Believing is Achieving:

Targeting Beliefs about Intelligence to Increase Learning in Bangladeshi Secondary Schools

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Abstract

Growth mindset interventions attempt to increase the perceived returns to effort by teaching students that the brain physically grows more powerful while we study. Such interventions have been shown to increase learning, especially among vulnerable populations, in the United States but their mechanisms are not thoroughly understood and they've yet to be tested in a developing country setting. I evaluate the impact of a growth mindset intervention in secondary schools in Dhaka using a field experiment designed to isolate the central claim in the literature that the intervention's impacts are due to changing students' beliefs about the malleability of intelligence. I do this by including a placebo arm that includes all of the same messaging on the returns to effort but makes no comment on whether the brain actually changes when we learn. I find the intervention increases test scores by 0.12σ on average and that the impact is heterogeneous across initial effort and gender, with the hardest working students at baseline receiving no impact and with a larger impact on girls than boys. Furthermore I find growth mindset significantly outperforms the placebo and I cannot reject that the placebo had no effect, corroborating theory.

1 Introduction

Student effort is a key input to the education production function (Stinebrickner and Stinebrickner, 2008; Bishop, 2006) yet our understanding of its determinants is limited. We have evidence that student effort responds to incentives (monetary and non-monetary) (Levitt et al., 2016; Barrow and Rouse, 2013; Hirshleifer et al., 2015; Fryer Jr, 2017), but what factors matter conditional on a set of incentives is less clear. Take the analogy of a firm, inputs are chosen to maximize profits and proper optimization requires knowledge not only of the incentive to sell (the sale price), but also of the production function and input prices. Similarly, a simple economic model of the student's effort decision would include beliefs about the learning production function and some cost to effort, but here is where the empirical work is thin. We know little about how students' beliefs about their own learning production functions impact their decisions. Interventions that change students' beliefs about their productivity have shown impacts in both directions (Ersoy, 2017; Krohn and O'Connor, 2005; Stinebrickner and Stinebrickner, 2012; Bandiera et al., 2015), and there are other elements to the learning production function that have not been explored in economics, such as the role of perceived intelligence.

Psychologists have posited that beliefs about the way intelligence factors into the learning production function are an important determinant of student effort (Dweck et al., 1995; Dweck, 2013). Specifically, believing intelligence to be a function of past effort, as opposed to fixed or pre-ordained, is thought to result in greater, or more effective effort and a tendency to sustain effort in times of challenge. They designed the growth mindset intervention to target these beliefs; programs as short as 45 minutes teach about the plasticity of the brain and how this implies that our effort today can increase our intelligence in the future (Blackwell et al., 2007). Multiple randomized trials in the have shown the intervention to increase effort and learning (Aronson et al., 2002; Good et al., 2003; Blackwell et al., 2007; Fabert, 2014; Outes, 2017; Paunesku et al., 2015; Rienzo et al., 2015; Yeager et al., 2014, 2016). However, the interventions often include additional messaging on the value of effort and strategies for coping with challenge so it is possible that changing beliefs about the relationship between intelligence and effort is not what's causing the observed effects.

If it is the case that growth mindset interventions work through the additional messaging on the value of effort, then they are theoretically similar to a positive performance feedback shock: if successful, they increase the student's perceived marginal product of effort (MPE). Given that theory and the empirical literature show such a shock can increase or decrease effort, we'd expect to find a growth mindset intervention causing reduced performance for some. However if psychologists are right that growth mindset successfully changes beliefs about intelligence and that this is the driving mechanism, then the finding is distinct from previous work in economics. In this case students may or may not change their beliefs about the MPE today, but they will believe that greater effort today can increase the MPE in the future. This information could have the additional impact of increasing a student's sense of agency since it implies that future ability is a function of their choices today. It is argued that personal agency (or locus of control) may be an important predictor of achievement in school (Almlund et al., 2011; Heckman and Kautz, 2013; Rotter, 1966). Furthermore, Ersoy (2017) finds that it is a college student's sense of personal agency or locus of control that explains whether they react positively or negatively to a perceived productivity shock: those with a greater sense of agency (internal locus of control) intend to increase (decrease) their effort when perceived productivity increases (decreases) whereas those with an external locus of control may shift in the opposite direction. Thus, an intervention that promotes an internal locus of control and increases the perceived MPE may more consistently result in increased effort. These differences may explain why growth mindset interventions have had consistently positive, or at least non-negative impacts on learning in contrast to interventions studied in economics which have moved outcomes in both directions. Despite the different implications of these two possible explanations, to my knowledge, no prior study on growth mindset has disentangled the impacts of the messaging on beliefs about intelligence from that on the general value of effort.

In this paper I seek to expand our understanding of the determinants of student effort in economics and test the claim in psychology that growth mindset works by changing beliefs about intelligence with evidence from a randomized-controlled trial (RCT) in secondary schools of Dhaka, Bangladesh[1]. Roughly 1000 students from grades 6, 7 and 8 in two large, government-curriculum

[1]While previous work has shown growth mindset to be most effective among vulnerable populations, this is one of only two papers I am aware of to test the intervention in a developing country, the other is an ongoing pilot in

schools were assigned to one of three groups: control, growth mindset, or growth mindset without beliefs about intelligence (no-plasticity hereafter). Students in the growth mindset group received a standard growth mindset intervention, modeled after those done in the US. This consisted of four 1-hour weekly sessions designed to teach students that the brain physically grows stronger while we learn, and that the quantity and quality of our effort today is the key to our success. Those in the no-plasticity group received the same messaging on the importance of effort, but instead of learning about plasticity they learned about how information is filtered through different parts of the brain before arriving in our long term memory. The two neuroscience lessons were designed to yield the same take-away lessons for learning, while maintaining the key distinction, that the no-plasticity group made no comment on whether the brain could change. This design allows me to measure the overall impact of the growth mindset intervention and to test whether the inclusion of the "beliefs about intelligence" material has a significant impact over the rest.

I find students in the growth mindset group were twice as likely as those in the control to be mentioned by teachers as having increased effort in the second semester (post-intervention). The no-plasticity group showed a slight increase, however it was not statistically significant. On other measures of effort–self-reported effort ranking, reported study hours, friend's report of effort ranking—I find no effect. It is possible that students only increased the quality of their effort, and not the quantity, however time use data is notoriously noisy and effort rankings are subject to updating based on shifting peer effort so I am not equipped to draw a strict conclusion here.

