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Effects of the COVID-19 pandemic on academic success in higher education

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Abstract

The emergence of the COVID-19 pandemic resulted in temporary closures of educational institutions and has shifted the educational process towards the use of distance education. Despite the efforts, severe learning losses and larger educational inequality are found in compulsory education. To complement this knowledge, the present prospective study focuses on higher education by analyzing academic success data of Flemish first-year university students ($N = 24{,}404$) spanning six years. COVID-19 learning losses are assessed in a natural setting, considering various background and (non-)cognitive student characteristics. Results for the full pandemic year 2020–2021 indicate that although the overall negative impact of the pandemic on academic success is rather small, the variance in academic success does increase. Low socio-economic status students show larger learning losses, and the socio-economic gap widens. Our findings imply that COVID-19 learning losses in higher education are less pervasive than in compulsory education, though inequality issues also arise.

Keywords COVID-19 · Higher education · Academic success · Student characteristics · Educational inequality

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The COVID-19 pandemic has affected society globally across different areas. Educational institutions have faced the largest disruption in recent history, with closures that impacted 94% of the global studying population (United Nations, 2020). To guarantee teaching and learning continuity, a rapid and unprecedented transition towards (partial) distance education was necessary (Donnelly & Patrinos, 2021; Iterbeke & De Witte, 2021). Concerns about this disruption's effect on students' academic success and related learning losses are voiced in the literature (Azevedo et al., 2022; OECD, 2021). It is also suggested that learning losses are more severe among low socio-economic status (SES) students (Berger & Archer, 2016; Betthäuser et al., 2023; Moscoviz & Evans, 2022), which makes the pandemic a threat to global educational equality. However, existing research mainly focused on younger children and adolescents in compulsory education.

Currently, empirical research assessing pandemic learning losses and inequality is less prevalent in *higher education* than in compulsory education. Also, little is known about (non-)cognitive student characteristics other than SES and assigned sex (hereafter: sex)[1] that may have influenced the relationship between the pandemic and academic success (Betthäuser et al., 2023; Iterbeke & De Witte, 2021). Studying these interactions is highly relevant as literature already indicates that individual differences in terms of cognitive ability and personality traits can have specific effects on learning outcomes (Azevedo et al., 2022; Voyer & Voyer, 2014). Also, the determination of outcomes like academic success involves the interplay between personal and environmental factors, among others, according to Bandura's (1986) Social Cognitive Theory (SCT).

The present study therefore investigates two research questions. First, from a macro-level perspective, we examine how the COVID-19 pandemic affects academic success, measured as the percentage of obtained ECTS credits[2], in higher education. Second, we evaluate the moderating role of various background and (non-)cognitive student characteristics in the relationship between the COVID-19 pandemic and academic success in higher education. As such, specific consideration is given to the suspected learning losses of low-SES students and other determinants of academic success. By using a large dataset of six first-year university student cohorts between 2015 and 2021 ($N = 24{,}404$) derived from a running longitudinal project, the present study clarifies the scope and determinants of learning loss in higher education, informing educators, researchers, and policymakers about targets of learning remediation (OECD, 2021; Pokhrel & Chhetri, 2021).

1 Impact of the pandemic on higher education learning

The pandemic necessitated institutions to make a swift transition from traditional face-to-face education to (partial) distance education (i.e., online and blended learning) to ensure the continuity of high-quality education (Donnelly & Patrinos, 2021;

[1] We surveyed this background student characteristic as "stated on your passport," which typically reflects sex assigned at birth rather than gender identity. Consequently, following American Psychological Association (2022), the term 'sex' is more appropriate than 'gender' for the present study (see also Table 1).

[2] European Credit Transfer and Accumulation System credits (European Commission, 2015). See also *Measures.*

Table 1 Overview student characteristics

Variable	Cat.	Values	Survey (example item)	n_{items}	α	*M* (*SD*)
Sex[1]	B	Male (0) Female (1)				
SES	B	High-SES (0) Low-SES (1)[2]				
Education Type SE[3]	C	General (0) Technical (1)				
Hours Maths SE	C					5.1 (1.8)
Vocabulary (/20)	C		LexTALE[4] ("Is this an existing Dutch word or not?")	60	.72	17.6 (1.7)
Self-Control (/20)	NC		Brief Self-Control Scale[5] ("I am able to work effectively toward long-term goals")	13	.75	13.0 (1.9)
Motivation:	NC		Academic Self-Regulation Questionnaire[6]			
Autonomous (/20)			("I study because I want to learn new things")	8	.86	15.0 (2.4)
Controlled (/20)			("I study because I am supposed to do so")	8	.87	8.3 (3.2)
Academic Self-Efficacy:	NC		College Academic Self-Efficacy Scale[7]			

Table 1 (continued)

Variable	Cat.	Values	Survey (example item)	n_{items}	α	*M* (*SD*)
Effort (/20)			("Attending class regularly")	8	.76	15.2 (1.9)
Comprehension (/20)			("Understanding most ideas you read in texts")	14	.81	14.8 (1.7)
Test Anxiety (/20)	NC		Cognitive Test Anxiety Scale Revised[8] ("I am not good at taking exams")	25	.92	10.0 (2.5)

Note. B = background, C = cognitive, NC = non-cognitive. SE = secondary education

[1]As stated on the passport

[2]Neither parent of the student has completed secondary education and/or the student receives a scholarship

[3]General secondary education prepares students for higher education (ISCED level 7), while technical secondary education also prepares for professional careers and thus serves a dual purpose (university colleges, ISCED levels 5 and 6)

[4]Lemhöfer and Broersma (2012)

[5]Tangney et al. (2004)

[6]Vansteenkiste et al. (2009)

[7] Fonteyne and colleagues (2017) adapted from Owen and Froman (1988). The items are preceded by: "To what extent do you believe you are capable of performing each of the following tasks?"

