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## Longitudinal Data of High-school Students' Grades during the COVID-19 Pandemic in Relation to Their Skills

Liena Hačatřjana\*   
University of Latvia, LATVIA

Rita Graustiņa  
University of Latvia, LATVIA

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**Abstract:** The longitudinal changes of the average grades in four study semesters before and during the COVID-19 pandemic and distance learning are presented in the current study. 11th grade students' ( $n=586$ ; age  $M=17.38$ ,  $SD=0.53$ ) average grades were assessed, as well as their verbal and non-verbal reasoning abilities, and self-evaluations of problem-solving and self-management skills. The main findings of the study are: 1) There is a general pattern for the grades to increase during the four semesters from the autumn 2019 to the spring 2021; 2) The general tendency of changes in the grades is similar to various students' groups based on their level of skills; 3) Higher level of students' skills and cognitive abilities determined that students' grades were higher and were more likely to increase during the "second wave of the pandemic", compared to the middle and low-level skill groups. Results of the current study show a tendency for the average grades to increase during the pandemic and distance learning, however, there are group differences in the findings, relating the grade level to the individual level of students' skills and abilities.

**Keywords:** Average grades, cognitive abilities, distance learning, COVID-19, longitudinal, problem-solving skills.

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### Introduction

Distance learning was implemented as a response to the spread of the COVID-19 pandemic in many countries around the world (Barron Rodriguez et al., 2021; Lindblad et al., 2021; Organisation for Economic Co-operation and Development [OECD], 2020). Learning remotely due to the pandemic can be defined as a new, unprecedented situation with new demands on students that faced new daily challenges. Students had to swiftly grasp both how to use new technologies for learning remotely and how to study individually, indicating a demand to use their cognitive abilities, problem-solving skills, and self-regulated learning skills. Researchers and specialists around the world immediately started focusing on research, understanding that the pandemic and distance learning might have a huge impact on education systems and students. On one hand, risks of psychological problems, learning losses and even potential dropping out of school were reported (e.g., Azevedo et al., 2020; Kaffenberger, 2021; Rogers et al., 2021), especially for students that were already in risk groups. On the other hand, relatively fast changes in education and increase in the use of technologies were reported that would have possibly taken much more time if not for the pandemic (e.g., Bishop, 2021; Ministry of Education and Science of Latvia, 2020; Rubene et al., 2021; van der Velde et al., 2021). There are several reports with a focus on how students dealt with distance learning and what could the impact be to their learning outcomes (e.g., Adler et al., 2021; Birkelund & Karlson, 2021; Hacatřjana, 2021a). However, there is a lack of longitudinal monitoring data on students' grades and skills during the pandemic. Analysis of such data is important to accurately conclude how students' learning and academic achievement were really affected by the pandemic, thus the policymakers can propose necessary means to help students after the pandemic. This study aimed to analyze longitudinal data of students' average grades in four study semesters (2019-2021) and to analyze what abilities and skills were related to maintaining their individual grade levels during this time.

### *Changes for Schools and Changes for Students Due to the COVID-19 Pandemic*

The pandemic brought rapid changes in the lives of schools and students, both at the level of the school as an organization and at the level of the student as an individual. OECD had pointed out the importance of all these levels to

\* Corresponding author:

Liena Hačatřjana, Faculty of Education, Psychology and Art, University of Latvia, Latvia. ✉ [liena.hacatřjana@lu.lv](mailto:liena.hacatřjana@lu.lv)



mitigate the consequences of the pandemic (OECD, 2020). In the following section, a brief overview is given of the changes that schools as organizations and students as individuals experienced during the pandemic.

As a response to the pandemic, most governments took action to limit the spread of the COVID-19 virus. There were different approaches to continuing the education process, and distance learning was applied in many countries (Barron Rodriguez et al., 2021; Bormann et al., 2021; Lindblad et al., 2021; Reimers & Schleicher, 2020). Schools and teachers had to find ways how to provide education to students in these different circumstances (Bishop, 2021; Morgan, 2022). The type of distance learning was often adjusted to the available means of technical provisions, such as access to the internet and computers. In most countries, multimodal approaches were used (Barron Rodriguez et al., 2021). For example, in Latvia, where the data for the current research was gathered, mixed forms of both synchronous and asynchronous distance learning were implemented (Ministry of Education and Science of Latvia, 2020). Students had either online synchronous lectures with a teacher, or they were asked to do tasks individually at home (for example, to read, write and fill out given tasks). About 50% of students reported that they lacked support and explanations from teachers in the first lockdown period (Ministry of Education and Science of Latvia, 2020).

There were also different approaches applied around the world regarding the length of learning distantly (Barron Rodriguez et al., 2021; OECD, 2021). In Latvia, the first distance learning period lasted for more than two months in spring 2020, and then, the next distance learning period started in October 2020 for the high school students and lasted until the end of the school year in May 2021. Latvia is a country with relatively many days that were spent learning distantly (OECD, 2021). There is a reason to believe that the amount of time spent away from traditional face-to-face schooling is related to students' results in academic performance and possible learning losses (Birkelund & Karlson, 2021). It is reported that the availability of online learning tools and the general digitization in the country, among other socio-economic factors, are important factors that might have affected students' success during the school closures (Bormann et al., 2021; Mitescu-Manea et al., 2021; van der Velde et al., 2021). Teachers have reported difficulties in implementing the learning process in low socio-economic status (SES) groups with limited technological availability, and a lack of interest from parents for some groups of students (Frohn, 2021; Haser et al., 2022).