My primary measure of learning is a set of six monthly, math quiz scores (3 pre, 3 post-intervention) that were written and graded by the research team. I find the growth mindset intervention increased scores by 0.12 standard deviations (σ hereafter) on average and evidence that the effect size varies by effort starting point and gender. There is no effect for those who state they are "one of the hardest working" or who report study hours in the top quintile at baseline, consistent with a theory of diminishing marginal returns to effort. The effect on girls is more than 0.1σ greater than for boys at 0.18σ, in line with previous work that has shown growth mindset to be more effective for marginalized groups that perform lower on average. While these effect sizes are on the small to medium end of those reported in the development literature, the cost

Peru (Outes, 2017)

per student is roughly \$1 per 0.1σ, on par with the most cost effective interventions listed in a recent review (Glewwe and Muralidharan, 2016). If the intervention were properly targeted to those for whom the impact is largest the cost could drop to less than half of the most cost effective previously listed interventions.

The most surprising result is in comparing the growth mindset intervention to the no-plasticity group: while I cannot detect a difference between the two (or reject the null for the no-plasticity group) in the full sample, if I examine the difference within groups where growth mindset had an unambiguous effect (girls and those not in the top effort quintile), I see the standard growth mindset intervention significantly outperformed the no-plasticity group with the no-plasticity group having close to zero effect. This is remarkable since the interventions were identical on 3 out of the 4 days, and the take-away lessons on the day they differed were the same. Evidence from the survey data shows that growth mindset may have caused students to form more accurate beliefs about their current preparedness, reducing over-estimation, which may have contributed to motivating additional effort. At least one previous growth mindset study found the same effect on overconfidence (Ehrlinger et al., 2016). The no-plasticity group had no effect on beliefs. I find no impact on beliefs about the returns to effort from either group, however these were very noisy measures.

The primary contribution of this paper to the economics literature is the demonstration that subtly different beliefs about the nature of the learning production function (in this case, whether intelligence factors in dynamically or not) can have practically significant impacts on a student's behavior and learning. Furthermore, these beliefs are manipulable and, combining my findings with previous work on growth mindset in schools, manipulation appears to cause relatively consistent effects across a variety of settings.

These findings appear to be closely related to new and growing literature on aspirations. Defined as the future opportunity set an individual considers attainable, there is evidence that aspirations can be increased simply by screening videos with role models from similar backgrounds who have attained success in some way, and that increasing aspirations can lead to a host of welfare improving behaviors (Genicot and Ray, 2017; Tanguy et al., 2014). A recent study showed that increasing

aspirations of secondary school students in Uganda in this way increased test scores by a magnitude similar to that found in my study, and that this effect was larger for girls than for boys, as in my study (Riley et al., 2017). This is not entirely surprising given the growth mindset intervention teaches that effort today can increase ability in the future, since greater future ability implies a greater set of opportunities, growth mindset may have the effect of increasing aspirations.

Also related is the literature which examines the role of perceived monetary and non-monetary returns to schooling in educational investment decisions (Avitabile and De Hoyos, 2018; Fryer Jr, 2017; Hastings et al., 2015; Jensen, 2010; Nguyen, 2008; Wiswall and Zafar, 2014). Interventions studied in these papers are similar to growth mindset in that they provide information that changes the perceived returns to investment in education. However they accomplish this by changing the perceived returns to learning (eg. an additional year of schooling provides an additional unit of human capital and that additional unit is worth more on the labor market than you thought). Growth mindset interventions affect the perceived returns to the investment itself (effort) on learning (eg. an additional year of schooling, assuming you apply yourself over this year, will provide you with more units of human capital than you thought). Importantly, I find an increase in learning, while the papers from this literature that are set in developing countries do not. As with incentives, it may be that this is because it is more effective to target inputs directly than to target outputs.

The rest of this paper is structured as follows: section 2 explains the setting and study design, section 3 presents the results on effort and learning, section 4 discusses mechanisms, section 5 considers cost-effectiveness and policy implications, section 6 concludes.

2 Setting and Study Design

2.1 Sample Selection

The experiment was conducted in Dhaka, Bangladesh for a number of reasons: 1) Growth mindset interventions have the potential to be a cost effective way to increase learning in developing countries but at the start of my study, there had been no test outside the developed world; 2)

Bangladesh's education trends follow those observed in the developing world more broadly (enrollment up, learning still lags) making it a relevant test case; 3) Cultural norms specific to south Asia may promote more of a fixed mindset in comparison with the US (where most prior experiments were run), thus a greater change in beliefs is possible, which could imply a greater change in effort and learning; 4) A pilot survey before the study showed that belief in a malleable theory of intelligence was correlated with performance in school, the same trend found in the US that motivated the original interventions; 5) Transportation costs made rural field sites infeasible given budget constraints; 6) The author's prior field work in Bangladesh ensured that running a study there would be logistically feasible.

Secondary school was chosen for three reasons: 1) The growth mindset intervention was originally designed for middle school students in the United States as middle school was shown to be a turning point in student's academic trajectories, especially in STEM fields. Students who fell behind in STEM courses in middle school typically were not able to catch up later on; 2) Secondary school is a similar turning point in Bangladesh. Performance on the Junior School Certificate exam taken at the end of grade 8 determines the track students take from level 9 onwards (Science, Business or Humanities); 3) Much of the research on improving education in developing countries has been conducted in primary school, more research is needed to understand how to improve post-primary education.

While it was not feasible to choose a representative sample given that budget constraints limited me to randomizing at the student level within two to three schools, I attempted to select schools that were typical and contained students from the largest income bracket. My search criteria were: government curriculum, Bengali medium, and medium sized (120 to 240 students per grade level). I used the vast network of my implementing partner, Innovations for Poverty Action, Bangladesh to identify a list of 15 schools that met this criteria and set up meetings with their headmasters. The majority of headmasters were willing to participate but some were very difficult to communicate with (not always returning calls). For this reason we narrowed the list to five schools whose administrators seemed responsible and enthusiastic enough to make coordinating the study feasible. From these five schools three were chosen for the study and two were selected

to act as back-ups in case a school dropped out. The back-ups were slightly less conveniently sized, one was small (90 students per grade), the other large (300 per grade). One of the three schools was dropped from the study after the second month when our contact person went on maternity leave and her replacement failed to take up her responsibilities. After updating power calculations I determined it was not necessary to use a back-up school.

The two schools that participated were University Laboratory School (ULAB) in Shahbag neighborhood and Hazrat Shah Ali Model School (HSAM) in Mirpur neighborhood. ULAB has 120 students per grade level and is coed. HSAM has 240 students per grade level and is single-sex, dividing boys and girls into two separate shifts (girls come in the morning and boys in the afternoon) so class sizes are roughly the same in both schools. Mean income rank is the same for both schools, both have 95% of students in low to middle income families; ULAB has a larger share of the lowest earners, possibly owing to a lottery system used to enroll roughly half of its students. Compared to the Dhaka city average, the students in my sample come from slightly wealthier families: in the study sample 40% are low income and 55% are middle income, city wide it's 57% low and 41% middle income. An important distinction is that while my sample may provide reasonable insight into citywide behavior, Dhaka city demographics are quite different from the rest of the nation where 85% of secondary students come from low income families and 15% come from middle income. In terms of academic performance, ex post I found out that ULAB students score significantly higher than HSAM students on the JSC board exam. In 2017 HSAM passed 82% of students while ULAB passed 100%. For reference, the national pass rate on the JSC is 82% and the pass rate in Dhaka city is 90%. This pass rate for ULAB is higher than expected, though high pass rates are not extremely rare in the capital city with 30% of schools passing 97% and above.

