (1 - \sigma_2^n) \zeta^2 \right] \overbrace{\frac{\partial \zeta}{\partial \sigma_1^n}}^-}{[\zeta + \nu]^2 [\zeta(1 - \sigma_2^n) + \nu(1 - \sigma_2^m)]^2} \quad (\text{A.34})$$

By assumption I we know that $\sigma_2^n \geq \sigma_2^m$. If the signals students receive in periods one and two are not completely uninformative and there are approximately as many entrepreneurs as employees in the population ($\phi/(1 - \phi) \approx 1$), then the change in beliefs of those receiving correct signals in both periods is *decreasing* in the precision of the first period signal. To see this note that in this case the overall sign of equations (A.33) and (A.34) is negative as the following analysis of the terms in square brackets in the numerators shows:

$$\sigma_2^m \omega^2 - \sigma_2^n v^2 = \sigma_2^m \omega^2 \left(1 - \frac{\sigma_2^n \sigma_1^{n2} \phi^2}{\sigma_2^m \sigma_1^{m2} (1 - \phi)^2} \right) \quad (\text{A.35})$$

$$(1 - \sigma_2^m) v^2 - (1 - \sigma_2^n) \zeta^2 = (1 - \sigma_2^m) v^2 \left(1 - \frac{(1 - \sigma_2^n)}{(1 - \sigma_2^m)} \frac{(1 - \sigma_1^n)^2 \phi^2}{(1 - \sigma_1^m)^2 (1 - \phi)^2} \right) \quad (\text{A.36})$$

The terms in square brackets in the numerators of equations (A.33) and (A.34) have the opposite sign to the signed terms at the end of each expression leading to an overall negative sign if *signals are sufficiently informative*. This means that $\sigma_1^n \rightarrow 1$ and $\sigma_1^m \rightarrow 0$. In this case expression (A.35) is negative and so is the derivative at (A.33). Equally, expression (A.36) is positive and the derivative at (A.34) is negative.

Note that, if there are very few entrepreneurs in the population ($\phi/(1 - \phi) \rightarrow 0$) employees' changing beliefs will dominate those of the few remaining entrepreneurs. Employees' beliefs are still *decreasing* in the precision of the first period signal however.

If the proportion of entrepreneurs in the population is very high ($\phi/(1 - \phi) \rightarrow \infty$), then the entrepreneurs' changing beliefs will dominate those of the few remaining employees. Entrepreneurs' beliefs in this case are also *decreasing* in the precision of the first period signal.

Note that the analysis for an increase in the precision of the employees' first period signal ($\sigma_1^m \rightarrow 0$) leads to the same conclusion. This is intuitive as nothing in the model prevents us from relabeling employees and entrepreneurs.

We have now shown that entrepreneurs and employees receiving correct and consistent signals will display *lower* changes in beliefs from period one to period two if their first period signals are more precise and these signals are sufficiently informative.

In contrast, if students receive uninformative signals then the effect of stronger first period information differs by the type of student and by the type of signal. We do not pursue this case here.

Misleading signals:

$$\frac{\partial \Delta_{m,m}^n}{\partial \sigma_1^n} = \frac{v(\sigma_2^m - \sigma_2^n) \left[v^2(1 - \sigma_2^m) - \zeta^2(1 - \sigma_2^n) \right] \overbrace{\frac{\partial \zeta}{\partial \sigma_1^n}}^{-}}{[\zeta + v]^2 [\zeta(1 - \sigma_2^n) + v(1 - \sigma_2^m)]^2} \quad (\text{A.37})$$

$$\frac{\partial \Delta_{n,n}^m}{\partial \sigma_1^n} = \frac{v\omega(\sigma_2^m - \sigma_2^n) \left[\sigma_2^m \omega^2 - \sigma_2^n v^2 \right] \overbrace{\frac{\partial v}{\partial \sigma_1^n}}^{+}}{[v + \omega]^2 [\sigma_2^n v + \sigma_2^m \omega]^2} \quad (\text{A.38})$$

We can apply the same arguments as above to these two expressions. The common term $(\sigma_2^m - \sigma_2^n)$, which is negative, now changes the signs of both expressions above.

We have now shown that entrepreneurs and employees receiving misleading and consistent signals will display *greater* changes in beliefs from period one to period two if their first period signals are more precise and these signals are sufficiently informative.

Conflicting Signals. Now focus on those receiving contradictory signals. Here there are two groups to distinguish depending on the sequence in which the correct and the misleading signal arrive.

