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Evaluation of a Deliberate Practice and Growth Mindset Intervention on Mathematics in 7th-grade Students

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Abstract

Deliberate practice and having a growth mindset have been hypothesized to increase school performance. But previous studies are few, have been limited to very short interventions, and on average resulted in small effect sizes on school performance. This study compared the attitudes, performance, and behavior of 130 7th-grade students taking part in eight 30-minute sessions of deliberate practice and growth mindset over 14 weeks to a same-age active control group. The intervention had no significant effects on attitudes related to deliberate practice, growth mindset, or mathematical performance. However, students who participated in the intervention engaged in more deliberate practice behavior in a mathematics test. We pre-registered our hypothesis and research design at aspredicted.org/13742.

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Deliberate practice; growth mindset; effortful behavior; grit; mathematics; intervention

Introduction

One way of affecting the developmental trajectory in school performance is motivating the students to practice more (Butler & Roediger, 2011; Karpicke & Blunt, 2011). Two theoretical frameworks hypothesized to be relevant for adopting a more persistent learning behavior are a *growth mindset* where you see your capacity as malleable (Dweck & Yeager, 2019), and *deliberate practice* where you work towards a goal that is currently outside your reliable performance (Ericsson, 2006). In this study, we investigate how a school-based intervention teaching deliberate practice and growth mindset, affects attitudes about the same, mathematical performance, and deliberate practice behavior.

Deliberate Practice

Correlational studies suggest that Deliberate practice is associated with expertise in several areas (e.g., Ericsson, 2006, 2008) but just a few studies have investigated if such behavior can be increased by training in a primary school setting. Central to the present investigation is the study by Eskreis-Winkler et al. (2016). Here it was shown that single occasion interventions aimed at improving deliberate practice with a length between 25 and 50 min affected school performance, deliberate

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practice behavior, and expectancy value-believes in 5th and 6th graders (Eskreis-Winkler et al., 2016). In these studies, important parts of the deliberate practice intervention were to (a) set a well-defined goal outside your current knowledge, (b) get feedback, (c) concentrate 100%, and (d) repeat until mastery.

Growth Mindset

Another theoretical framework that is often used when trying to affect academic performance is Growth mindset. Having a growth mindset, as opposed to a fixed one, means that you are more open to that talent and ability can develop over time (Dweck & Yeager, 2019). A recent, large-scale one-hour growth mindset intervention demonstrated how school grades were affected (Yeager et al., 2019), while a previous meta-analysis and a study investigating key premises of mindset theory raised doubt about the effectiveness of growth mindset interventions (Burgoyne et al., 2020; Sisk et al., 2018). However, a lack of studies to base conclusions on has been concluded in yet another meta-analysis focusing specifically on primary school (Savvides & Bond, 2021).

Combining Deliberate Practice and Growth Mindset

A third concept that is increasingly discussed in relation to deliberate practice and growth mindset is Grit (Duckworth et al., 2007). Grit is a behavior associated with the Big Five psychological trait conscientiousness. Grit is related to deliberate practice as this involves persisting with practice (Duckworth et al., 2011). Recent popularization of concepts such as growth mindset, deliberate practice, and grit, has led to an increasing number of educational practitioners being interested in affecting these traits/abilities as means of affecting academic performance (Credé, 2018). A recent large-scale study including 9–16-year-olds showed that study time had a positive effect on mathematical performance (Spitzer, 2021). However, very few controlled trials evaluating growth mindset, deliberate practice, and grit interventions exist. At this point, it is therefore important to investigate the effectiveness of such methods in a primary school setting so that informed decisions can be made. In this study, we used the same content as in the intervention used by Eskreis-Winkler et al., 2016 which targets both deliberate practice and growth mindset but extended it based on recent suggestions (Credé, 2018). Instead of 1 occasion we included 8 and extended the learning period to 14 weeks. A rationale for increasing the length is that previous efforts are based on brief interventions (Savvides & Bond, 2021) and limited to small effect sizes (Eskreis-Winkler et al., 2016; Yeager et al., 2012). Increasing the dose could therefore lead to larger effects. The content of the present intervention also meets recent suggestions in that it targets study skills and habits (Credé et al., 2017) which are some of the strongest predictors of college GPA (Credé & Kuncel, 2008) and in the same time seem to be malleable (Hattie et al., 1996). Also, another important aspect included in this intervention is advising fellow students. Giving advice is believed to be working through psychological processes such as believing the advice you advocate, deeper reflecting on the advice you give, and increasing confidence (Eskreis-Winkler et al., 2019). Furthermore, great effort was spent on applying a collaborative approach where schools and researchers work together for better implementation as this was recently pointed out as a challenge to succeed with growth mindset intervention (Savvides & Bond, 2021). In the present study, we had a special interest in investigating how attitudes and performance in mathematics were affected as it, to a large extent, is perceived by students as a fixed trait (Sun, 2018) and is surrounded by several myths (Boaler, 2016). For example, previous studies have also shown that gender stereotypes regarding mathematics begin at an early age (Cvencek et al., 2011). Targeting attitudes relating to growth mindset and deliberate practice could therefore hold great potential for affecting attitudes related to mathematics that in turn could increase study time. To our knowledge, this is one of the most extensive interventions both within the deliberate practice and growth mindset-based field and will contribute