I enrolled all students from grades six, seven and eight from ULAB and HSAM, providing a total sample of roughly 1000 students.

2.2 Intervention

The growth mindset intervention I evaluate was designed after those done in the United States by the intervention's creators and drew heavily from materials available online at mindsetkit.org and mindsetworks.com, two websites that try to make it easy for educators to do their own growth mindset lessons. While computer based growth mindset interventions as short as 45 minutes in length have shown impacts in previous studies, I decided a more intensive treatment, similar to earlier versions of the intervention would likely produce larger effects allowing for more a more detailed analysis of mechanisms in this new setting. The most intensive intervention from previous work was an eight day version used in one of the key papers in the psychology literature (Blackwell 2007). Given budget constraints I settled for three days of interactive class time with a fourth day used for a quiz on the intervention material, a quick review of the correct answers after the quiz and student feedback[2]. Intervention leaders were recent university graduates with a passion for teaching and helping the poor. They were recruited primarily through the Teach for Bangladesh network. The intervention took place over the first four weeks of the second semester of the 2017 school year (school years run from January to December in Bangladesh).

On the first day students in both treatment groups received a general introduction to the brain, a common primer in growth mindset interventions before getting into the more complex topic of neuroplasticity. They were taught facts such the weight of the brain, the percentage of your body's energy it uses, and that it is made of many small building blocks called neurons. They learned the anatomy and basic function of a neuron and played a game called the "neuron relay race" where students act out the functions of the various parts of the neuron as it receives a message and passes it on to the next neuron. The main take-away lesson from the first day is that sleep and proper nutrition are important for learning as the brain needs these to function at its best.

On the second day the topic was "What happens in the brain when we learn?" Students in the growth mindset group learned that the brain physically changes, forming new connections as we learn, while students in the no-plasticity group were taught that information is filtered through sensory and working memory and only the things we really learn make it to long term memory.

[2]For a detailed description of each day of the intervention, see appendix N, forthcoming

Both interventions teach about what goes on in the brain when we learn, but the normal growth mindset group emphasizes that the brain grows more powerful as we learn while the no-plasticity group makes no comment on whether the brain changes. While material taught differed across treatments, the take-away lessons emphasized were the same: "To really learn you must..., 1) Practice, 'Practice makes perfect'; 2) Challenge yourself; 3) Don't just memorize details, aim to learn the concepts that tie them together."

On the third day both groups shifted from learning about the science of the brain to learning about how our attitudes, or mindsets about learning can affect our success, and how to cultivate a good learning mindset, a "growth mindset". Importantly, no mention was made on this day about whether the brain can change. Students learned that one thing many successful people have in common is a determination that is not set back by challenge or even failure. The example of Abdul Kalam a famous Indian engineer, scientist and politician was given. Kalam oversaw India's first and failed attempt to launch a satellite into space, but continued to work on the project until India eventually succeeded. He later went on to become the President of India. A key message was that a life without mistakes meant a life without challenge and a life without learning, mistakes and failures are the pillars of success. Students were taught that a good strategy for maintaining this mindset is to set learning goals, not performance goals, then even when the performance result is not as desired, one assesses the more relevant factor of what was learned along the way. A final tip was, don't say "I can't do something", say "I can't do something yet!" All of the lessons from day 3 were gleaned from previous growth mindset interventions, however ours may be the first to separate these from the day two material. This was done to ensure that both treatment groups would receive this messaging in full and to test the hypothesis that perhaps it is this information, and not changing beliefs about the malleability of intelligence, that causes growth mindset interventions to work.

On the fourth day both groups took the same quiz that included questions on shared material (intro to the brain, mindset, common take-away messages) as well as questions on material unique to each treatment. Students were told that they were not expected to know all the information on the quiz and that we expect them to leave some questions blank. To discourage guessing on

multiple choice questions (which could increase noise and reduce precision in measuring a treatment effect on knowledge), students were told that there was at least one question that had no correct answer so it would be clear if a student guessed, furthermore, students would get negative points for each guess and as an incentive, students with the highest points in each class would win a small prize. After the quiz, intervention leaders reviewed the answers that students in their respective treatment should have known, and ignored questions on material they were not taught. Finally, students were asked to fill out a short feedback on the intervention sessions and intervention leaders they had.

2.3 Control Design

As randomization was done within schools and as the intervention had to be done during class time, it was not possible to have a pure control, something had to be done with the students in the control group, however the goal was to mimic that of a pure control, having as little an effect as possible relative to business as usual schooling. I settled on "supervised study". Students were told that they could use the time however they liked as long as they remained in class and did not disturb their classmates, similar to being in a library. They were allowed to work on reading or homework for classes, or spend the time reading or drawing for pleasure. They could talk to fellow students quietly as long as it was not causing a distraction. It was assumed that most students would not take advantage of this time to get ahead in their studies and that those who did would not be at a significant advantage relative to those in the treatment as 4 hours of extra studying over the remainder of the school year would not constitute a significant difference.

2.4 Explaining the Division

Students in the control and treatment groups were told that we had come to their school to try out some new activities that might help them to do better on their exams. One of those activities was a lecture with information that might help students, the other was providing quiet time for students to study. We explained that while some students might prefer to attend the lecture and others might prefer to attend the free study time, it would not be possible to allow students to

choose on their own, so we made the selection using a lottery system. We made clear to students in the control that any material taught to other students was not material they would be expected to know, or that would appear on an exam.

2.5 Randomization

Students were assigned to growth mindset, growth mindset without plasticity or control using a stratified randomization approach. Stratification attempted to balance the randomization within school, grade level and gender, as well as over the baseline outcome tercile and over the number of others who mention a student in the baseline survey, high vs low number (we asked students to list their friends and other connections in the baseline survey). Number of mentions was included to avoid imbalanced network effects across treatments and increase power for using networks to detect spillovers.

2.6 Data

2.6.1 Learning

While the effort decision is of primary theoretical interest, to accurately measure effort requires regular, repeated data collection from students, which was not feasible. I included several cheaper measures in attempt to in detect changes in effort which I summarize below, but due to their unreliability, I took learning outcomes, as measured by grades on quizzes and exams to be the primary outcome of the study. Indeed if the intervention changes learning for treated students relative to their control counterparts (who have all the same school inputs), then one can conclude that the quantity or quality of effort has changed.