Students experienced challenges also on the individual level during the time of distance learning (e.g., Tannert & Gröschner, 2021), while being restricted from socializing, fearing of their health and still having their academic duties (Scott et al., 2021; Singh et al., 2020). Students have reported both problems with mental health (for example, lack of motivation, feeling depressed or anxious) and problems with their physical health (for example, pain from sitting at the computer, pain in the eyes, and others) (Belousova et al., 2022; Hacatrjana, 2021a). Longitudinal data that compared students' self-assessments before and during the pandemic showed a slight increase in symptoms of depression and anxiety (Rogers et al., 2021). Students reported problems with motivation to keep on with learning distantly (Hacatrjana, 2021a). Motivation to study during the pandemic period was found to be related to the need for communication and the need to succeed, as it is shown in a research with undergraduate level students (Drozdikova-Zaripova et al., 2021).

Despite the challenges and problems that schools, teachers and students faced, the education process was ongoing during this time, meaning that reaching the learning goals and accumulating new knowledge was expected from students, and the academic achievement was assessed also during this time in various forms. We can assume that students were forced to self-manage their time and learning, to deal with many problems on their own and that their academic performance might have been affected by these skills.

#### *Academic Achievement During the Pandemic*

First, it is important to understand what types of assessments were implemented for assessing academic performance during the pandemic and whether they were different from the types of assessments made before the pandemic. Second, it is necessary to analyze available data on how students' academic performance has changed during the pandemic, compared to the time before the pandemic and distance learning.

During the COVID-19 and the distance learning various types of learning methods, as well as assessment of students, were implemented in different countries (Kuhfeld et al., 2020; Reimers & Schleicher, 2020; Thorn & Vincent-Lancrin, 2021). OECD (2021) reports that 56% of the countries did not implement any standardized assessments after school closures in 2020, and even more, 63%, did not in 2021. It leads to a lack of standardized data, thus making it difficult to be compared to previous years. During such an unprecedented situation it was justified to change the way students were assessed and to give up the usual means for assessment. For example, in Ireland summed scores were calculated and posted by teachers (Doyle et al., 2021). In Estonia and other countries, the usual exams were canceled and replaced with other forms of evaluations (Barron Rodriguez et al., 2021). In Latvia, the usual exams at the end of primary school were defined as "diagnostic tests" (Regulations on the duration of state examinations in the school year 2020/2021, 2021). The general grading system of students was not changed in Latvia and the mean grades were calculated for each study subject twice a year, in the same manner as it was before the pandemic and distance learning. Studies show that calculating mean grades were overall a valid tool for assessment as it can predict further achievements as well as SAT scores (Kurlaender & Cohen, 2019).

There currently seems to be a lack of longitudinal data comparing students' academic achievement and skills before and during the pandemic. Mostly, such data may have been available as a part of research programs that had involved students already before the pandemic. In general, the pandemic period has illuminated the importance of gathering monitoring data from schools and having longitudinal data to make accurate conclusions about changes in educational outcomes (e.g., Barron Rodriguez et al., 2021). Data from nonlongitudinal research are also discussed further, which reflect the cohort differences, nevertheless, they illustrate tendencies in changes in students' academic achievement.

Currently available data show somewhat mixed results on the dynamic of students' academic achievement (e.g., Donnelly & Patrinos, 2021). For example, large-scale data show a decrease in math and reading at the beginning of the school year in autumn 2021, compared to typical years (Kuhfeld et al., 2020; Lewis & Kuhfeld, 2021). Reading results were affected more for younger students (3rd grade) but the decrease in math was similar in several grades (3rd to 8th grade). Comparison of cohort data from national assessments in math and reading from the UK indicates that results in both tests were lower during the pandemic when comparing the standardized score in autumn 2020 to the standardization sample (Rose et al., 2021). In another sample results in Mathematics were lower for the 9th grade students during the pandemic, compared to the previous cohort (Moliner & Alegre, 2022).

Data analysis based on students' academic achievement in Denmark indicates that there is no reason to claim a major learning loss occurred for children, especially in younger groups that spent less time in distance learning (Birkelund & Karlson, 2021). It was estimated that there was a drop in test scores in 2020, but the scores increased again in 2021. It is argued that the amount of time that was spent away from traditional face-to-face schooling in classrooms has to be taken into account when analyzing the results of changes in academic achievement, as it might be an influencing factor. The number of days spent in distance learning varies a lot among different countries, and in some countries, it is reported that students have spent more than a year away from traditional school settings, indicating that results might be very different from those countries that had a smaller number of days of distance learning. A negative correlation was found between the number of days schools were fully closed in a country and performance in reading in PISA 2018 testing (OECD, 2021). Analysis of other data sets indicates a slight decrease in students' academic performance, and it shows that students from disadvantaged homes were affected more (Engzell et al., 2021).

A large amount of data is available in countries that have an existing experience with using online learning tools and gathering data of their use. For example, it was found in data from the Netherlands that students had increasingly used an online learning tool for language learning when the pandemic started, and the students had been more accurate and less hasty when doing the tasks (van der Velde et al., 2021). It was also found that students in the higher education track were quicker to go through the content of this online learning program, and in general, no delays in mastering the subject were found, thus not indicating any learning losses. In Switzerland, an analysis of a large data set from an online assessment system showed that learning gains during the school closure period were affected more for students in younger classes and less for secondary school students that might be due to various factors, including the development of students' self-regulation capacities (Tomasik et al., 2021).

We can see that the results of the data published so far about students' academic success during the pandemic show mixed results on whether the performance of students dropped or stayed relatively stable, and there seem to be a wide variety of individual-level factors and wider socioeconomic factors linked to these results. The learning loss might not be as extreme as it was predicted for all students, however, there is a lack of large-scale data and longitudinal data from different countries.