[8]Cassady and Finch (2015). Test Anxiety was measured through a 4-point Likert scale, whereas a 5-point Likert scale was used for the other non-cognitive variables to indicate the degree of agreement with the items

Moscoviz & Evans, 2022). Blended learning can be defined as a combination of face-to-face and online teaching and learning (Means et al., 2013). The use of online or blended learning does not necessarily imply a problem. Meta-analytic evidence, including 45 (quasi-)experimental studies across educational stages, shows that academic success appears to be equivalent in the studies that compared purely online learning with face-to-face learning (Means et al., 2013; Nguyen, 2015), which is also confirmed in a recent meta-analysis focused on undergraduate medical students (Pei & Wu, 2019). However, some researchers also find lower academic success for online learning versus face-to-face learning in higher education (e.g., Bettinger et al., 2017). Meta-analyses involving studies that compared blended with face-to-face learning, of which two specifically focused on higher education (Bernard et al., 2014; Vo et al., 2017), indicate that academic success increases through blended learning (range mean Hedges' g [0.33–0.39]) (e.g., Means et al., 2013). The extra learning time, additional instructional resources, and interaction encouraging course elements that characterize good blended learning are put forward as possible determinants of learning gains (Means et al., 2013; Vo et al., 2017).

In general, a (partial) distance learning environment seems to be associated with positive learning outcomes. However, (partial) distance learning imposed by the pandemic has not been a typical case of planned and prepared (partial) distance learning and often merely crisis management (Adedoyin & Soykan, 2020; OECD, 2021). The above meta-analyses only contain good practice implementations of (partial) distance learning on a small scale (e.g., in the context of single courses), whereas the pandemic now forced entire institutions and countries to shift to (partial) distance education without much preparation or a conceptual and didactic framework. And, of course, the context of the pandemic also implied many other (e.g., social) restrictions and health issues for students. The present study's goal is to assess the effects of the pandemic on academic success from a macro-level perspective (Betthäuser et al., 2023; OECD, 2021).

The question of learning losses following this crisis-response transition towards (partial) distance education is relevant for all educational stages. However, the majority of research that specifically examined the influence of the COVID-19 pandemic on academic success is mainly focused on compulsory education (e.g., Engzell et al., 2021; Lichand et al., 2022). In minors, and opposite to the positive effects of good practice (partial) distance learning (across educational stages) reported above, findings are disturbingly negative. For example, a recent systematic review and meta-analysis of 42 studies across 15 countries provide evidence of student learning losses with an overall Cohen's $d = -0.14$ (Betthäuser et al., 2023). In addition, on average across OECD countries, PISA[3] 2022 scores drop by about ten (in reading) to nearly fifteen (in mathematics) score points compared with PISA 2018 (i.e., $d = 0.10$ to $d = 0.15$ in the PISA distribution), which corresponds to a loss of one-half to three-fourth of a year of learning due to the pandemic (OECD, 2023).

[3] Programme for International Student Assessment. PISA tests 15-year-old students in three core domains (Mathematics, Reading and Science). The first assessment took place in 2000 and is managed every three years. Per cycle, one domain is considered the major one. A difference of 10 PISA points is equivalent to an effect size $d = 0.10$ (Azevedo et al., 2020).

To our knowledge, currently only a few studies report data regarding the pandemic's impact on academic success in higher education by comparing pre-pandemic and pandemic learning and using an objective outcome measure. The results of the higher education pandemic studies are mixed, showing no academic success differences (El Said, 2021), learning losses (Bird et al., 2022; De Paolo et al., 2022; Orlov et al., 2021) and learning gains (Gonzalez et al., 2020; Iglesias-Pradas et al., 2021; Rodríguez-Planas, 2022). Importantly, all these studies contrasted academic success in academic year 2019–2020 with one or more previous academic years. The researchers thus only included a few months of (partial) distance learning, with lockdowns starting in March 2020. Because learning losses are likely to accumulate, the present study also focuses on academic year 2020-2021, which started on the last Monday in September and entirely took place in full pandemic. Also, we analyze a large sample, across study domains and a six-year period, in order to ensure generalizability and to control for normal fluctuations in academic success.

In the present study, we examine how the COVID-19 pandemic affects academic success in higher education (RQ1). In sum, pre-pandemic meta-analytic evidence indicates that (partial) distance learning may benefit academic success (e.g., Means et al., 2013). The pandemic, of course, has much broader co-occurring negative effects, and most published COVID-19 studies report substantial learning losses in compulsory education (Betthäuser et al., 2023; Moscoviz & Evans, 2022). Subsequently, we expect student cohorts who experienced the COVID-19 pandemic in higher education to show lower academic success compared with student cohorts from pre-pandemic academic years (H1). Indeed, the pandemic is associated with a crisis-response migration to (partial) distance education, concurrently with other pandemic restrictions and health concerns (Adedoyin & Soykan, 2020). A forced implementation of (partial) distance education on a larger scale was thus unavoidable (OECD, 2021). To the best of our knowledge, no study has compared academic success in one or more pre-pandemic years and a full pandemic year in higher education.

2 Role of student characteristics

The SCT of Bandura (1986) highlights the interplay between cognitive or personal (e.g., self-efficacy) and environmental factors (e.g., support, barriers), among others, to understand their effects on outcomes like academic success. Interactions of SES and other student characteristics with the pandemic's impact on academic success could thus (partially) explain which types of students are more influenced by the pandemic (Kintu et al., 2017; Rodríguez-Hernández et al., 2020). Therefore, we evaluate the moderating role of various background and (non-)cognitive student characteristics in the relationship between the COVID-19 pandemic and academic success in higher education (RQ2). Due to the unforeseeable nature of the pandemic outbreak, the present study includes the student characteristics that are already used in a longitudinal project linking study orientation with academic success. A unique opportunity thus presented itself to collect numerous student-level variables during the pandemic in an exceptionally large population.

2.1 Background characteristics

Pre-pandemic meta-analyses on SES reveal a moderate to strong relation between SES and academic success in primary (Liu et al., 2020) and secondary education (Çiftçi & Cin, 2017), in favor of high-SES students. The same applies for higher education, although the association is weaker here (Rodríguez-Hernández et al., 2020). In the (partial) distance learning context, high-SES students also seem to benefit more from the mainly positive influence of (partial) distance learning on academic success (López-Pérez et al., 2011). Indeed, consistent with Bandura's (1986) SCT, an economically and/or socially disadvantaged background can create barriers in terms of accessibility and affordability to e-learning infrastructures and hinder the desired (parental) supportive environment for (partial) distance learning (OECD, 2021; Pokhrel & Chhetri, 2021). Meanwhile, systematic reviews show that, both in compulsory and higher education, the pandemic effect seems to interact with SES. Low-SES students appear to have larger learning losses than high-SES ones (Betthäuser et al., 2023; Donnelly & Patrinos, 2021; Moscoviz & Evans, 2022). PISA 2022 results also show that the SES (mathematics) academic success gap widens with seven score points (i.e., $d = 0.07$) compared with PISA 2018, averaged across OECD countries (OECD, 2023). Several underlying reasons can cause this gap. First, families with a high-SES background are more likely to foresee (psychological) support, which is understood as especially relevant in a crisis situation (Hammerstein et al., 2021). Second, low-SES students often experience more difficulty in obtaining access to technology needed for compensating the absent on campus student-teacher interactions (Azevedo et al., 2022; OECD, 2021). Third, lower SES seems to be associated with a higher risk of COVID-19 infection and mental distress (Anderson et al., 2020; Betthäuser et al., 2023), which could lead to lower study involvement. Therefore, in the present study, we expect to find lower academic success among low-SES students compared with high-SES ones. An additional negative impact of the pandemic, resulting in a wider socio-economic academic success gap, is hypothesized (H2).