Both schools provided copies of their gradebooks, but ex ante I did not trust that they would be reliable measures of whether students were learning the curriculum. Discussions with IPA employees and educators revealed many anecdotes of teacher bias in grading and of teachers providing the questions before exams so students merely have to memorize material instead of learning the concepts. To combat these two issues, we administered our own monthly math quizzes, three before and three after the intervention. The research team wrote and graded the exams to eliminate

any bias or memorization. The team worked with secondary school students from other schools in Dhaka to create the exams and with teachers in our schools to ensure the material reflected the teaching that month. Schools agreed to replace their own math quizzes with ours and incorporate our quizzes into the students' term grades.

2.6.2 Effort

Teacher Survey: Around the same time as the endline I survey teachers and ask them to list students whom they have observed increasing or decreasing their effort in the second term (post-intervention) compared to the first (pre-intervention). While experience observing the intervention gives me confidence that the teachers were blind to treatment, after listing the students I ask the teachers if they know which group any of the listed students were in ("...the group receiving lecture/activities or the group with quiet study time?"). If they say they know, then I ask them to state which group they were in.

Questionnaire: I measure effort in three ways at baseline (just before the intervention) and endline (2.5 months after intervention): 1) Self-reported hours spent studying per week; 2) A coarse self-reported effort ranking: "How hardworking are you compared to your classmates? Average or above (below)?" Then if above (below): "Just above (below) average or one of the most (least) hard working?"; and 3) An average of the rankings given to a student by his or her friends (when asking students to list their friends I ask them to provide the same coarse effort ranking of each).

Attendance: The schools also provide daily attendance data, however it is unclear in our context what level of agency students have in the decision to attend. Discussions with the research team suggest in most cases this decision is entirely made by the parent(s).

2.6.3 Knowledge and Beliefs

To test whether the intended information was learned by students in the treatment groups and that this produced a difference in knowledge or beliefs between groups, students in both treatments were quizzed on the intervention material immediately following the intervention and the key quiz

questions were repeated in the endline survey administered to all groups. Control students did not receive the quiz immediately flowing the intervention as this could have acted as a treatment in itself. The set of questions in the quiz, and at endline, were the same regardless of the student's groups, allowing for comparison in performance on material students were taught and that which they were not.

In addition to measuring knowledge and beliefs directly affected by the intervention, I sought to detect changes in beliefs that may be indirectly impacted, such as perceptions of the returns to effort (marginal product of effort, returns to schooling (monetary and non-monetary)) and perceptions about one's own intelligence. The baseline and endline questionnaires included a number of questions targeting these beliefs (for a full accounting, see appendix).

2.6.4 Networks

Student network data is collected for three reasons: 1) to enable some analysis of potential spillovers, 2) to provide a less biased measure of student effort, and 3) to learn about how networks may affect belief formation.

Spillovers could occur if control students learn treatment information, or if they observe fellow students changing behavior and are inspired to change their own as a result. Both forms of spillover are conceivably more likely to occur the more a control student interacts with treated students, as these interactions increase likelihood of exposure to treatment material and its resulting behaviors. If we know who students are connected to then we can measure the degree of this exposure and see whether it indeed has an impact.

While asking students to list their network connections (siblings, friends, study partners, and other respected students), I also ask them to state for each a coarse effort ranking ("How hard working is .... relative to other students at his grade level in this school?") with the same options as the coarse self-effort ranking and a coarse performance ranking ("How do ....'s grades compare to others students at his grade level in this school?"), with similar options. Using this data I can construct measure of each student's friends' perceptions of his or her effort (as long as at least one other student mentioned him or her). This may be a slightly less biased effort measure than the

one reported by the student about himself or herself. Lastly, using each student's perception of their friends' efforts and the rewards they reap to construct an observed product of effort ranking and I can compare this to other measures of the student's MPE and speculate on the role of social networks in formation of these beliefs. Furthermore if treatment provides exogenous shifts in networks that wouldn't have occured otherwise I may be able to infer the causal impact of networks on these beliefs, though it is unlikely I will have power for this.

2.6.5 Quiz Score Guess

Prior to each quiz, students were asked to guess their quiz score. Guesses, being a function of actual preparedness and confidence, could provide additional insight into effort, if confidence stays constant. Alternatively, if the accuracy of students' perceptions of their own preparedness changes as a result of the intervention we may be able to detect it here controlling for other measures of effort[3].

2.6.6 Other

In addition to collecting data on the main outcomes and potential mechanisms listed above, a number of other measures were included that might be related to the outcome and might interact with the treatment: Socio-economic status has been shown to interact with the treatment previously (cite paunesku?); students were asked about their parents occupations and education as well as some details of the type of housing they live in. Hours per week spent in tutoring was asked in the questionnaire; while it may not be subject to the student's decision making, it likely has an impact on other decisions and on performance. Prior to each monthly quiz students were asked if anything had occurred that made it more difficult than usual to study; the idea is to soak up random noise affecting scores not accounted for in the regressions. Students' preferences regarding schooling and future careers might affect motivation and might interact with treatment so a few questions were included to measure this. Lastly students' perceptions of their teachers' support (ok to ask questions in class, ok to ask after class, treated fairly), were measured. For a

[3]The guesses may be used in future work to estimate perceived production functions using the measured student inputs to predict the reported guessed outputs.

full accounting, see appendix.

3 Results

3.1 Balance and Attrition

The randomization worked and though attendance was low, 2/3rds during the intervention and quizzes, this was equal to the average attendance on any given school day and did not differ by treatment arm. A more detailed breakdown is forthcoming.

3.2 Specifications

The main specification is a standard Difference and Difference model controlling for stratification variables. To check for robustness I also run ANCOVA regressions (recommended by McKenzie in "The case for more T", cite) and examine impacts with a host of additional controls. Binary dependent variables are treated with a logistic regression model also controlling on stratification variables.

3.3 Impact of Treatments on Learning and Effort

3.3.1 Math Quiz Scores

Students who received the growth mindset intervention scored 0.12 std. dev. higher on the math quizzes than their counterparts in the control group (std. err. 0.06, $p<.05$, Table 1, Panel A). The no-plasticity group's scores were not significantly different from control, but with a small positive point estimate (0.05 std. dev, Table 2), they could not be distinguished from growth mindset group either in the full sample[4]. This finding is robust to a host of controls that predict the outcome and that were not stratified over in the randomization (Table 1, Panel B). The effect size is close to the average of previous RCTs done on growth mindset (cite meta) and is quite large in terms of

[4]The full sample includes populations that were not affected by GM which lowers the ATEs and makes it more difficult to distinguish impacts. I examine the difference again after reviewing heterogeneity below

cost effectiveness, ranking among top programs tested at around $1 per 0.1 std. dev (cite karthik dev ed review).