#### *Relation Between Academic Achievement and Other Variables*

Academic achievement is widely studied and its relations to other concepts are well determined in research, some of the important ones being: cognitive abilities (or intelligence in general), various skills and motivation of a student, as well as sociodemographic factors, such as parental education (e.g., Frey, 2019; Greiff et al., 2013; Idris et al., 2020; Kryshko et al., 2020). It is assumed that these variables would be also crucial for students to keep their academic performance during the pandemic. Indeed, it was shown that results of tests in Mathematics and in the native language (Latvian) at the end of primary school (9th grade) during the pandemic were related to reasoning abilities, self-assessed problem-solving skills, self-management skills, and parental education level (Hacatrjana, 2022). Similar results would be expected from the analysis of the academic achievement of 11th grade students. The main concepts and their relations are briefly discussed further.

Academic achievement is significantly related to various indicators of cognitive abilities (e.g., Frey, 2019; Kampa et al., 2021) that are some of the strongest predictors of academic achievement. Considering that intelligence is a relatively stable indicator, we can assume that measurements of cognitive abilities would also show a strong relation to academic achievement during the pandemic as there is no doubt that during distance learning persons with higher cognitive abilities had a higher potential to grasp new knowledge, remember study materials and to understand concepts, similarly as in the regular learning settings.

Previous research shows that academic achievement is also related to self-regulated learning and various facets of this broad concept. Studies carried out before the pandemic show that several aspects of self-regulated learning are

connected to academic achievement and learning outcomes (e.g., Abd-El-Fattah, 2010; Alessandri et al., 2020; Gunzenhauser & Saalbach, 2020; Veenman et al., 2014; Zimmerman & Martinez-Pons, 1988), studied at various education levels. Self-regulated learning is an important concept in education, and it might have been even more important during the pandemic and distance learning. Self-management is a part of the broader concept of self-regulated learning (Garrison, 1997), and it relates to how the activities associated with learning are carried out and controlled, for example, how the student organizes one's work and how all the necessary resources are managed. If a student has highly developed self-management skills, they are able to motivate themselves, plan how to implement their tasks, and evaluate the results (Veenman et al., 2014), indicating that the student would be highly capable of functioning during the remote learning when students had to do most of their schoolwork independently (Hacatrjana, 2021a). In a study with high-school students it was discovered that students' self-directed learning skills, especially skills for using digital learning tools and planning skills, were sufficient during the distance learning, based on their own evaluations, though they admit to having problems with assessing their learning gaps (Lāma, 2021). Data from the pandemic period show that self-management skills were correlated to students' test results in math and language but were not statistically significant predictors of these results, compared to other variables (Hacatrjana, 2022).

Distance learning can be in general viewed as a novel situation with many problems that students had to solve individually, both minor everyday problems and challenging school tasks, therefore it can be assumed that general and domain-specific problem-solving skills should be crucial for students to maintain the level of their academic results during this period. A study showed that students who had higher self-assessed problem-solving skills reported having less stress about their ability to deal with distance learning (Hacatrjana, 2021a). There is a variety of approaches to studying problem-solving, and based on various methodological and theoretical approaches, problem-solving skills are significantly related to academic outcomes and cognitive abilities, studied with tests or questionnaires (e.g., Ellis et al., 2021; Fitzpatrick et al., 2020; Greiff et al., 2013; Kretzschmar et al., 2017). Definitions of problem-solving vary but most researchers agree that there are several processes that occur during the solving of the problem, such as exploring and understanding, representing and formulating, planning and executing, and monitoring and reflecting (OECD, 2013). In the complex problem-solving approach problem-solving is operationalized as having two main processes: knowledge acquisition and knowledge application (Fischer et al., 2012). Problem-solving skills can be defined, in the context of the current research, as a set of skills and operations performed by an individual that are applied to successfully understand the key concepts involved in the problem (e.g., a school task), to generate possible solutions and implement them, to be flexible in the process of solving the problem, and to evaluate the result. These skills are operationalized in the current research by two aspects of problem-solving that are self-evaluated by students: a) solution development and evaluation and b) flexibility to change the solution (Hacatrjana, 2022). Flexibility is a construct also studied in the specific field of mathematical problem-solving and it is shown to be related to academic outcomes (e.g., Hästö et al., 2019).

Another important factor related to the academic achievement of students is the level of parental education (e.g., Idris et al., 2020), therefore parental education, a relatively stable factor, should be an important predictor for academic achievement also during the pandemic (Easterbrook, 2021; Hacatrjana, 2022). It was already mentioned that various socio-economic aspects might play an important role during the pandemic as risk facilitators or mitigators, as they reflect the tendencies for options the students had when the pandemic started, including social support and financial means for affording extra education options (Goulas & Megalokonomou, 2020). It is reported that even in the early school years several socio-economic factors, including parental education, as well as cognitive skills were found to have an impact on the academic achievement of students (Alves et al., 2017). Socio-economic factors can relate also to the self-efficacy of students (Ikeda & Echazarra, 2021), and these group differences may have implications for future opportunities for the students.

The research overview of this section showed the well-established relationship between academic achievement and several important concepts that the current research focuses on cognitive abilities, problem-solving skills, self-management skills, and parental education. Most of the previous research has taken place before the pandemic in regular learning settings, therefore it is important to expand the research further to address these patterns of relations in connection to students' academic achievement during the pandemic and the unprecedented learning settings.