For sex[4], literature reports that females outperform males in academic success across different educational stages (Voyer & Voyer, 2014). Related to (partial) distance learning, a meta-analysis finds no differences between females and males in online learning outcomes (Yu & Yu, 2021), even though males appear to hold a more favorable attitude towards technology use than females (Cai et al., 2017). Across OECD countries and compared with 2018, PISA 2022 findings reveal a widened (mathematics) academic success gap between females and males with four score points (i.e., $d = 0.04$) on average, in favor of males (OECD, 2023). However, the limited number of COVID-19 studies in higher education that investigated to what extent the pandemic's effect on academic success differs for females and males shows no interaction (El Said, 2021; Orlov et al., 2021). Other research indicates that female versus male university students experience greater negative impacts from the

[4] We recognize that the referenced studies use the term "gender" rather than "sex." The meta-analyses, however, included both research that uses "gender" as well as "sex."

COVID-19 pandemic in academics, struggling more with the shift to online learning and its effects on schoolwork (Prowse et al., 2021). This trend also applies to perceived social isolation, stress, and mental health (McQuaid et al., 2021; Prowse et al., 2021). Furthermore, frequent social media use as a coping mechanism during the pandemic intensifies the perceived negative effects on academics and stress for females, while affecting the perceived social relationships and mental health of females and males similarly (Prowse et al., 2021). In the present study, we hypothesize that sex does not moderate the relationship between the pandemic and academic success (H3), based on previous COVID-19 higher education studies (El Said, 2021; Orlov et al., 2021).

2.2 (Non-)cognitive characteristics

Meta-analytic evidence emphasizes that cognitive ability is arguably one of the strongest predictive factors of academic success (ρ =.54) that increases throughout educational stages (Roth et al., 2015). In the (partial) distance learning context, most researchers only control for prior academic success, used as a proxy for cognitive ability, when explaining the variance in academic success (e.g., Vo et al., 2020). Some higher education studies also investigated the potential moderating role of prior academic success in the relationship between online (Bettinger et al., 2017) or blended learning (Asarta & Schmidt, 2017) and academic success. Their results indicate higher academic success in face-to-face versus blended learning for students with lower levels of prior academic success (Asarta & Schmidt, 2017). Bettinger et al. (2017) also discover larger negative effects of online learning on academic success among students with lower prior academic success. Some COVID-19 research, only in compulsory education, examined how academic success of low-, (average-) and high-achieving students, using population percentiles (Schult et al., 2021) or relative error rates (Spitzer & Musslick, 2021), differ between spring 2020 and at least one previous academic year. However, these studies did not include measures of (prior) academic success derived from a pretest or academic success in one or more previous courses/educational stages. The present study contributes to fill this void by including prior academic success measures (i.e., hours of mathematics in secondary education and the secondary educational track), and language proficiency as proxies for cognitive ability. These factors are known as determinants of first-year academic success in higher education (Ashford et al., 2016; Heeren et al., 2021).

Besides cognitive characteristics, academic success is also influenced by non-cognitive socio-emotional skills and traits (Pierre et al., 2014), that are also assessed in our student sample. First, self-control can be described as the regulation of attentional, emotional, and behavioral impulses to accomplish long-term goals (Duckworth et al., 2019). This characteristic has a positive impact on academic success across different ages, as reported in a systematic review (Duckworth et al., 2019). Self-control even seems to explain academic success above and beyond predictors such as cognitive ability (Stadler et al., 2016). In a (partial) distance learning environment, self-control also positively influences students' higher education academic success. This characteristic encompasses, among others, the ability to

avoid distraction from interruption and to use time effectively. But, when adding self-regulated learning and online engagement, these factors mediate the relation between self-control and academic success, and the direct effect of self-control disappears (Zhu et al., 2016).

Second, motivation as a process of setting and striving for goals (Yu, 2021) can be distinguished in controlled (driven by external factors) and autonomous (driven by internal factors) motivation (Deci & Ryan, 2008). Recent meta-analytic evidence, including both compulsory and higher education studies, indicates that improved academic success is mainly found in students with higher autonomous motivation (Howard et al., 2021). Another recent meta-analysis, but focused on the (partial) distance learning environment, also shows positive effects of motivation on academic success across the world. Indeed, highly motivated students could be more (cognitively) engaged in (partial) distance learning (Yu, 2021).

Third, academic self-efficacy can be described as an individual's conviction to successfully attain the desired academic goals (Bandura et al., 1999). This characteristic is positively associated with academic success across different educational stages, according to a systematic review of meta-analyses (Schneider & Preckel, 2017) and a more recent meta-analysis (Talsma et al., 2018). Meta-analytic evidence in a (partial) distance learning context shows that self-efficacy positively influences academic success as this characteristic could also greatly impact (partial) distance learning engagement (Yu, 2021), persistence, etc. (Talsma et al., 2018). However, self-efficacy can also negatively influence academic success (Vancouver & Kendall, 2006), emphasizing the importance of distinguishing between the effort and comprehension dimensions of self-efficacy (Fonteyne et al., 2017). The effort dimension pertains to confidence in the ability to exert effort towards achieving academic goals and is positively associated with academic success. Conversely, the comprehension dimension relates to confidence in the ability to grasp course content. Overconfidence in the ability regarding this latter comprehension dimension can in fact reduce endeavor and subsequently result in diminished academic success (Fonteyne et al., 2017; Vancouver & Kendall, 2006).