knowledge regarding if a more extensive intervention leads to larger effects on attitudes and performance in primary school.

Aims

In this study, attitudes, performance, and behavior of 130 7th grade students taking part in eight 30-minute sessions teaching deliberate practice and promoting a growth mindset over 14 weeks were compared to a same-age active control group. Important features of this study were that an active control group was included, long-term, as opposed to one-time advice sessions, was used, advising other students was included, and that we used both ratings of beliefs and behavior as well as objective measures of mathematics and number of times retaking the test (deliberate practice behavior). The following research questions were investigated:

- Does an 8-session intervention, teaching deliberate practice and growth mindset, lead to a change in belief about deliberate practice, growth mindset, grit, mathematical performance, and retaking the test (deliberate practice behavior)?
- Do the effects of the intervention differ based on gender or previous grades at the National Test in mathematics?

Methods

Design and Participants

The overall design of this study was an intervention study with one intervention and one active control group who did baseline testing at the start of the intervention and post-testing within a week of completing all modules. An ethical application was submitted to the regional ethics committee in Stockholm who approved the study (2018/1406-31/5). Legal guardians of the students who wanted to participate in the study signed informed consent. Participants were n = 237 (54% girls) students attending grade 7 in Sweden (12–13 y.o.); 138 (55% girls) students were assigned to the intervention group, while 99 (52% girls) students participated in the control group.

Five primary schools, each including all students in grade seven, were included in the sample. Each school included both intervention and control groups. A number of 18 teachers from all five schools participated in the study. The teachers worked as mentors for unsystematically composed groups of 10–12 students. The teachers performed the randomization on a group level. The number of students at each school can be found in Table 1. Also shown in the table, are some characteristics of the schools. Note that no exact numbers are presented, since that would make the schools identifiable, as the school statistics are public and available online.[1]

As can be seen in Table 1, School A is a small school with a low proportion of immigrant students and where the majority of parents have a higher educational degree. Only about half of the

Table 1 . The number of students from each school in the sample, as well as school characteristics.

	School A	School B	School C	School D	School E
N:o of students in the sample	42	24	34	69	68
N:o of students in total	<300	<300	>500	>700	>400
The proportion of immigrant students (%)	<10	<60	<40	<10	<50
The proportion of parents with a higher education degree (%)	>60	<50	>50	>75	>50
The proportion of students passing all subjects (%)	>90	>70	<70	>90	<70

[1]School data has been collected from https://siris.skolverket.se/siris (2020-11-10).

students are awarded passing grades in all subjects. Schools C and D, in contrast, are relatively large schools. School D, differ from School C in having almost no immigrant students, the majority of parents having a higher educational degree, and virtually all students leave school with a passing grade in all subjects. School B and E are intermediate concerning the number of students but have instead a high proportion of immigrant students and a lower proportion of students how passed all subjects.