### *The Focus of the Current Research*

There have been rapid changes in education induced by the COVID-19 pandemic that affected the way students had to learn and deal with school tasks and acquire knowledge. Risks of learning losses for students are discussed in the literature, especially for vulnerable groups, therefore emphasizing the importance of monitoring students' academic achievement in this period and the variables that were related to students' ability to maintain their level of academic results. Consequently, the main research questions posed in this study are: Q1: What are the longitudinal changes of students' average school grades during four school semesters, including the period before and during the pandemic? Q2: What are the relations between students' grades and other important variables measured during the pandemic? It is hypothesized that students with higher cognitive abilities, problem-solving skills, and self-management skills had higher grades and were able to maintain their mean grades at least at the initial grade level before the pandemic.

## Methodology

### Research Design

A quantitative research design was used in the current study with the main aim to analyze high-school students' cognitive abilities and skills during distance learning and their relation to academic achievement. Longitudinal data of the 11th grade students' average grades were also obtained from four measurements over time.

### Sample

The total sample consists of  $n=586$  students (344 females, 58.7% and 242 males, 41.3 %) studying in the 11th grade (in the school year 2020/2021) from general education schools in Latvia, aged 16 to 19 years ( $M=17.38$ ,  $SD=0.53$ ). Students reported that most often (30.5%) they had parents with a finished Bachelor's degree (the level of the highest education of a parent had to be stated, if parents had different levels of education), followed by students who had parents with a finished secondary (high-school) education (25.8 %), and Master's degree (22.7 %). Data were gathered in May 2021. The sample size used in some of the analyses is smaller due to a smaller amount of the gathered data. In such cases, the precise amount of analyzed cases are reported within the results.

### Measurements

1) Problem-solving skills were evaluated with the Problem-solving questionnaire, a self-assessment method with 10 items composing two scales: (a) Solution development and evaluation (6 items with a maximal score of 30 points) and (b) Flexibility to change solution (4 items with a maximal score of 20 points) that originally showed internal consistency of respectively  $\alpha=.79$  and  $\alpha=.71$  (Hacatrjana, 2021b), and in the current sample  $\alpha=.81$  and  $\alpha=.72$ , respectively. Each item had to be rated on a scale from "Never" to "Always" (0 to 5 points) based on how often the student performed the mentioned activity (item examples: "When solving a situation or doing a task, I change my solution if I understand that it is not appropriate", "When I have finished a task, I think about what worked well and what didn't.").

2) Self-management skills were assessed with the Self-management questionnaire that is used for evaluation of students' skills to manage and organize themselves and their daily learning. It consists of six items (for example, "I write down all the tasks in a certain place", "If I lose motivation at some point, I remind myself why it was important for me to do it"), that originally showed the internal consistency of Cronbach's  $\alpha=.77$ , and  $\alpha=.75$  in the current sample. Each item had to be rated on a scale from "Never" to "Always" (0 to 5 points) based on how often a student performed such an action (Hacatrjana, 2021b). The scale has a maximum score of 30 and a minimum of 0.

3) Fluid nonverbal reasoning was measured with a short version (10 items) of Sandia Matrices test (see Harris et al., 2020; Matzen et al., 2010) that assesses reasoning abilities with typical figural matrices tasks where one has to understand the patterns existing in a set of drawings and choose the most appropriate answer (a drawing that continues the pattern) from eight answer options. Internal consistency of the test measured with Cronbach's alpha indicator in the current sample was  $\alpha=.71$ . Each answer is rated with 0 or 1 points. The test represents maximum skill with a score of 10 and minimum of 0.

4) Verbal reasoning was assessed with a short version of the verbal analogies test (10 items) that has been previously developed and used in the research with students (Kretzschmar et al., 2017). In the test, one pair of words and the first word of the second pair is given (for example, "snow - to ski" and "ice - ...") and the participant has to understand the type of relationship for these words and write an answer to the second pair of words. Each answer is rated with 0 or 1 points. The internal consistency of the test measured with Cronbach's alpha indicator in the current sample was  $\alpha=.79$ . Maximal score is 10 and minimal is 0.

5) Academic achievement was measured by gathering the average grades in the last four semesters (autumn 2019 to spring 2021) in all study subjects. The average grades were calculated from the periods when these students were in grade 10 (school year 2019/2020) and in grade 11 (school year 2020/2021). It has to be noted that the main subjects (e.g., Mathematics, Latvian, English) are the same for all students but there are variations for some subjects based on the type of school and the track chosen by the student (e.g., some students have in-depth Music or Programming studies, but others don't). Therefore, only the data from comparable subjects were analyzed. In Latvia, the average mean grade can vary between 1 to 10 (maximum grade), accordingly, each subject's grade is a value from 1 to 10.

6) Additional questions on the subjective experience during distance learning were asked to students. They were asked to rate their perceived difficulty to deal with the distance learning situation, to rate if the technological means available to them were sufficient for studying during the distance learning, rating them on a Likert-type scale with 0 to 5 points. Students had to answer if they had been to individual consultations with a teacher (a comment: individual face-to-face consultations were allowed in schools in spring 2021 in Latvia as an exception during the distance learning for those students that were facing difficulties).

7) Demographic questions were asked to students: gender, age, the language they mostly spoke at home, the level of parental education (from "1-Finished primary school" to "6-Doctoral degree").

### Procedure

Data were collected in two ways: 1) Students filled out the tests and questionnaires online using a specialized testing platform. Students from each class joined an online lesson that was planned for them on a platform typically used by the particular school during the distance learning. At the beginning of the online lesson students were informed and instructed about the study, and then completed surveys and tests in 40-50 minutes. 2) A representative from each participating school compiled academic performance results for their students: the mean grades of all study subjects for the last four semesters. Grades were collected in an anonymized form: each student had an individual code. The codes were assigned and stored by the school, and they consisted of letters and numbers indicating school, class, and number. Students were informed of their individual codes shortly before the testing, and the same code was entered on the testing platform during the assessment and used when the mean grades were compiled and sent to the researcher. Before the research project each participating school was informed about the aims and planned procedure of the research, and an informative letter to parents was sent by each school to allow their child's participation in the study.