Lastly, test anxiety can be defined as fear of or worry about negative evaluation (von der Embse et al., 2018) and shows a negative relation with academic success, as stated in a meta-analysis including compulsory and higher education studies (von der Embse et al., 2018). Some researchers find this negative influence of test anxiety on academic success as well when controlling for cognitive ability (Thomas et al., 2017). Further, the negative impact of test anxiety seems to be greater in an online proctored setting (Woldeab & Brothen, 2019). Other studies address that students with high test anxiety, in contrast, benefit more from online exams. However, these studies used an unproctored online setting (Stowell & Bennett, 2010) or online exams in a secure computer laboratory (Cassady & Gridley, 2005).

In general, interesting findings are found regarding the main effects of (non-)cognitive characteristics on academic success in the (partial) distance learning context. However, researchers rarely investigated the (non-)cognitive characteristics' moderating influences on the relation between (partial) distance versus traditional learning and academic success. In COVID-19 studies additionally, (non-)cognitive

factors' effects on academic success are currently understudied, which complicates the formulation of well-supported hypotheses in this regard. Simultaneously, belief in the pandemic's different impact on students is omnipresent (Iterbeke & De Witte, 2021), which emphasizes the relevance of including student characteristics in pandemic research. The present study addresses this research gap by investigating to what extent the pandemic interacts with (non-)cognitive characteristics in its effect on academic success in higher education.

3 Method

3.1 Participants

For the present study, we used secondary data from first-year university students of a large European university with eleven faculties and 42 bachelor programs, ranked in the top 75 of the Academic Ranking of World Universities (formerly Shanghai Ranking, see https://www.shanghairanking.com/rankings/arwu/2022). The FPPW Ethics Committee at Ghent University provided favorable advice for the project (application number *2016/82)*. The university is characterized by an open access system[5] with strictly stratified study programs; full-time first-year students do have an identical curriculum within a study program. Only students who enrolled in an open access higher education study program for the first time in the academic years 2015–2016 to 2020–2021 and participated in the longitudinal university-wide study orientation project at the start of their first year in higher education (Fonteyne et al., 2017) were considered.[6] A wide range of student characteristics were assessed through this platform, and linked to the first-year university students' academic success for the present study. This resulted in data from $N = 24{,}404$ (58% female, 23% low-SES group) over a six-year period. For more detail, see *Supplementary Information* (*SI)*, Tables S1 and S2.

3.2 Measures

3.2.1 Academic success

In Belgium, an academic year in higher education is split into two semesters, each ending in a first-chance exam period. For each course, students receive a score from 0 to 20, with a score of 10 necessary to pass. After the summer break, it is possible for students to retake an exam in the second-chance exam period if they failed on their first attempt. Furthermore, a number of ECTS credits (European Credit Transfer and Accumulation System credits) (European Commission, 2015) is linked to

[5] With only one exemption for the study programs Medicine, Dentistry, and Performing and Visual Arts. Students have to pass an entrance exam to follow these programs. For other programs, secondary education qualifications suffice.

[6] Re-registrants were not taken into account. This group of re-registrants includes students who did not fully pass their first year of the bachelor's program and re-enrolled for the same study program for a second time.

every course. Students in the model trajectory can take on and obtain a total of 60 ECTS credits per academic year. The distribution of these credits among the semesters depends on the study program but is approximately balanced.

For the present study, academic success was operationalized by using the final study success scores, thus including the results of the second-chance exam period (August–September). This dependent variable, study success, shows the ratio of a student's obtained amount of ECTS credits over a student's subscribed amount of ECTS credits. Study success was scaled from 0 (failed all enrolled courses) to 100 (passed all enrolled courses).

3.2.2 Cohort

The cohort variable was used as a measure for the COVID-19 pandemic. In general, all Flemish universities switched to (partial) distance education since March 2020. Key to our between-subjects study design is that the cohorts 2015–2016 until 2018–2019 relate to the students who started their first year of higher education in a non-pandemic academic year. Cohort 2019–2020 consists of the first-year students who experienced one-third[7] of a pandemic academic year (see also *SI*, Fig. S1 and S2), while cohort 2020–2021 experienced their entire first year of higher education in full pandemic (see also *SI*, Fig. S1, S3 and S4).

3.2.3 Student characteristics

The longitudinal university-wide study orientation test battery, deployed for first-year higher education students at the beginning of the academic year (see also *Participants*), was used to measure the student characteristics. For an overview, please see Table 1.

3.3 Analyses

For RQ1, we examined the relation between the pandemic and academic success in higher education, through a multilevel analysis using linear mixed-effects modeling. The cohort variable concerned the fixed factor and higher education study program the random factor. We calculated the conditional R-squared $\left(R_c^2\right)$ and marginal R-squared $\left(R_m^2\right)$ of the linear mixed model (Nakagawa & Schielzeth, 2012).[8] Further, Bonferroni-adjusted pairwise comparisons were performed to investigate the multiple comparisons of the estimated marginal means of study success (i.e., controlled for higher education study program as a random factor) between the cohorts. Because the cohorts have varying sample sizes, we used Hedges' g to calculate the effect sizes, which is adjusted based on the relative sample sizes. We applied the

[7] Note that two of the three exam periods (i.e., the first-chance exam period in the second semester and the second-chance exam period) did take place during the pandemic.

[8] Conditional R-squared reflects the proportion of the total variance in the multilevel analysis that is explained by both fixed and random effects. Marginal R-squared represents, on the other hand, the proportion of the variance explained solely by the fixed effects.

following rule of thumb: $g = 0.10$ (very small), $g = 0.20$ (small), $g = 0.50$ (medium), $g = 0.80$ (large), $g = 1.20$ (very large) and $g = 2.00$ (huge) (Marfo & Okyere, 2019).

For RQ2, Akaike's Information Criterion (AIC) was first employed within a stepwise model selection process to identify the best predicting model for academic success. Specifically, the AIC formula is expressed as:

$$AIC = wk - 2\ln L(m)$$

Here, k is the number of estimated parameters, w represents the weight of the parameter, and $L(m)$ signifies the maximum likelihood of the model m. The stepwise selection method considers all possible models with all available predictors. Ultimately, the model with the lowest AIC is identified, ensuring the optimal balance between model complexity and goodness of fit. As such, information loss is minimalized, and overfitting is avoided by sanctioning excessive use of predictors. In the present study, this best predicting model is the one that limits the prediction error between students' actual outcomes and their predicted results. Unlike traditional stepwise regression, this AIC-driven approach avoids reliance on statistical tests for the model selection criterion and is independent of the order in which variables are introduced, evaluating every conceivable model with the potential predictors (Burnham & Anderson, 2004). This method was particularly useful given our model's requirement to handle a considerable number of predictors, including cohort, the background and (non-)cognitive student characteristics and their interactions with cohort.