The intervention. In this study, we used the same intervention as Eskreis-Winkler et al., 2016, but translated it, extended it, and made it suitable for the 7th graders. This was done by a team of developmental psychologists and a research and development expert from the municipality in which the study was conducted. A pilot study was conducted to test the feasibility and get feedback from participants and teachers on where clarification was needed and adjustment was made accordingly. To increase the load of the intervention, instead of using two modules, we created four modules adhering to the same themes used (Eskreis-Winkler et al., 2016). Modules 1 and 3 were about: 1) to set a long-term goal, 2) how to focus, and 3) to find feedback. Modules 2 and 4 were about: 1) how deep practice involves failure, 2) is frustrating, and 3) how students often think talent is all that matters. As in the original modules, didactic slides were interspersed with activity prompts, quotes from other students, illustrative videos, and letter-writing exercises intended for other students. A new addition was that each module concluded with three concrete suggestions on how to proceed on their own. The modules were implemented in Google Drive, which was used by all participating schools. Through a link, students could easily enter each module.[2]

The four online modules were administrated to the participants in the intervention group on eight occasions. The modules were first completed over 5 weeks and then completed again after a 2-week break. In the second round, a one-week break was used after each module. Each session was 25–35 min, which means that the total amount of time for the intervention was approximately four hours. At the same time, the control group worked with news quizzes that took 20–30 min. The teachers had to prepare for each quiz to be able to answer the students' questions. New quizzes were created for each week and were purchased via agreement. The sessions were scattered across 14 weeks during a semester and they were organized on "mentoring time", when students, both controls and students in the experimental group, meet with their mentoring teacher. To increase fidelity, students in the intervention group worked through the slides together with the teacher, to ensure that they understood and thought through each exercise in the modules. The teachers introduced each slide and opened up for questions. The instruction they received was to make sure that students understand the questions and/or the instructions on each slide. To ensure that the teachers followed the instructions, they were introduced on two occasions to the content of the modules and the type of support they were to give the students. The time for the teachers' introduction was a total of 3 h. The lessons learned from the pilot study helped create an adequate introduction to the teachers. Teachers were regularly reminded during the weeks that each module was to be completed. Students' attendance during the implementation of the modules ranged between 86 and 93 percent. Participating in the intervention was mandatory but not in the pre and post-testing that were part of the research study.

Measures

Students in both groups were tested before and after taking part in the intervention. Testing and self-assessment were done in the schools. Teachers administrated the testing in the same manner as a test usually is performed.

Self-assessment of Growth mindset, Deliberate practice, and Grit. For all scales, a 1–5 point Likert scale was used with alternatives "Not true at all" to "Completely true". When needed,

[2]To view the whole intervention, please contact the corresponding author.

items were reversed so that high values indicate a belief or behavior that corresponded to the desired effects of the intervention. Questions of Growth mindset were measured with three items measuring belief about intelligence as fixed or malleable (Dweck, Chiu & Hong, 1995). These items had a Cronbach's alpha = .82. High values indicated a belief of one's own intelligence as malleable. Inspired by these questions, we created similar questions but for beliefs about mathematics rather than intelligence. Also, the questions reflect self-confidence about mathematics. The six items had a Cronbach's alpha = .83. Items were reversed so that high values indicated mathematics ability as something that can change. The questions can be obtained from the authors on request.

Questions about the themes in the deliberate practice intervention were included. Modules 1 and 3 were about: 1) to set a long-term goal, 2) how to focus, and 3) to find feedback. The twelve items (see appendix 1) had Cronbach's alpha = .76. Modules 2 and 4 were about: 1) how deep practice involves failure, 2) is frustrating, and 3) that students often think talent is all that matters. The seven items (see appendix 1) had a Cronbach's alpha = .72. Grit was measured using the short grit scale.

The Short Grit scale measures perseverance and passion for long-term goals on trait-level and has been shown to have superior psychometric properties than the longer version (Duckworth & Quinn, 2009). In the present study, Cronbach's alpha was = .70 for the Grit scale.