### Analyzing of Data

To answer the research questions, the following statistical analysis methods were used: one-way ANOVA to assess differences between different student groups' average grades, repeated measures ANOVA for the difference between all semesters' average grades of a specific student group, Tukey's Honest Significant Difference test and t-test were used as post-hoc tests for one-way ANOVA and repeated measures ANOVA respectively, Spearman's correlation coefficients, on the SPSS version 22 and with R package. Both ANOVA tests' main assumptions are normality, equality of populations' variances, and independence between observations. The normality of mean grades was checked using the Shapiro-Wilk test, and Bartlett's test was used to check equality of variances, and both assumptions proved to hold true. The assumption of independence also holds true, as mean grades between students are unrelated. Tukey's Honest Significant Difference test and t-test have the same assumptions as ANOVA tests.

## Results

First, the general statistics are presented, followed by an insight into the dynamic of students' average grades longitudinally in four semesters. Afterward the results on the relation of students' grades, cognitive abilities, and skills are presented to show that the skills were influential for students to maintain their level of academic achievement.

### Statistics of the Indicators Measured in the Study

In Table 1 descriptive statistics of the measured variables are presented. The number of data available for each indicator is also presented, as some questions were not answered by all students.

Table 1. Descriptive Statistics of the Variables Measured in the Study.

Measurement	N	Min	Max	M	SE	SD
I have felt difficulties in dealing with studies during distance learning	494	0.00	5.00	3.04	.06	1.33
The technological means available to me at home are sufficient to study remotely	494	0.00	5.00	4.39	.04	.90
Fluid nonverbal reasoning	402	0.00	10.00	5.66	.13	2.51
Verbal reasoning	462	0.00	10.00	6.12	.12	2.67
Problem-solving: scale Solution development and evaluation	504	0.00	30.00	15.14	.25	5.59
Problem-solving: scale Flexibility to change the solution	504	4.00	20.00	13.36	.16	3.49
Self-management scale	503	2.00	30.00	16.80	.27	6.11

Further, it was calculated that  $n=123$  students from the current sample had attended individual consultations, but 484 students had not attended any face-to-face consultations, indicating that a smaller proportion of students were identified as the ones who needed individual extra support and who received it. Analysis of group differences show that students who had participated in individual face-to-face consultations had lower verbal reasoning skills ( $M=6.38$  vs.  $M=5.30$ ;  $t=3.61$ ,  $p=.00$ ), lower grades in four previous study semesters (the highest difference in spring 2021:  $M=6.82$  vs.  $M=6.00$   $t=4.5$ ,  $p=.00$ ), parents with lower education ( $M=3.58$  vs.  $M=3.16$ ;  $t=3.32$ ,  $p=.00$ ), compared to students who had not participated in an individual consultation. No significant differences were found in self-reported measures of skills for solving problems and self-management.

### Longitudinal Data of Students' Mean Grades During Four Semesters

The dynamic of students' average grades longitudinally in four semesters is presented, based on calculations using three main study subjects, Mathematics, Latvian and English, are presented (see Figure 1). All sample of students are presented together here.

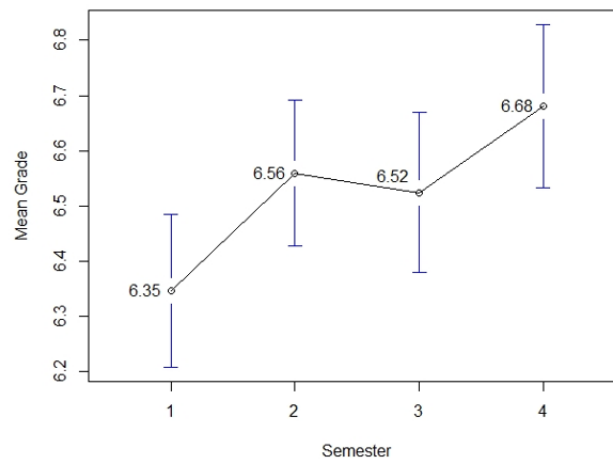


Figure 1. Longitudinal Changes in Students' Average Grades During Four Semesters (1-Autumn 2019; 2-Spring 2020, 3-Autumn 2020 and 4-Spring 2021) Based on Calculation of Three Main Study Subjects (Mathematics, Latvian and English).

In Figure 1 mean grades of each semester and their 95% confidence intervals for  $n=368$  students are shown. There are statistically significant differences between the mean grades (repeated measures ANOVA,  $F=21.51$ ,  $p<.01$ ). Post-hoc tests indicate statistically significant differences between all semester mean grades, except for the second and third (paired samples t-test,  $t=-6.53$ ,  $t=-3.88$ ,  $t=-6.58$  for the first semester compared to the second, third, and fourth semester respectively with all adjusted p values less than .01,  $t=-2.72$ ,  $t=-4.45$  for the fourth semester compared to the second and fourth, with adjusted p values  $p=.04$  and  $p<.01$ , Bonferroni correction). The mean grades over the semesters have increased, and the seemingly slight decrease in the mean grade of the third semester is statistically insignificant.