Second, a multilevel analysis on the resulting most optimal model to predict study success was conducted by using linear mixed-effects modeling. This time, the cohort variable and the other included background/(non-)cognitive student characteristics and interactions with cohort concerned the fixed factors and higher education study program the random factor. Prior to this, we also checked for multicollinearity by producing Variance inflation factor (VIF) values for each of the independent variables. VIF values below ten are generally acceptable, but values above five can indicate significant multicollinearity. Therefore, maintaining VIF < 5 is recommended to ensure reliable results (Marcoulides & Raykov, 2019). We also calculated R^2_c and R^2_m of the linear mixed model, and both R^2_m and unique R^2_m values of the fixed effects. The latter effect size measure concerns the differences between the R^2_m of the full model and the R^2_m of the model without a specific fixed factor. See also Footnote 8.

Third, the significant interactions in this model according to the multilevel analysis were examined in more detail through Bonferroni-adjusted pairwise comparisons. These comparisons rely on the estimated marginal means, which are the means extracted from our most optimal statistical model and thus controlled for higher education study program as a random factor and for the other appearing predictors in the model. Hedges' g was used for the effect size calculations of these pairwise comparisons (Marfo & Okyere, 2019).

4 Results

For RQ1, we investigated the effect of the pandemic on academic success (i.e., study success) in higher education, controlled for higher education study program as a random factor. Study success is expressed as the ratio between a student's obtained

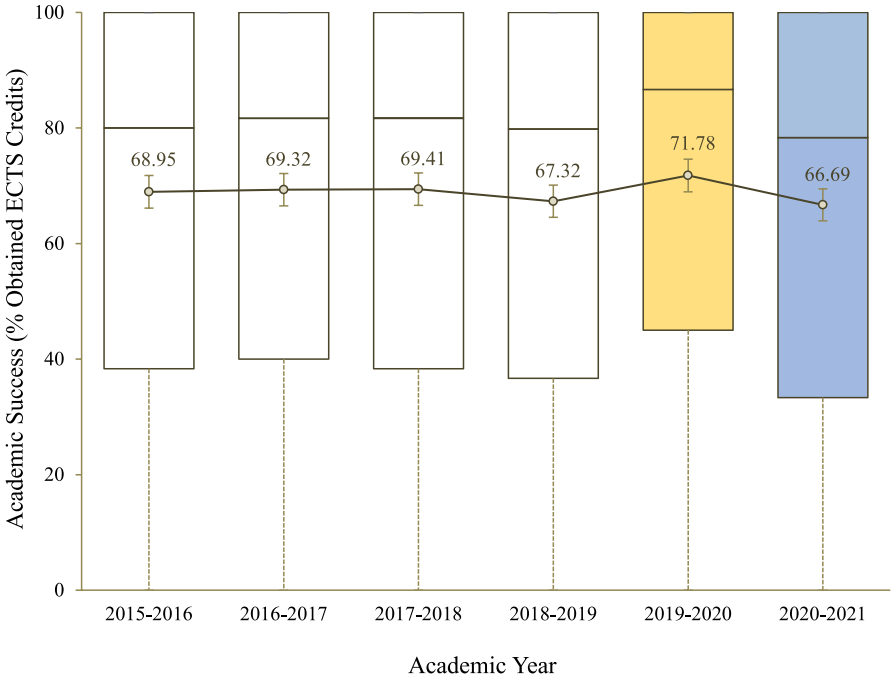

Fig. 1 Academic success per cohort. *Note*. Students' study success after the second-chance exam period (%) from cohorts 2015–2016 to 2020–2021. The white boxplots show the data distributions of the pre-pandemic cohorts, while the yellow and blue boxplots represent the cohorts of students who experienced a one-third and a full pandemic year, respectively. The estimated marginal means (i.e., controlled for higher education study program as a random factor) are represented by the grey dots, and the grey error bars show the 95% confidence intervals of these means. See also *SI,* Tables S3 and S4

amount of ECTS credits over a student's subscribed amount of ECTS credits (%). In what follows, study success should always be interpreted as the estimated marginal mean study success (i.e., controlled for higher education study program as a random factor and for other appearing predictors in the model). H1 stated that student cohorts who experienced the COVID-19 pandemic in higher education have lower academic success compared with student cohorts from pre-pandemic academic years. The linear mixed-effects model shows a significant difference between study success of the cohorts ($F(5, 24{,}377) = 11.04$, $p < .001$, $R^2_m = .002$, $R^2_c = .05$). See also Fig. 1. The Bonferroni-adjusted pairwise comparisons indicate that study success of the one-third pandemic cohort 2019–2020 ($M = 71.78$, $SE = 1.41$) is significantly higher in comparison with study success of the four pre-pandemic cohorts (difference range [2.36, 4.45], p's $\leq .049$, g's ≤ 0.13). Further, study success of the full pandemic cohort 2020–2021 ($M = 66.69$, $SE = 1.37$)[9] is significantly lower than the pre-pandemic cohorts 2015–2016, 2016–2017, and 2017–2018 (difference range [2.26, 2.72], p's $\leq .041$, g's ≤ 0.08). Additionally, cohort 2020–2021 shows lower

[9] Note that we find the largest variance for the full pandemic cohort 2020–2021.

study success than the year before (p <.001, g = 0.15). The differences in study success between two pre-pandemic cohorts are non-significant.[10] Considering these results, H1 is partially supported. For the descriptives, multilevel analysis results and pairwise comparisons' extensive results, see *SI*, Tables S3 to S4.

For RQ2, we examined how the impact of the pandemic (i.e., the different cohorts) on academic success (i.e., study success) interacts with background and (non-)cognitive student characteristics. For the correlation matrix, we refer to *SI*, Table S5. H2 stated an interaction between the pandemic and SES on academic success, with a wider socio-economic gap for the student cohorts who experienced the COVID-19 pandemic in higher education. H3 stated that sex does not moderate the relationship between the pandemic and academic success. An AIC procedure (see *Analyses)* on a pool of predetermined possible predictors selected an optimal regression model for the prediction of academic success. This final model contains (1) a set of predictor main effects including cohort, sex, SES, education type secondary education, hours of mathematics secondary education, vocabulary, self-control, self-efficacy (effort), self-efficacy (comprehension), test anxiety, autonomous motivation and controlled motivation, and (2) the interaction between the cohort variable and the student background variable SES. For a full overview, see *SI*, Table S6. No VIF-value above 2 is present, indicating no multicollinearity issues.