The mathematical performance. Data on students' mathematical performance was collected in the form of knowledge tests. The items in the test were constructed to cover assessment criteria in the Swedish curriculum for the 7th grade in algebra and number sense. Cronbach's alpha for the 12 items included in the test was .70. The items were administrated digitally to monitor students' behavior during the test. After each item, students entering an erroneous answer received feedback and were offered the possibility to resolve the problem. At the end of the test, the students could see the number of correct answers, and they were given the possibility to take the whole test again. Students' initial answer, answers after receiving feedback, and the number of times they took the test is reported. The students' results were recorded as a proportion of correct answers.

Statistical Analysis

Statistical outliers in all outcome measures were screened using boxplots in SPSS version 26. The few extreme outliers (1st/3rd Quartile ± 1,5) that were identified did not significantly affect the results and were therefore retained in the subsequent analyses. The data were tested for normal distribution using Shapiro–Wilk. As data in some cases was not normally distributed we used both parametric and non-parametric tests to investigate the difference between the groups. As the tests showed the same results, we report only parametric tests. Chi^2 test was used to investigate whether there were any differences between the groups concerning the background variables, gender, previous grades at the National Test in grade 6 in mathematics[3], and performance in the pre-test. Since Chi^2 showed no significant difference between the groups concerning gender and previous grades in mathematics, these variables were not used as a covariate in the main analyses.

To investigate the effect of the intervention, the two groups were compared on the post-test using ANCOVAs. The post-test results were used as dependent variables, the control/intervention group as an independent variable, and the pre-test scores as a covariate. Effect sizes were calculated using partial eta-squared (η^2) following recommendations, .01 was considered a small effect, .06 a medium-sized effect, and .14 a large effect (Cohen, 1988). Furthermore, interaction effects (group x gender/grades) in the ANCOVAs were used to investigate if the intervention had different effects on

[3]National tests are compulsory tests that exist to give students the same conditions to show what they can do. They are meant to be a support for the teacher to give students fair assessments to base grades on. (https://www.skolverket.se/undervisning/grundskolan/nationella-prov-i-grundskolan/provdatum-i-grundskolan#h-Nationellaproviarskurs6)

the main outcomes depending on gender, students' previous grades at the National Test in grade 6 in mathematics.

Next, correlational analyses (Pearson's r) between changes in students' views measured by the questionnaire and changes in students' mathematical performance were investigated in the intervention group. In all the analyses, the level of significance was set at $p < .05$.

Results

Self-assessment of Growth Mindset, Deliberate Practice, and Grit

The pre-test results showed no significant difference between the intervention and control group concerning the variables measured in the questionnaire i.e., grit, growth mindset, growth mindset for mathematics, and deliberate practice ($p > .05$). The mean values in the pre-test were between 3.31 and 4.21. The post-test results show some changes in students' views, but still no significant difference between the groups ($p > .05$). The mean values were between 3.16 and 3.89.

The ANCOVAs showed that there was no significant difference between the control and intervention groups on the post-test for grit, growth mindset, growth mindset for mathematics, or the values taught during the session of deliberate practice. When gender and students' grades were added to the model, no significant interaction effects were found ($ps > .14$) for the main outcomes, indicating that these variables did not affect how the intervention affected the participants.

The Mathematical Performance/ Deliberate Practice Behavior

On the pre-test, there was no significant difference between the groups concerning their results on the mathematics test ($F(1,236) = 3.033$; $p = .083$) or the number of times they choose to retake the test ($F(1,236) = 1.426$; $p = .234$) before the intervention. As can be seen in Table 2, there was no significant difference at the post-test ANCOVA between the control and intervention groups for the scores on the mathematics test ($F(1.198) = .50$; $p = .48$). When gender, students grades at the National Test in Mathematics, were added to the model, no significant interaction effects on mathematical performance were found ($ps > .37$)

There was a significant difference between the control and intervention groups concerning the number of times students choose to retake the mathematics test ($F(1.198) = 7.22$; $p = .008$; $\eta^2 = .035$). Students in the intervention group used the possibility to retake the test to a greater extent (M = 1.21), as compared to the students in the control group (M = 1.05).

Table 2 . Results from the ANCOVAs comparing the intervention group with the control group after the intervention.