### The Dynamic of Students' Average Grades in Relation to Their Cognitive Abilities and Skills

The aim of this section is to further unravel the dynamic of students' grades during the pandemic by examining the skills and abilities to which they were related. First, correlations between the mean grades and other variables measured in the study in spring 2021 were analyzed (see Table 2). As the Spearman's correlation coefficients show, average grades in spring 2021 are significantly related to several indicators: parental education level, non-verbal and verbal reasoning, two scales of problem-solving skills, and self-management skills. There is overall a similar tendency of correlations with grades in previous semesters.

Table 2. Correlations Between the Mean Grades in Four Semesters and Parental Education Level, Reasoning Abilities, Problem-solving Skills, Self-management Skills, and Other Indicators Measured in the Study.

		Average grade in autumn 2019	Average grade in spring 2020	Average grade in autumn 2020	Average grade in spring 2021
Parental education level	r	.15**	.14**	.21**	.21**
	n	315	354	313	357
I have felt difficulties in dealing with studies during distance learning	r	-.04	-.06	-.04	-.14*
	n	303	342	299	343
The technological means available to me at home are sufficient to study remotely	r	.13*	.10	.08	.11
	n	303	342	299	343
Fluid nonverbal reasoning	r	.36**	.30**	.34**	.31**
	n	261	289	258	288
Verbal reasoning	r	.46**	.39**	.39**	.38**
	n	294	332	299	334
Problem-solving: scale Solution development and evaluation	r	.01	.07	.10	.17**
	n	315	353	315	355
Problem-solving: scale Flexibility to change the solution	r	.27**	.22**	.27**	.32**
	n	315	353	315	355
Self-management scale	r	.07	.13*	.15**	.21**
	n	316	354	314	354

\*  $p < .05$ ; \*\*  $p < .01$



The next aim was to analyze more elaborately how the level of students' skills and abilities was related to the changes in their average grades, by dividing the participants in three skill-level groups. First of all, when each of the measured skills (e.g., nonverbal-reasoning or problem-solving) were looked at separately, they all portrayed similar effects on the dynamics of mean grades over the four semesters for the students with different skill levels for each skill. Therefore, it was decided to create a combined skill score to look at how all five skills contributed to students' mean grades dynamic longitudinally.

A combined score for defining the level of skills was calculated for each student based on results in several measurements: verbal reasoning, non-verbal reasoning, problem-solving skills: solution development and evaluation scale, problem-solving skills: flexibility to change the solution scale, and self-management skills. For each measurement, a student could get a score on the scale of 0 to 2, depending on which group the student fitted in. The groups for each measurement were made using the 33rd and 67th percentile. The group with the lowest scores got assigned score 0, group with the average scores got assigned 1, and with the highest scores 2, for each measurement. Then, from the total score, three skill level groups were calculated (named: group 1 to group 3 in Figure 2), using the division from the 33rd and 67th percentiles.

Additional analysis showed that the correlation between mean grades of each pair of semesters in all three skill level groups (low, average and high) was strong and very strong (always higher than  $r=.6$ ), which indicated that within each skill level group rank of a particular student's mean grade overall had stayed the same during all four semesters, therefore, the mean grade did not go up or down based on a specific skill, but mean grades were affected by all skills.

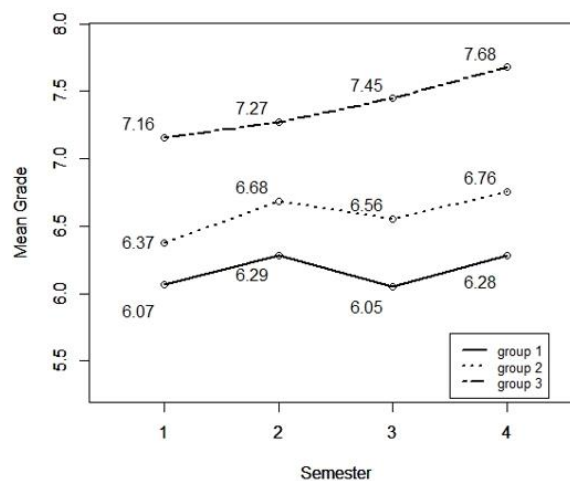


Figure 2. Longitudinal Changes in Mean Grades During Four Semesters (Autumn 2019 to Spring 2021) Based on Calculation of Three Main Study Subjects Divided in Three Groups by Level of the Combined Score of the Skills

In Figure 2 the sample size for group 1, group 2, group 3 is  $n=63$ ,  $n=100$ ,  $n=53$  respectively. For all groups repeated measures ANOVA shows statistically significant differences between semester mean grades ( $F=3.29$  and  $p=.02$  for group 1,  $F=11.36$  and  $p<.01$  for group 2,  $F=6.79$  and  $p<.01$  for group 3). Paired samples t-test with Bonferroni correction as a post-hoc test was used to determine the exact semesters between which there were differences for each group. Group 1 (representing students with the lowest skills) only had statistically significant differences between the first and the second semester ( $t=-3.08$ , adjusted  $p=.02$ ). Group 2 (representing students with average skills) had statistically significant differences between the first and the second semester ( $t=-4.53$ , adjusted  $p<.01$ ) and the first and the fourth semester ( $t=-4.78$ , adjusted  $p<.01$ ). Group 3 (representing students with the highest skills) had statistically significant differences between the first and the fourth semester ( $t=-3.48$ , adjusted  $p<.01$ ), the second and the fourth semester ( $t=-2.83$ , adjusted  $p=.04$ ), and the third and the fourth semester ( $t=-2.98$ , adjusted  $p=.03$ ).