To continue, a multilevel analysis through a linear mixed-effects model on this most optimal predictive model for academic success was performed $\left(R_c^2 = .23,\ R_m^2 = .17\right)$, which shows a significant interaction effect between cohort and SES ($F(5, 24{,}348) = 2.92$, p =.012). See also Fig. 2. For the detailed multilevel analysis output, please see *SI,* Tables S7 and S8. The estimates for the interaction between cohort and SES are shown in *SI,* Table S9. Bonferroni-adjusted pairwise comparisons indicate that the study success of students from the low-SES group is significantly lower than for students from the high-SES group. This is the case for the four pre-pandemic cohorts (difference range [5.40, 7.63], p's ≤.010, g's ≤ 0.24), and a similar effect is found for the one-third pandemic cohort 2019–2020 ($|\Delta EMM| = 5.95$, p <.001, g = 0.19). The full pandemic cohort 2020–2021 shows a larger SES effect ($|\Delta EMM| = 10.23$, p <.001, g = 0.32). H2 is partially supported. Please see *SI,* Table S10 for an overview. As the interaction between cohort and sex is not included in this most optimal predictive model for academic success, we can support H3.

5 Discussion

To guarantee the continuity of learning, the COVID-19 pandemic required educational institutions to make an unprecedented and rapid shift to (partial) distance education (Moscoviz & Evans, 2022; OECD, 2021). As a cost of these educational

[10] Multilevel analyses by using linear mixed-effects modeling and Bonferroni-adjusted pairwise comparisons between cohorts regarding the included (non-)cognitive variables show that only minor fluctuations are found when controlled for higher education study program as a random factor, distributed across the cohorts. See also *SI*, Tables S14 to S16.

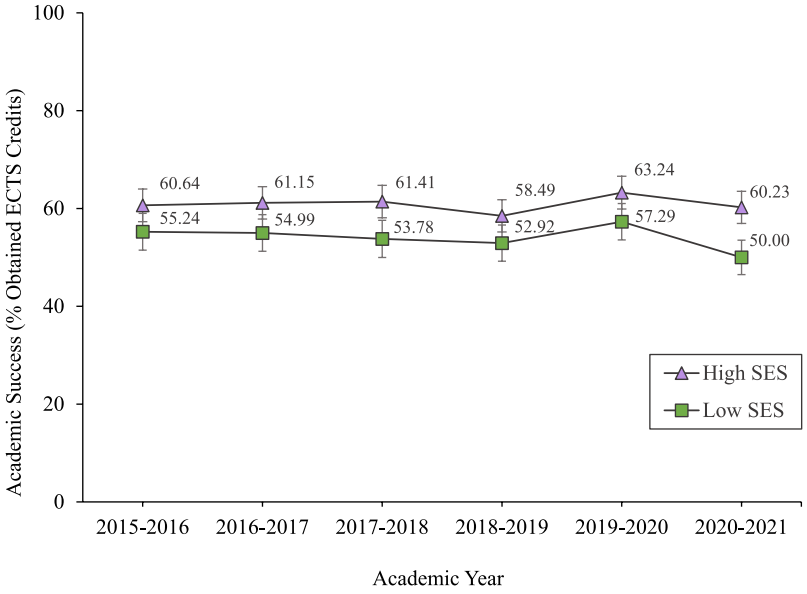

Fig. 2 Interaction between cohort and socio-economic status on academic success. *Note.* Differences in high- and low-SES students' study success after the second-chance exam period (%) from cohorts 2015–2016 to 2020–2021, based on the estimated marginal means from our most optimal predictive model. Students from the cohorts 2015–2016 to 2018–2019, cohort 2019–2020 and cohort 2020–2021 experienced a "normal," a one-third, and a full pandemic academic year, respectively. The estimated marginal mean values (i.e., controlled for higher education study program as a random factor and for the other appearing predictors in the model) are represented by the markers, and the error bars show the 95% confidence intervals of these means. See also *SI,* Tables S9 and S10

institution closures, potential learning losses and reinforcement of pre-existing educational inequality were assumed, and also observed (Azevedo et al., 2022; Berger & Archer, 2016; Betthäuser et al., 2023). To our knowledge, however, no study investigated possible learning losses in the full pandemic year 2020–2021 compared to one or more pre-pandemic years for higher education. Also, including both background as well as (non-)cognitive student characteristics as possible moderators in the relationship between the pandemic and academic success considers the principles of the Social Cognitive Theory of Bandura (1986) but is often overlooked (Betthäuser et al., 2023; Iterbeke & De Witte, 2021). Consequently, the present empirical study used data from a running longitudinal project to first investigate the pandemic's effect on academic success in higher education, measured as the percentage of obtained ECTS credits, from a macro-level perspective. Second, we examined the interactions between the pandemic and a range of background and (non-)cognitive student characteristics that are related to academic success (Schneider & Preckel, 2017; Voyer & Voyer, 2014). Therefore, we used a large sample of more than 24,000 students of a Flemish, top-100 university, across six years. The final two cohorts experienced a one-third (2019–2020) and a full (2020–2021) pandemic year.

Regarding the first research question, a surprising main finding of our study is the higher mean study success of students from the one-third pandemic cohort

2019–2020 compared with two out of four pre-pandemic cohorts. Translated to ECTS credits, these differences correspond to two to three obtained ECTS credits[11] (to put this in perspective: three ECTS credits is equivalent to a small one-semester course). For the sake of argument, we also compared the mean study success of this cohort with the four pre-pandemic year cohorts as a whole, controlled for higher education study program. Students from cohort 2019–2020 show higher study success than students from cohort 2015–2016 to 2018–2019, with a two obtained ECTS credits difference.[12] The increase in study success for cohort 2019–2020 differs from what we expected and observed in compulsory education (Betthäuser et al., 2023), but the effect sizes are small. From a macro-level perspective, the crisis-response migration towards (partial) distance education and the simultaneous other pandemic restrictions and health issues in 2019–2020 do not seem to negatively affect academic success in higher education. Some researchers address adaptation of learning content and exams, provision of alternatives for tasks and practical sessions, and/or grading differences as possible reasons for improved academic success (e.g., Bird et al., 2022; Rodríguez-Planas, 2022).[13] These factors, in turn, could have been beneficial in terms of additional learning time for the students, which is also voiced as a possible contributor to increased academic success in a blended learning environment (Means et al., 2013; Vo et al., 2017).[14] In compulsory education, however, the amount of learning time halved from 7.50 hours to 3.70 hours per day during the first school closures (Werner & Woessmann, 2021). Students and parents appear to invest more time in learning activities when diversified educational inputs are provided (e.g., live contact hours) (Bansak & Starr, 2021). In March 2021, one year later, students are found to spend 4.6 hours per day on school-related activities (Werner & Woessmann, 2021). Further, some researchers conclude that a general change in the autonomous learning process of students can be responsible for the