	Intervention group (n = 118)		Control group (n = 83)		ANCOVA
	Pre-test M (SD)	Post-test M (SD)	Pre-test M (SD)	Post-test M (SD)	F (η^2)
Mathematical performance					
Mathematics	.63 (.21)	.69 (.23)	.58 (.24)	.61 (.27)	.50 (.01)
Mathematics with feedback	.73 (.19)	.78 (.19)	.66 (.22)	.72 (.23)	.28 (.01)
Number of times retaking the mathematical test	1.12 (.43)	1.21 (.55)	1.20 (.55)	1.05 (.22)	7.22 (.03)*
Students' views					
Grit scale	3.31 (.56)	3.16 (.54)	3.33 (.56)	3.27 (.53)	2.82 (.01)
Growth mind set scale	3.56 (1.03)	3.50 (1.08)	3.36 (.94)	3.24 (.92)	2.44 (.01)
Growth mind set in math scale	4.20 (.76)	3.65(.62)	4.05 (.76)	3.68 (.48)	2.89 (.01)
Values taught in Module 13	3.73 (.50)	3.56 (.57)	3.62 (.58)	3.63 (.56)	5.22 (.02)*
Values taught in Module 24	3.92 (.66)	3.89 (.65)	3.86 (.57)	3.77 (.64)	1.32 (.06)

*$p < .05$

Table 3 . Correlations (Pearson's) between the changes in variables in the intervention group; post-test (T1) – pre-test (T0)

	Math test[a] T1 – T0	Redo math test T1 – T0	GM math T1 – T0	GM T1 – T0	Grit T1 – T0	Module 13 T1 – T0	Module 24 T1 – T0
Math test T1 –T0	1	.062	.057	.030	.058	.137	.142
Redo math test T1 –T0		1	-.038	.041	-.018	.047	.123
GM math T1 –T0			1	.032	.235**	.259**	.241**
GM T1 –T0				1	.055	.033	.116
Grit T1 –T0					1	.388**	.357**
Module 13 T1 –T0						1	.443**
Module 24 T1 –T0							1

*$p < .05$,
**$p < .01$
[a]The mathematics correlation is based on variables were feedback had been offered

Students' Views and Mathematical Performance

As can be seen in Table 3, there was no significant correlation between changes in mathematical performance and changes in students' views measured by the scales in the questionnaire. Also, there was no significant correlation between changes in the number of times the students redid the math test and changes in students' views measured by the scales in the questionnaire.

Discussion

The results of this study show that eight 25–35-minute sessions teaching deliberate practice and growth mindset over 14 weeks did not affect beliefs about deliberate practice, growth mindset, or mathematical performance in 7th-grade students as compared to an active control group. However, students that participated in the intervention engaged in more deliberate practice behavior. Below we discuss the results in relation to previous studies and suggest future directions.

An increasing number of educational practitioners are interested in training traits/abilities related to deliberate practice or growth mindset as means of affecting academic performance. At the same time, a recent review pointed out that there are surprisingly few peer-reviewed studies that evaluate interventions that are based on the principles of a growth mindset (Savvides & Bond, 2021). It could therefore be seen as a strength that this intervention was evaluated in a real-world setting, had an active control group, and included both self-report and objective performance measures.

Fidelity to the intervention protocol and adherence was high. This could have been related to that a pilot study was performed before the intervention and that instructions to teachers were given before and during the intervention. Also, this intervention was developed as a collaboration between researchers in developmental psychology and staff from research and development in the school sector. The need for a collaborative strategy between schools and universities has been mentioned as an important challenge to get growth mindset interventions to work effectively (Savvides & Bond, 2021) and was a strength in this study. Although this intervention was longer than what has been observed for interventions based on similar theoretical principles, this study showed that conducting this type of intervention is feasible. Thus, the overall limited effects of this deliberate practice and growth mindset intervention are likely not due to students not paying attention or failing to understand the content.