Sequence: misleading, correct We start with those who get a misleading signal and then a correct signal.

$$\frac{\partial \Delta_{n,m}^n}{\partial \sigma_1^n} = \frac{v(\sigma_2^n - \sigma_2^m) \left[\sigma_2^m v^2 - \sigma_2^n \zeta^2 \right] \overbrace{\frac{\partial \zeta}{\partial \sigma_1^n}}^{-}}{[\zeta + v]^2 [\sigma_2^n \zeta + \sigma_2^m v]^2} \quad (\text{A.39})$$

$$\frac{\partial \Delta_{m,n}^m}{\partial \sigma_1^n} = \frac{\omega(\sigma_2^n - \sigma_2^m) \left[(1 - \sigma_2^m) \omega^2 - (1 - \sigma_2^n) v^2 \right] \overbrace{\frac{\partial v}{\partial \sigma_1^n}}^{+}}{[v + \omega]^2 [v(1 - \sigma_2^n) + \omega(1 - \sigma_2^m)]^2}$$

Again we can apply the same reasoning as above. This shows that those who receive a misleading signal first, will change their beliefs *less* as the precision of the first period signals increases if signals are sufficiently informative.

Sequence: correct, misleading

$$\frac{\partial \Delta_{m,n}^n}{\partial \sigma_1^n} = \frac{v\omega(\sigma_2^m - \sigma_2^n) \left[(1 - \sigma_2^m) \omega^2 - (1 - \sigma_2^n) v^2 \right] \overbrace{\frac{\partial v}{\partial \sigma_1^n}}^{+}}{[v + \omega]^2 [v(1 - \sigma_2^n) + \omega(1 - \sigma_2^m)]^2} \quad (\text{A.40})$$

$$\frac{\partial \Delta_{n,m}^m}{\partial \sigma_1^n} = \frac{\zeta v(\sigma_2^m - \sigma_2^n) \left[\sigma_2^m v^2 - \sigma_2^n \zeta^2 \right] \overbrace{\frac{\partial \zeta}{\partial \sigma_1^n}}^{-}}{[\zeta + v]^2 [\sigma_2^n \zeta + \sigma_2^m v]^2} \quad (\text{A.41})$$

Again we can apply the same reasoning as above. This shows that those who receive a correct signal first, will change their beliefs *more* as the precision of the first period signals increases.

Appendix B. Additional Descriptive Results

This section provides several additional tables with evidence on the quality of the entrepreneurship course which this study is based on. First we provide a table with evidence about the course impact. Next we provide additional evidence on entrepreneurial intentions which supports the results we report in Table 4 above.

Assessment of Course Impact. An overall positive assessment of the course emerges from course evaluation questions available for 274 students participating in the course evaluation. These are tabulated in Table B.12. 81.4% (9.1%) percent of the students agreed (were neutral) to the statement that they "better understand the steps that one has to take to found a firm." The cooperation with real-world entrepreneurs yielded a smaller effect. 57.5% (25.1%) agreed (were neutral) that they "better understand the attitudes, values and motivation of entrepreneurs."²⁴ An improvement of practical management skills for founding a firm was confirmed by 66.8% percent of students, 19.7% were neutral, 13.5% percent did not see an improvement. Asked whether the course has had the effect that "I will consider founding or taking over an enterprise" 41.6% responded positively, and 38.3% negatively. 20.1% percent of students gave a neutral response. 34.7% percents stated that as an effect of the course, they would tend to prefer an employee position, 41.2% disagreed with that statement, and 24.1% were neutral.

Table B.12: Students' Assessments of Course Impact

Statement	Agreement to the statement		
	negative	neutral	positive
The course has had the effect ... that I understand the attitudes, values and motivation of entrepreneurs better.	17.5%	25.1%	57.5%
... that I understand the steps that one has to take to found a firm better.	9.5%	9.1%	81.4%
... of improving my practical management skills for founding a firm.	13.5%	19.7%	66.8%
... of improving my networking skills.	27.0%	26.3%	46.7%
... of improving my skills to recognize business ideas.	24.8%	22.6%	52.6%
... that I will consider founding or taking over an enterprise.	38.3%	20.1%	41.6%
... that I will tend to prefer an employee position.	41.2%	24.1%	34.7%

Note: N=196 - data from the ex post survey and course evaluation.

Data were originally coded on a 1 to 7 rating scale and have been recoded to 1/3=negative, 4=neutral, 5/7=positive.

Cross-tabulating the last two responses shows that at the end of the course, about 40% percent of students indicated that they have entrepreneurial intentions (and a dislike of an employee position), and about 35% have the opposite preference.

Entrepreneurial Intentions. Table B.13 shows that the share of students indicating that they want to found their own business at some point has decreased at the conclusion of the course. In the pre-course survey, 71.4% of the 196 students indicated entrepreneurial intentions. At the conclusion of the course, this share has decreased to 63.8%. The differences are highly significant in a chi-square test (Pearson's chi-squared=71.6, $p < 0.001$).

²⁴ The somewhat smaller effect is probably due to the fact that student teams engaged in considerable division of labor, and that only some students within the respective teams directly interacted with the cooperating entrepreneurs.

Table B.13: Ex ante and ex post Entrepreneurial Intentions

Would you like to found your own enterprise at some point?

		Ex post response		Total	
		no	yes		
Ex ante response	no	46	10	56	28.6%
	yes	25	115	140	71.4%
Total		71	125	196	100.0%
		36.2%	63.8%	100.0%	

Note: N=274 - data from the ex post survey and course evaluation.