One-way ANOVA was used to determine whether there were any significant differences between the mean grades of each group for each semester. There were significant differences between the group mean grades in each semester ( $F=12.52$ ,  $p<.01$  for the first semester,  $F=10.87$ ,  $p<.01$  for the second semester,  $F=17.61$ ,  $p<.01$  for the third semester,  $F=17.84$ ,  $p<.01$  for the fourth semester). Tukey's Honest Significant Difference test was used to determine which groups had significantly different mean grades in each semester. In the first semester there was not a statistically significant difference between group 1 and group 2 (diff=0.30 and adjusted  $p=.26$  for group 1 and 2, diff=1.09 and adjusted  $p<.01$  for group 3 and 1, diff=0.78 and adjusted  $p<.01$  for group 3 and 2). In the second semester there was no difference between the group 1 and group 2 (diff=0.40 and adjusted  $p=.08$  for group 1 and 2, diff=0.98 and adjusted  $p<.01$  for group 3 and 1, diff=0.59 and adjusted  $p<.01$  for group 3 and 2). In the third semester, there were statistically significant differences between all groups (diff=0.51 and adjusted  $p=.04$  for groups 1 and 2, diff=1.40 and adjusted  $p<.01$  for groups 3 and 1, diff=0.89 and adjusted  $p<.01$  for groups 3 and 2), and for the fourth semester there was a significant difference between all groups (diff=0.48 and adjusted  $p=.05$  for group 1 and 2, diff=1.40 and adjusted  $p<.01$  for group 3 and 1, diff=0.98 and adjusted  $p<.01$  for group 3 and 2).



and 1,  $\text{diff}=0.92$  and adjusted  $p<.01$  for group 3 and 2). Students with a high level of skills also had significantly higher mean grades than the rest of the groups over all semesters, as well as students with a low level of skills, tend to have the lowest mean grade, especially in the third and fourth semester.

Next, an additional indicator was calculated for each student to understand if a student's individual grades had increased, remained stable, or decreased from semester to semester (presented in Figure 3, based on the skill-level-groups of students). Figure 3 shows that student groups with low and average skills (based on the previously explained grouping) had a higher proportion of students whose mean grade had decreased (close to 50%) from the second to the third semester, while the group with high skills had more students (over 50%) whose mean grades had increased over the same time period, thus showing that students with lower skills were more susceptible to decrease in mean grades between the second and the third semester (in the "second wave" of the pandemic).

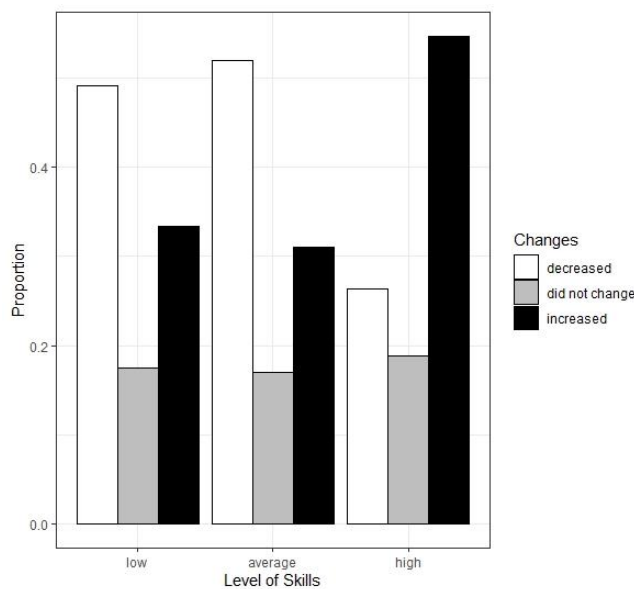


Figure 3. The proportion of the Type of Changes in Mean Grades of the Three Main Subjects From the second to Third Semester (Spring 2020 to Autumn 2020) For Each Level of Skill Group

## Discussion

Longitudinal data of average grades of the same students in four semesters were analyzed to draw grounded conclusions on the changes in academic achievement before and during the pandemic. It is important for researchers to analyze the actual longitudinal data and to compare it with the prognosis and simulations that indicated a major learning loss that would happen during the pandemic (e.g., Azevedo et al., 2020). Further, two main themes of the current results are discussed: a) the general tendency of students' average grades during four semesters and b) group differences in the changes of students' grades based on the level of their skills and cognitive abilities.

There is a general pattern for average grades to increase during the four monitored semesters. It was found that the only decrease in academic results occurred at the end of 2020 (defined as "Semester 3" in the results), but only for specific groups of students, when studied more elaborately. These results relate to the results from Denmark, where a slight decrease was estimated in test scores in 2020, but there was an increase again in 2021 (Birkelund & Karlson, 2021). Similarly, a decrease was also detected in 2020 in another study (Engzell et al., 2021). Contrary to the simulation data and other results showing a decrease, the longitudinal data of this study do not show a dramatic image. As other researchers have already indicated, the results might be related to the specifics of the country where the research has taken place, for example, the overall good availability of the Internet coverage, technologies, and digital tools. More actual data from other countries is necessary for a more comprehensive view on how the pandemic affected academic achievement.

An important goal of the current study was to assess to what extent reasoning abilities, problem-solving skills, and self-management skills were related to academic achievement during COVID-19 pandemic and distance learning, and to what extent these skills were related to students' ability to maintain the level of their grades during the pandemic. It was found that both non-verbal and verbal reasoning abilities, problem-solving skills (flexibility to change the solution and solution development and evaluation), and self-management skills were positively correlated to the grades. This emphasizes the importance of the development of various skills and abilities in education. It can be interpreted that during distance learning, when students had to do a lot individually, for example, read and grasp new concepts and understand tasks, the individual ability to understand verbal or non-verbal concepts and relationships between them was crucial, as well as the ability to manage their daily learning. Also, these results imply that it was important for

students to be flexible during distance learning in the ways they dealt with school tasks and solved problems, as having this skill was associated with an increase in their grades. Flexibility to change the solution means that a student is able to recognize when the initial strategy to solve a task is not working and is able to make a decision to change something in the way they are solving the problem, also implementing the new solution, and this individual ability was especially important during learning at home.