3.3.2 Effort

The teacher's survey reached 64 teachers in total, each listed 1 to 4 students that had increased their effort after the intervention for a total of 99 student listings (some students were listed more than once). Growth mindset students were twice as likely as control students to be listed by a teacher as having increased effort after the intervention (P(listed—control)=0.05 , P(listed—GM)=0.10); Diff = 0.05, std. err. 0.02, p<0.05, Table 2). As with learning, the no-plasticity group could not be distinguished from the control or growth mindset group (Table 2). 92% of teachers said they did not know which group ("lecture" or "study-time") the student was in. Those who claimed to know were correct 50% of the time, suggesting teachers were in fact blind to treatment[5].

The results from the teacher's survey combined with the observed gains in learning suggest the growth mindset intervention did cause students to increase effort, however, I see no impact of either treatment on self-reported effort rank, study hours, or friend's report of effort rank. While effort ranking effects could be attenuated by updating (if treated students see their peers increasing effort as well they may not report being harder working even if they have increased their effort), I expect self-reported study hours to increase. It could be that the gains in learning are driven by increased quality of effort, not quantity, or simply that the measure of quantity is imprecise or inaccurate. I can't rule either out, though I will speculate further on the accuracy of the measure when I discuss mechanisms below.

I see no impact on attendance from either treatment, possibly owing to students lacking agency in the decision of whether to attend school.

3.3.3 Administrative Grades

Schools provided term one (pre-intervention) final grades for all students and term 2 (post-intervention) final grades for students in grades six and seven. Grade eight students take Junior

[5]This is as we would expect, given that my team members and I diligently patrolled the halls to ensure teachers did not even peer into the classrooms to see what was being done.

School Certificate national exam, in lieu of final exams at their schools. Board exam scores were obtained online. Table 3 shows the growth mindset intervention increased scores in math, science and world studies but not in English. Bengali, religion, physical education, and home economics all had a null result as well but are not displayed. Prior work on growth mindset has shown a similar subject heterogeneity (cite), as has work on aspirations (cite riley). Education RCTs in the United States have also found that interventions often impact math scores but not English, some evidence suggests language skills are formed at an earlier age and are more difficult to change (cite Fryer review). I find no impact on grade eight board exam results in any subject.

These results are remarkably consistent with the math quiz scores. For direct comparison, Table 4 shows the impact on quiz scores excluding grade eight, we see the impact is quite a bit larger than in the full sample at 0.2 std. dev. (std. err. 0.076, $p<0.01$). If we look within grade eight only we find no impact of either treatment. I speculate below on the cause of this heterogeneity.

3.4 Heterogeneity in the treatment effect

3.4.1 Effort starting point

A surprising finding of the baseline survey and subsequent investigation was that 90% of students attend after school tutoring five to six days per week and that the quantity of tutoring is not correlated with income or parents education. Even the poorest students in our sample receive daily tutoring. This is made possible by a large variety of types of tutoring available: from expensive one-on-one tutoring with university graduates down to extremely cheap "coaching" sessions in which a tutor of lesser qualifications guides a tightly packed room of students through memorization of pages in a text. This observation strongly contrasts with the context in which growth mindset has been effective in previous studies. In the US, vulnerable students typically do not have structured learning time after school.

Given that growth mindset increases learning via increasing effort, this led me to question 1) whether students in Dhaka would have the scope to change their effort if their time was already scheduled for them and 2) if an increase in effort would be beneficial if starting effort is high

and there are diminishing returns. While I'm unable to disentangle these two channels, I do find evidence that students with the highest effort starting points are not impacted by the program. Adding hours of tutoring to hours of self-study at baseline and interacting with treatments reveals those in the top quintile (those spending more time on schooling than 80% of their peers at baseline) are not impacted by the treatments; point estimates on the interaction are almost equal and opposite the treatment for the rest, however the interaction term is not significant at the 10% level (p=0.13, Table 5(forthcoming)). Interacting self effort ranking has a similar effect, those who state they are "One of the most hardworking" compared to their classmates are not impacted by treatment, however standard errors are much larger on this estimate (p=0.417).

It appears that it is a difference in effort starting point that is driving the heterogeneity we see going from grades six and seven to grade eight. Table 6 shows that students in grade eight are spending an additional 5 hours per week outside of school compared to students in grade six and that goes up to 6.9 additional hours in the post-intervention period when changes in effort are needed to realize gains ($p<0.01$ for both)[6]. Students in grade seven may spend 1 to 2 hours per week more than those in grade six but this difference is not significant (the difference between 7 and 8 is significant, $p<0.01$). The higher effort level in grade eight is almost surely due to the pressure to perform well on the national board exam, results from which have implications for future educational opportunities. This higher level of pressure to prepare for the national exams may also make students less open to trying different study strategies and thus less likely to change the quality of their effort.

While I cannot disentangle these mechanisms, it is clear that students in grade eight face a different set of starting conditions when choosing their effort quantity and quality, thus it reasonable to conduct analyses separately (only grade eight vs. without grade eight) in further investigation. In particular, if we are interested in understanding what factors contribute to the success of the intervention, it makes sense to focus on grades six and seven where the intervention was successful, as including grade eight only reduces power in hypothesis testing to this end.

The key finding in utilizing this insight is that the growth mindset intervention was significantly more effective than growth mindset without plasticity (Diff. = 0.17 std. dev., $p<0.05$, Table 4).

[6]Regression sample is control group only

Furthermore we still cannot reject the null that the no-plasticity group had no effect. This is a striking result given that the two interventions differed only in portions of the material in one out of three lessons. It's a strong affirmation of the theory behind the development of the growth mindset intervention which posited that changing student's beliefs about the malleability of intelligence is key to changing their behavior.

Manipulation checks show that indeed, the growth mindset intervention significantly increased the fraction of students who believe the brain changes when we learn. On the last day of the intervention, 66% of students in the growth mindset group believed this, compared to 25% in the no-plasticity group (Diff. in P(believe can change) is significant, p<0.01). At endline, in both control and the no-plasticity group, 24% of students believed the brain changes, compared to 44% in the growth mindset group (Diff. in P(believe can change) is significant, p<0.01). While the drop from 65 to 44% appears to show some attenuation in the effect, the number of students answering "changes" has remained roughly the same (142 to 141) it's just that the endline survey covered the full sample, while the intervention quiz was taken only by those in attendance. Attendance is 2/3rds on average.