[11] We calculated the amount of obtained ECTS credits by multiplying the percentage of academic success by the amount of subscribed ECTS credits. The number of subscribed ECTS credits is fixated on 60, as this is the standard program in the EU Bachelor (ISCED level 6) for first-year higher education students. One ECTS credit is equivalent to a mean of 30 study hours in order to successfully complete a course.

[12] We are aware of the difference in sample size between these groups. See also *SI*, Tables S11 and S12.

[13] For the present study, possible indications of altered requirements during the pandemic in 2019–2020 can be found in study progress analyses presented for the Education Council (personal communication, March 17, 2022). These analyses show that by the end of 2019–2020, within the group of re-registrants (see Footnote 6), the results are remarkably higher than in previous cohorts. Moreover, at the end of 2019–2020, fewer first-year students receive a binding condition (i.e., academic success lower than 50% at the end of the first bachelor's year), but this group does score lower in 2020–2021 compared with previous cohorts. Similarly, re-registrants without a binding condition (i.e., more than 50% but less than 100% academic success at the end of the first bachelor's year) show a decrease in academic success in 2020–2021 in comparison with cohort 2019–2020.

[14] One might wonder whether students had more opportunities to cheat in the academic year 2019–2020. During the second semester of 2019–2020, undergraduate exams at Ghent University were conducted on campus with strict social distancing measures. Exams were held in three daily sessions in large auditoria and convention halls, each lasting no more than three hours with breaks for disinfecting. Students wore masks, sat 1.50 meters apart, and movements were managed carefully (Van de Velde, 2020). These controlled conditions likely reduced opportunities for cheating and underscored the university's commitment to academic integrity during the pandemic.

improved academic success during the pandemic in higher education. In fact, the pandemic has caused a new scenario for the students. No previous similar experience may have contributed to more consistent course attendance by students and more continuous monitoring of their learning process (De Paolo et al., 2022).

On the other hand, the full pandemic cohort 2020–2021 shows the lowest mean study success contrasted to the pre-pandemic cohorts 2015–2016 to 2017–2018. The differences are small and amount to approximately one to two obtained ECTS credits. The effect of the pandemic is thus limited, but important to point out. In fact, during the pre-pandemic years, we observe normal fluctuations, while academic success differences are found between the full pandemic cohort 2020–2021 and certain pre-pandemic years. Similar to cohort 2019–2020, we also examined the mean study success of cohort 2020–2021 with the four pre-pandemic year cohorts as a whole, controlled for higher education study program. Students from cohort 2020–2021 show lower mean study success than students from cohorts 2015–2016 to 2018–2019 (i.e., difference of two obtained ECTS credits) (see Footnote 12). The many side effects of the pandemic seem not to have compensated for the favorable learning effects of (partial) distance learning in pre-pandemic times (e.g., Vo et al., 2017). The findings are partly in line with our expectation to observe learning losses, as perceived in compulsory education (Donnelly & Patrinos, 2021; Moscoviz & Evans, 2022). However, the effect sizes are rather small and not comparable to the months of cognitive delay demonstrated for younger children (i.e., PISA scores) (OECD, 2023). From a developmental perspective, this implication is not that surprising. Indeed, assumptions are made that younger students seem to rely more on cognitive scaffolding during instruction, and their development of self-regulated learning skills might not yet be sufficient. Also, their vulnerability towards pandemic-related stress might be higher than among older students. Consequently, the pandemic can hit them harder in their learning compared with the university students tested here (Tomasik et al., 2021).

When specifically comparing students from cohort 2019–2020 and cohort 2020–2021[15], the first cohort obtained about three ECTS credits more than students from the second cohort. Several factors could contribute to the accumulation of learning loss in the first full pandemic year 2020–2021 relative to the partial pandemic year 2019–2020. A first possible explanation is that students of cohort 2019–2020 have experienced a "normal" first two thirds of their first higher education year and thus went through their first exam period when there was no pandemic yet. In this way, they had already become acquainted with the functioning of higher education. Second, these students had been able to be more socially integrated in the academic environment, which makes them better positioned to improve their academic success (Kassarnig et al., 2018; Rayle & Chung, 2007). These experiences do not apply to students from cohort 2020–2021, as they started their first year of higher education in full pandemic. Moreover, these

[15] During the second semester of the one-third pandemic year 2019–2020, a shift to distance education (i.e., online education) occurred. During the full pandemic year 2020–2021, both distance and partial distance education in the form of blended education were in effect. See also *SI,* Figures S1 to S4.

students from cohort 2020–2021 also had to complete their last year of secondary education during the pandemic, where large learning losses are observed (Betthäuser et al., 2023; Donnelly & Patrinos, 2021; Moscoviz & Evans, 2022). Third, while changes to assessment systems or course content/structure in 2019–2020 as a rapid response to the crisis may explain the higher academic success results for that cohort (e.g., Bird et al., 2022; Rodríguez-Planas, 2022), these altered requirements may have been less prevalent in the subsequent academic year of 2020-2021 (see also Footnote 13).

An additional interesting finding concerns the largest variance in academic success found for the full pandemic cohort 2020–2021. Some compulsory education studies also address the increase in heterogeneity of academic success during the pandemic (Tomasik et al., 2021). For example, the SES of students might explain the increasing heterogeneity in a full pandemic year, as low-SES students experience little to no access to and less support in (partial) distance learning than high-SES students (Kintu et al., 2017; Pokhrel & Chhetri, 2021). For more details, see *SI*, Table S13. In what follows, we elaborate on the possible moderating role of background and (non-)cognitive student characteristics in the relationship between the pandemic and academic success. Due to the unpredictability of the pandemic outbreak, the choice of these student characteristics was contingent on the accessibility of data from the running longitudinal project (see *Method*).