Regarding the self-reports of attitudes, we found contrary to Duckworth et al. (2007) and Yeager & Dweck (2012) no difference between the groups and the students who took part in the intervention did not become more open to that performance could be affected by deliberate practice or their capacity as more malleable. These results are however in line with a recent meta-analysis (Sisk et al., 2018) and with the present study, we also show that extending the length of the intervention did not make a difference. One possible explanation may be that growth mindset development is related to the perception of academic struggle (Limeri et al., 2020). The perception of struggle could be due to

increasing demands during the semester or in this particular study, a lack of improvement in the mathematics test. When they were asked to take the mathematics test once again they were met by the fact that the result did not change much. This might thus have been a stronger determinant of their attitudes than reading about the importance of deliberate practice and having a growth mindset in the intervention material. We speculate that it might be a good idea to pay more attention to the accompanying experiences while conducting growth mindset intervention in the future. Perhaps by setting individual goals that are possible to reach during working with the intervention.

Furthermore, in line with previous studies (Eskreis-Winkler et al., 2016) we found that there was no significant difference in students' performance in mathematics between the intervention and control groups. There was however a non-significant increase of Cohens' *d* 0,1 for controls and 0,3 for the intervention group which is similar to what has been observed in a recent study with power to detect effects of such magnitude (Yeager et al., 2012). The small effects observed on mathematical performance are perhaps not surprising given the short period of the study and the little mathematics changes usually observed in 7th grade (Bloom et al., 2008). It is possible that students need to put their new knowledge and behavior into practice for a longer period before differences in performance can be detected. Contrary to previous studies (Eskreis-Winkler et al., 2016) we found no advantage for the low-achieving students in the intervention group in terms of the previous achievement in mathematics.

Nevertheless, results show positive changes in students' deliberate practice behavior for the intervention group reflected by an increased number of times taking the mathematics test (pre-intervention mean = 1.12, post-intervention mean = 1.21). The discrepancy between the effect on beliefs and behavior may be due to the resilience nature of beliefs (Leder et al., 2002). According to Schonefeld (1992), it takes time to change beliefs that are context-dependent especially when it comes to affective beliefs. The deliberate practice beliefs which encompass, frustration tolerance and the importance of effort vs. talent belong to the affective part of beliefs and are therefore sensitive to contextual factors. However, the change in deliberate practice behavior is not easy to interpret because it does not appear to be driven by changes in students' attitudes which was the intention of the intervention.

Limitations

The sample size in this study was smaller than in previous studies where effects for similar types of interventions have been observed (Eskreis-Winkler et al., 2016; Yeager et al., 2012). This might have reduced our ability to detect differences in intervention effects, especially for the presence of interaction effects regarding baseline characteristics. The study is limited by that we could not randomize on student level and that teachers performed the randomization. However, intervention and control groups were included within the same schools to counteract pre-existing demographic differences and this was confirmed by that groups did not differ at baseline assessment. The initial belief in the importance of deliberate practice and a growth mindset was rather high (around 4 on a 1–5 scale) meant that they pretty much agreed with the principles of the intervention already from the start. This might have limited our ability to affect the attitudes of the students. Regarding performance, it is possible that the students were less motivated to engage fully in the mathematics test as they knew that the result would not affect their grades. Effects related to deliberate practice behavior need to be replicated as the effect was small and because the participants in the control group decreased rather than increased which could partially explain the difference post-intervention between the groups. This study would have benefitted from studying effects in other academic disciples as well to detect a more global change. Yet another limitation could have been that we did not have enough variance in socioeconomic status to detect possible interaction effects.

Conclusion and Future Directions

Beliefs related to deliberate practice and growths mindset as well as mathematics performance were not affected by 8-session deliberate practice and growth mindset intervention for7th-gradee

students. Students' behavior, on the other hand, possibly indicated making more efforts than before the intervention. Previous grades in mathematics or gender had on the other hand no effect on the results. Future deliberate practice and growth mindset interventions should investigate if a clearer connection between the module exercises and a particular subject, like mathematics, is more effective than a more decontextualized approach. Also, it could be important to investigate if paying more attention to the timing so that the experience of struggle/achievement of the students matches what is being taught in the intervention. Finally, a long-term follow-up will be important to include when evaluating the effects of the intervention.

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Data Availability Statement

Anonymized data will be made available by the corresponding author to check the accurateness of the results in this article.

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