Revisiting the effort analysis within grades six and seven reveals a larger impact from growth mindset (Diff. = 0.07 std. dev. (up from 0.05 std. dev.), std. err. 0.03, p<0.05), and a significant difference between growth mindset and no-plastisicy (Diff. = 0.04, p<0.05).

3.4.2 Gender

Previous studies on growth mindset have shown it can reduce the impacts of stereotype threat [7] (cite aronson) and be more effective for under-performing groups. Girls in Bangladesh are likely subject to pressures similar to stereotype threat as they are seen as fundamentally different both in conservative and popular culture. An anecdote from an enumerator on my team highlights the concern, his teacher when he was in school said that "...a girls brain is half that of a boys." It is therefore prudent to look at key results separately by gender.

Table 7 shows the main results (impact on math quizzes) separately for girls and boys, excluding

[7]Stereotype threat occurs when a member of a marginalized group has their group membership made salient prior to taking an exam or some other performance measure; studies have shown that this can cause affected students to underperform. (cite studies) have shown that growth mindset interventions can reduce this effect.

grade level eight. Looking at grade 8 alone we see no impact for boys or girls. While the difference between boys and girls is not statisitically significant, separating them reveals the striking impact of growth mindset on girls in this sample, 0.28 std. dev. (std. err. 0.101, p<0.01, Table 7). Note, the difference between growth mindset and the no-plasticity group is still significant. The point estimate for boys is still modest at 0.15 std. dev., but this is not significant in the smaller sample.

Revisiting the effort analysis for girls reveals an even larger difference between growth mindset and control (still excluding grade 8) (Diff. = 0.12 std. dev. (up from 0.05 std. dev.), std. err. 0.05, p<0.05), and a still significant difference between growth mindset and no-plastisicy (Diff. = 0.07, p<0.05).

3.4.3 SES

Interacting parents income rank and parents education with treatment (separately), I find growth mindset appears to be more effective for lower SES students, however these interaction terms are not significant.

3.5 Mediating Beliefs

3.5.1 Returns to Effort

As discussed above, a reasonable theory for why growth mindset is effective is that it changes the perceived returns to effort on some level, thus changing optimal effort. I wasn't however able to detect any shifts in beliefs about the returns to effort (tables forthcoming). This could be because these measures were imprecise, or because the intervention actually changes behavior through another channel. Further investigation and discussion forthcoming[8].

3.5.2 Perception of own intelligence

The growth mindset intervention tells students that their potential future intelligence level may be higher than they previously thought. I asked students at baseline and endline to rank their

[8]Using students' math quiz score guesses and data inputs the learning production function measured (effort, study hours, attendance, etc...) I can estimate production functions and calculate perceived MPEs. I can compare estimates to the actual production function and actual MPEs and see how perceived MPEs are impacted by treatments.

own intelligence relative to their peers. I hypothesized that students at endline who had taken the intervention to heart might believe they were now more intelligent as a result of their efforts. Surprisingly I found the opposite, that the growth mindset intervention reduced one's ranking of their own intelligence (tables forthcoming). In comparing intelligence rankings with actual performance ranking I see that the vast majority of students overestimate their intelligence and that growth mindset appears to result in a more accurate assessment of one's ability. This is consistent with one RCT that showed that fostering a fixed mindset (opposite of growth mindset) results in more overconfidence about one's abilities (cite ehrlinger, dweck 2016). If overconfidence results in a perception of less need for preparation, then it is logical that reducing overconfidence would cause effort to increase. This is an interesting channel that I hadn't considered when designing the experiment that is worthy of further investigation.

3.6 Spillovers

Table 8 shows the impact of exposure to treatment (using four measures of exposure) on quiz scores for students in the control group. I do not detect a statistically significant impact, however the point estimates are not trivial in size. Table 9 shows the estimates by gender. For girls we see estimates either close to zero or positive and not significant. This implies either no spillovers, or positive spillovers that would bias our treatment estimates downward, meaning out we may be underestimating the true impact on girls. For boys two of the estimates are negative and significant, implying boys in the control may have been discouraged upon seeing their friends in treatment and performed worse as a result. This would bias our treatment estimates for boys upwards, meaning the true impact of growth mindset on boys is smaller, and close to zero. Further investigation is needed to determine the reliability of the estimates and further investigation may reveal the likelihood of the negative spillover story.

4 Conclusion

While the story for boys is ambiguous at the moment, it is clear that growth mindset had a large impact on girl's performance in math and science. It is also clear by looking in samples where growth mindset worked, that the no-plasticity group did not work, showing that students' specific beliefs about the nature of the learning production function are important determinants of their chosen effort, and a that they are manipulable. This study contributes to a growing body of literature showing the reliable impacts of growth mindset interventions. Further work ought to be done to reveal the optimal target group and the optimal method of delivery. The designers of the growth mindset intervention envision an education system where teachers privy to the lesson of growth mindset reinforce the lessons with each teacher-student interaction. Could lessons from growth mindset be used to develop consistently more effective pedagogy? Future research seems promising.

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Table 1 - Did treatments impact math quiz scores?

Panel A: Controlling for Stratification Variables only

	DID - Y_t	DID - Y_4	DID - Y_6	ANCOVA
Growth Mindset	0.119**	0.157*	0.117	0.111**
	(0.0599)	(0.0859)	(0.0876)	(0.0526)
GM w/o Plasticity	0.0465	0.0546	-0.00110	0.0612
	(0.0603)	(0.0826)	(0.0894	(0.0518)
GM - No-Plast	0.0728	0.102	0.118	0.0497
Pvalue	0.230	0.231	0.199	0.347
N	5058	3451	3419	2412

*Panel B: Including additional controls**

	DID - Y_t	DID - Y_4	DID - Y_6	ANCOVA
Growth Mindset	0.118**	0.156*	0.108	0.113**
	(0.0600)	(0.0858)	(0.0876)	(0.0522)
GM w/o Plasticity	0.0496	0.0618	-0.00452	0.0642
	(0.0607)	(0.0829)	(0.0899)	(0.0517)

Standard Errors, clustered by student (across time) are in parentheses.

Outcome is math quiz Z-score at time t (pre: 1,2,3 / post: 4,5,6).

Z-score standardized by SD and mean of control in each school and grade level.

All regressions control for stratification variables: school, level gender, and number of mentions by other students. DID regressions also include time fixed effectes for all 6 quizzes. ANCOVA regression includes fixed effects for the last three quizzes and a control for the average of the first three.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

*Additional controls: household income rank, hours/week of house work or job, hours/week in tutoring, hours/week studying (aside from tutoring and class time), and a dummy for any random shock that reduced preparedness before a quiz (illness, family tragedy, etc…).

Table 2 - Did treatments lead to increased effort?