This study shows that the calculated score of students' skills (based on reasoning abilities, problem-solving, and self-management skills) was important for maintaining the level of grades during the distance learning or even increasing them in the semester of autumn 2020 when the second wave of the pandemic hit, and the students were again studying remotely. Having higher levels in the combined score of skills determined that a student was more likely to increase one's average grades during the pandemic or maintain the grades at the initial level, compared to students whose combined scores were lower. Overall, the results in the current study are consistent with previous research that has established the great role that cognitive abilities play in the academic achievement, assessed already before the pandemic (e.g., Frey, 2019; Kampa et al., 2021), as well as during the pandemic (e.g., Hacatrjana, 2022). In addition, we see that such transversal skills as problem-solving skills and self-management skills were important for students to deal with the daily demands during distance learning and the pandemic.

During this study the importance of the parental education level was also confirmed, showing that it was related to the level of students' mean grades during the pandemic, similarly as the research before the pandemic had shown (e.g., Idris et al., 2020). In the Latvian sample in the current research, it was also found that students with a lower level of parental education, as well as those with lower cognitive abilities and grades, were those who had attended face-to-face consultations when they were allowed. Data indicates that they attended these individual consultations because they were in need of extra support to deal with the demands from schools. This leads to a conclusion that such an individual support is indeed very important for the risk groups during the crisis. Analysis of data from previous pandemics (with another disease) has shown that students from poorer backgrounds more often continued to go to school when it was optional, explaining this with fewer other opportunities for their educational development and opportunities that parents might have provided (Goulas & Megalokonomou, 2020). International comparison reports highlight that students from poorer and less educated backgrounds had less support at home, due to lack of competence of the parents (e.g., Barron Rodriguez et al., 2021), on contrary, parents from high-SES backgrounds seemed to be more advanced in planning and organizing their child's timetable and offering extra activities (Delès, 2021). Other research also confirms the importance of parental education to the students' academic achievement, however also indicating that an individual's intelligence is a stronger predictor, compared to the whole SES measurement (Flores-Mendoza et al., 2021). The current research data showed a minor correlation between students' grades and available technologies and, in general, the ratings of the available technologies were high in Latvia, however, data from other countries have shown that there is a divide in the quality of technology provision based on students' backgrounds (Bell et al., 2022). The results lead to the conclusion that it is extremely important to think in advance about the support to vulnerable groups of students both during and after the pandemic. In addition, the term "vulnerability" should be perceived broadly, indicating both the lack of available support from others (e.g., parents) and the individual factors, such as level of skills and abilities.

To conclude, the current study shows an increase in students' grades during the pandemic and shows that reasoning abilities, problem-solving and self-management were significantly related to higher levels of grades and they were crucial to maintain the level of grades during the distance learning in the second wave of the pandemic. These results also justify the need for the development of problem-solving skills for students in schools because they might help students to solve both daily learning problems and to adapt to various unprecedented events in the future.

### Conclusions

The results of the current study present several important findings about the dynamic of high-school students' average grades longitudinally during the pandemic and distance learning. First, no significant decrease in students' mean grades was found in the period from autumn 2019 to spring 2021, as would be expected based on simulation studies. The overall tendency was for the grades to increase during this period. Second, the pattern for changes in most semesters is similar to all student groups based on their skill level, however in the autumn of 2020 grades increased mainly for the students in the high-level-skill group. Students in the highest-level group, based on their skills, were the least vulnerable to the decrease in grades in the period when lower-level groups experienced the decrease. These results confirm the previous findings of the importance of cognitive abilities to academic achievement, as well as problem-solving skills and self-management skills that were important to maintain the grade level during this unprecedented process of distance learning. Therefore, the development of these skills is crucial to foster students' ability to deal with novel and unprecedented situations in the future.

### Recommendations

One of the ways to develop this research further is to assess students' longitudinal data of grades from larger samples (for example, based on national databases), as it would allow to make conclusions about the whole population, and

even to compare the changes in different countries. Since students' skills, unlike the grades, were assessed at one-time point in this study, a follow-up on the same students that were involved in the current study and further assessment of their skills and grades would be highly beneficial to further monitor the situation in the aftermath of the pandemic.

### Limitations

Several limitations of the study are discussed further. The conclusions are limited to the schools that participated in the study. During the process of communication with schools, some schools noted that there was too much workload at the time for both students and teachers and chose not to participate in the study. We can only speculate whether schools with more problems (for example, if students were facing extreme hardship during distance learning) avoided participating. Measurements of students' skills (e.g., problem-solving skills and cognitive abilities) were collected only in 2021, when the current research project started. As the pandemic could not have been foreseen, it is consequential that no data was collected on students' skills in advance as there were no research projects going on regarding these topics in Latvia. It must also be considered that grading by teachers during the distance learning might have been somehow different, including the fact that students had various opportunities to cheat, and it might have influenced the grades. However, despite discussions about the reliability of average grades that are based on the assessment by teachers (as opposed to standardized tests), research proves that grades are a valid form of assessment. It is important that we calculated mean scores based on assessments from several teachers, calculating the grades in several study subjects. Also, students from all over the country and various schools participated in the study, thus reducing subjectivity in assessments.

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### Authorship Contribution Statement

Hačatrjana: Conceptualization, data acquisition, research design, writing, supervision, funding acquisition. Graustiņa: Editing, data analysis, interpretation.

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