	Increased Effort
Growth Mindset	0.0545**
	(0.023)
GM w/o Plasticity	0.0353
	(0.022)
GM - No-Plast	0.0192
Pvalue	0.334
N	1016

Outcome is binary (1 if teacher reported student increased effort).
Marginal effects are presented with standard errors
in parentheses. Regression control on stratification variables.
* p < 0.1, ** p < 0.05, *** p < 0.01

Table 3 - Did treatments impact school exam scores? (grades 6,7 only)

	Math	Science	English	World Studies
Growth Mindset	0.112*	0.151**	0.0181	0.151**
	(0.0674)	(0.0643)	(0.0597)	(0.0725)
GM w/o Plasticity	-0.0676	0.0218	-0.0169	0.0471
	(0.0661)	(0.0638)	(0.0590)	(0.0719)
GM - No-Plast	0.180***	0.129**	0.0350	0.104
Pvalue	0.00746	0.0457	0.558	0.156
N	622	622	624	624

Grade level 8 does not take school exams as they sit for national board exams.

Standard errors are in parentheses.

Outcomes are term 2 (post-intervention) final grades converted to Z-scores, standardized by SD an mean of the control group in each school and grade level. Regressions control for corresponding term 1 grades and stratification variables.

* p < 0.1, ** p < 0.05, *** p < 0.01

Table 4 - (Table 1 main results excluding level 8)

	DID - Y_t	DID - Y_4	DID - Y_6	ANCOVA
Growth Mindset	0.198***	0.203*	0.209*	0.189***
	(0.0758)	(0.110)	(0.108)	(0.0670)
GM w/o Plasticity	0.0328	0.0364	-0.0202	0.0715
	(0.0762)	(0.103)	(0.106)	(0.0674)
GM - No-Plast	0.166**	0.167	0.229**	0.118*
Pvalue	0.0311	0.120	0.0420	0.0816
N	3302	2222	2234	1608

Standard Errors, clustered by student (across time) are in parentheses.

Outcome is math quiz Z-score at time t (pre: 1,2,3 / post: 4,5,6).

Z-score standardized by SD and mean of control in each school and grade level.

All regressions control for stratification variables: school, level gender, and number of mentions by other students. DID regressions also include time fixed effectes for all 6 quizzes. ANCOVA regression includes fixed effects for the last three quizzes and a control for the average of the first three.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 6 - Is grade level 8 at a higher effort starting point?

	Baseline	Endline
Grade 7	1.26	2.18
	(1.324)	(1.545)
Grade 8	5.083***	6.90***
	(1.323)	(1.535)
N	329	329

I regress total study and tutoring hours per week (in baseline and endine)
on grade level fixed effects and stratification variables, within the control group.
Standard errors are in parentheses.
* p < 0.1, ** p < 0.05, *** p < 0.01

Table 7 - (Table 1 main results excluding level 8 and separated by gender)

Girls

	DID - Y_t	DID - Y_4	DID - Y_6	ANCOVA
Growth Mindset	0.283***	0.239	0.293***	0.248***
	(0.101)	(0.150)	(0.139)	(0.0910)
Placebo	-0.00358	-0.0592	-0.0324	0.0224
	(0.107)	(0.147)	(0.134)	(0.0931)
GM - Placebo	0.286***	0.299**	0.325**	0.226**
Pvalue	0.00589	0.0448	0.0210	0.0148

Boys

	DID - Y_t	DID - Y_4	DID - Y_6	ANCOVA
Growth Mindset	0.145	0.184	0.173	0.109
	(0.110)	(0.158)	(0.159)	(0.0976)
Placebo	0.0853	0.130	0.0148	0.100
	(0.103)	(0.141)	(0.154)	(0.0946)
GM - Placebo	0.0601	0.0543	0.158	0.00926
Pvalue	0.586	0.725	0.348	0.924

Table 8 - Did exposure to treated peers impact student learning in the control?

	Has friend in …	Proportion of friends in …	Number of friends in …	Number of friends in …
Growth Mindset	-0.0832	-0.173	-0.0595	-
	(0.0753)	(0.126)	(0.0603)	
Placebo	0.101	0.0571	-	0.0706
	(0.0749)	(0.118)		(0.0540)
N	823	823	823	823

Regressions use main ANCOVA specification from Table 1 but replace treatment variables with the exposure to treatment variable listed at the top of the column. For number of friends, the GM and Placebo regressions were run separately so I could control for the total number of friends listed and avoid perfect collinearity.

* p < 0.1, ** p < 0.05, *** p < 0.01

Table 9 - (Table 8, spillovers separated by gender)

Girls

	Has friend in …	Proportion of friends in …	Number of friends in …	Number of friends in …
Growth Mindset	0.0147	0.143	0.0470	-
	(0.104)	(0.171)	(0.0819)	
Placebo	0.0354	0.149	-	0.0129
	(0.107)	(0.154)		(0.0752)
N	362	362	362	362

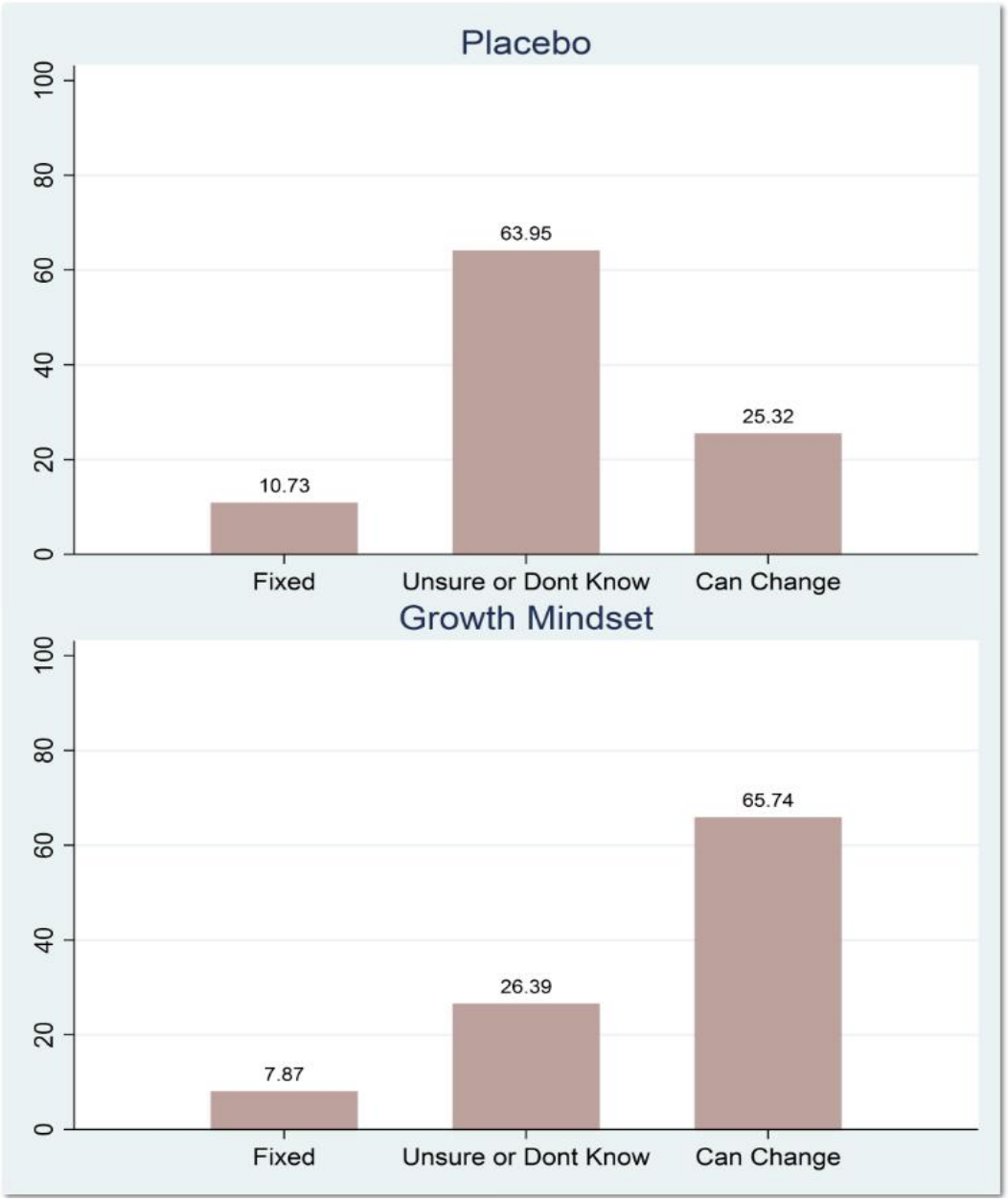
Boys

	Has friend in …	Proportion of friends in …	Number of friends in …	Number of friends in …
Growth Mindset	-0.166	-0.436**	-0.146*	-
	(0.104)	(0.173)	(0.0862)	
Placebo	0.138	-0.0512	-	0.0788
	(0.104)	(0.161)		(0.0739)
N	461	461	461	461

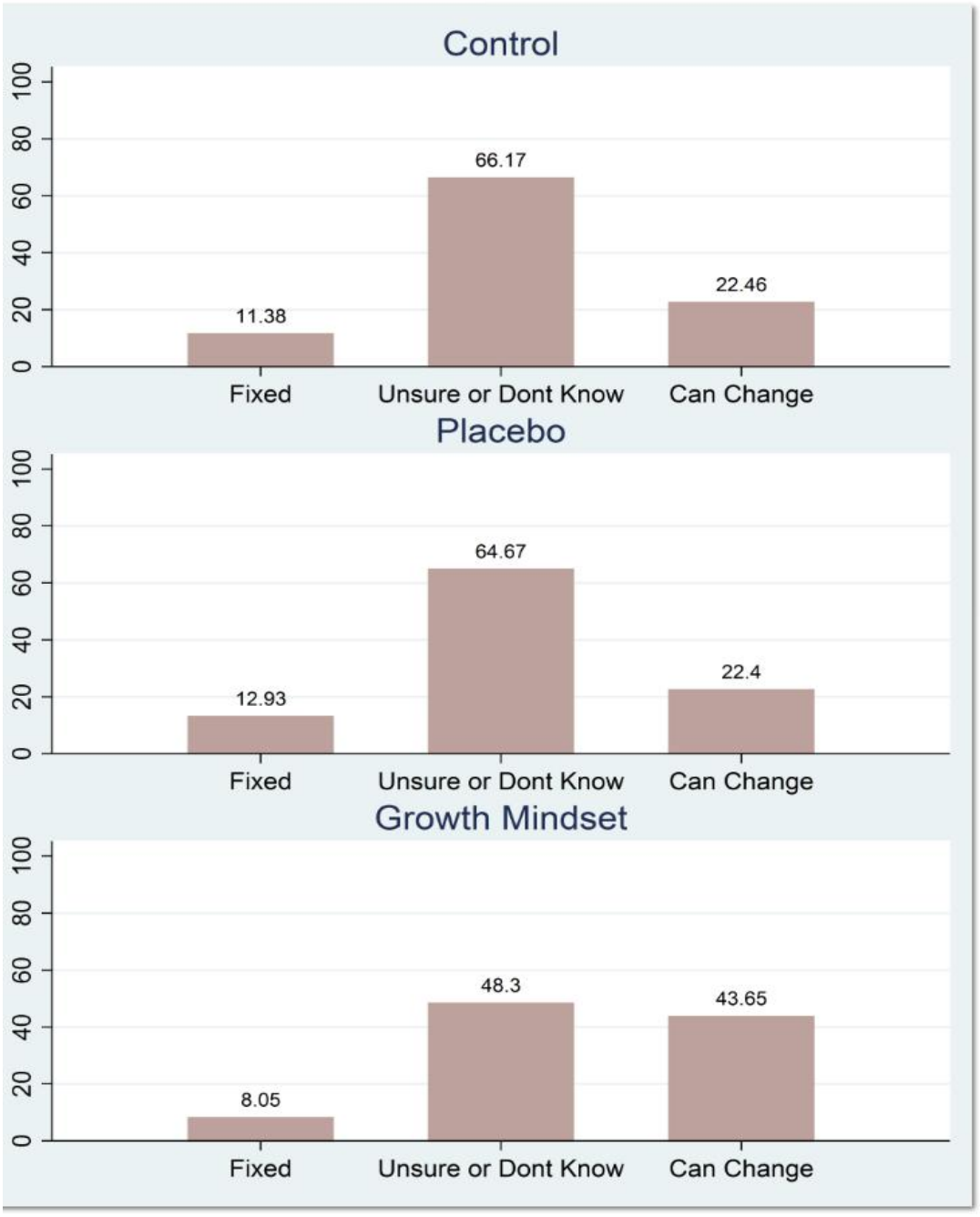
Responses to the key growth mindset question:

"Is the your brain power and ability fixed or something that can change with effort??

Immediately after the Intervention:



At Endline:


Control
0
20
40
60
80
100
66.17
22.46
11.38
Fixed
Unsure or Dont Know
Can Change
Placebo
64.67
22.4
12.93
Fixed
Unsure or Dont Know
Can Change
Growth Mindset
48.3
43.65
8.05
Fixed
Unsure or Dont Know
Can Change

Growth Mindset group at Intervention vs Endline (frequency):