Regarding the second research question, the present study shows that SES is a moderating factor between cohort and academic success in the most optimal predictive model, although the impact is rather small. As assumed and in line with (pre-) pandemic research (Betthäuser et al., 2023; Çiftçi & Cin, 2017), we find lower study success for low-SES students compared with high-SES students. This gap between the low-SES and high-SES students seems to be smaller for cohort 2019–2020 than for cohort 2020–2021, with a difference of four obtained ECTS credits in cohort 2019–2020. A possible explanation lies in the fact that in 2019–2020 the students first experienced a two-thirds "normal" academic year, followed by the sudden shift to (partial) distance education during the academic year. This quick crisis-response might have resulted in adaptions of learning content and assessment (Gonzalez et al., 2020; Iglesias-Pradas et al., 2021) to make the sudden and anything but easy situation for the students first and foremost more bearable. This approach could have been advantageous in terms of learning time and consequently academic success for both low- and high-SES students.

For the full pandemic cohort 2020–2021, on the contrary and as hypothesized, the largest socio-economic gap is found, with a difference of six obtained ECTS credits. These students had not yet experienced the normal course of events in higher education, making the accessibility and affordability of e-learning infrastructures (Azevedo et al., 2022; OECD, 2021) and a supportive environment (Hammerstein et al., 2021) definitely important. These factors align with the SCT (Bandura, 1986), which indeed includes the role of barriers and support in influencing learning outcomes. For low-SES students, however, overcoming these crucial barriers and obtaining support is even more challenging (Azevedo et al., 2022; OECD, 2021), and they are also more likely to suffer from COVID-19 infection and mental distress (Anderson et al., 2020).

Interestingly, our findings also indicate that, besides the rather small interaction effect with SES, the pandemic does not interact with the many other student characteristics included in the present study. In line with previous COVID-19 research in higher education (El Said, 2021; Orlov et al., 2021) and a meta-analysis regarding (partial) distance learning (Yu & Yu, 2021), sex (see also Footnote 1 and Footnote 4) does not moderate the relationship between the pandemic and academic success. Furthermore, no interaction effect is found for education type (i.e., followed track) in secondary education, hours of mathematics in secondary education, vocabulary level, self-control, self-efficacy (effort), self-efficacy (comprehension), test anxiety, autonomous and controlled motivation. Note that despite the absence of such interactions, we do observe main effects on academic success for each and every of these characteristics in our most optimal predictive model. These student characteristics are thus important for academic success but do not affect the, from a macro-level perspective, influence of the pandemic learning situation.

When controlling for the other variables, first, we replicate better study success for females (Schneider & Preckel, 2017). Second, hours of mathematics in secondary education and language proficiency positively influence study success, and following general secondary education (versus technical secondary education) is associated with higher study success, which confirms the findings of existing literature (Ashford et al., 2016; Heeren et al., 2021). Third, the positive main effects of self-control, autonomous motivation, self-efficacy (effort), and the negative main effect of test anxiety are also in line with previous research regarding the influence of these factors on academic success, both in a general (Howard et al., 2021; Talsma et al., 2018) and in a (partial) distance learning environment (Yu, 2021; Zhu et al., 2016). Fourth, in contrast to the effort dimension of self-efficacy, the comprehension dimension of self-efficacy negatively impacts study success. This finding is consistent with research that indicates that this comprehension dimension can result in reduced endeavor and consequently in decreased academic success, due to one's overconfidence in comprehension abilities (Fonteyne et al., 2017; Vancouver & Kendall, 2006). Such evidence reinforces the necessity of addressing both self-efficacy dimensions distinctly to fully understand their implications on academic success. Finally, whereas previous research does not find a positive effect of controlled motivation on academic success (Howard et al., 2021), we do notice a main effect when controlling for the other included variables.

To our knowledge, investigating the potential influence of student characteristics (other than SES and sex) on the relationship between the pandemic and academic success in higher education is missing in published COVID-19 studies. We find significant main effects of these included student characteristics in combination with null interaction effects. These results, observed in a large sample with lots of statistical power, confirm that these characteristics are not moderators of the pandemic's effect on academic success, unlike SES.

Strengths, limitations, and future research suggestions

The present study contributes to the currently less prevalent literature on the impact of the COVID-19 pandemic on academic success in higher education than in compulsory education, which we approached from a macro-level perspective. The crisis-situation instigated a sudden and compelled shift in (inter) national educational

organization toward (partial) distance education, simultaneous with other (e.g., social) restrictions and health issues. Although the data analyzed in this study are from a single university, eleven faculties and 40 bachelor programs were included and controlled for. Due to the unforeseen pandemic, we relied on secondary data from an ongoing longitudinal study orientation project. Indeed, this way we could track changes over several academic years and include both background and (non-)cognitive student characteristics. As a result of our prospective study over a time period of six consecutive years, we can make statements about academic success in terms of the percentage obtained ECTS credits (i.e., meeting minimum requirements) of different pre-pandemic cohorts compared with the one-third pandemic cohort 2019–2020 and the full pandemic cohort 2020–2021. Given the university's open access system (see also *Method*), with also low tuition fees, and scholarships, the observed small impacts of the pandemic on academic success in higher education are even more striking. Indeed, open access institutions can attract a more diverse student body, associated with varied academic and socio-economic backgrounds (e.g., Read, 2016). In such environments, the lack of barriers to entry might lead one to expect more substantial disruptions during a crisis like a pandemic compared with more selective systems, because of potential inequalities in students' access to resources and support. Yet, the small effects observed suggest effective mitigation, possibly resulting from sufficient institutional support and student resilience. This finding also highlights an opportunity for future research to compare open access systems with more selective environments, providing insights into the effectiveness of different educational models.

Moreover, the present study can contribute to the general discussion about (partial) distance learning. Indeed, our research can be viewed as a live case study, akin to an experiment with randomly varying resources. However, the use of cross-sectional data in the present study is important to acknowledge. Particularly, students in 2019–2020 experienced traditional higher education with social interaction. Additionally, during the onset of the pandemic in the second semester, one could say they had more time to study. This period thus comprised face-to-face learning followed by complete distance learning. Speculatively speaking, the combination of these two factors may have resulted in higher academic success and not widening the gap between low- and high-SES students. In contrast, students in 2020–2021 spent the entire academic year during the pandemic, without a period of only face-to-face learning. Although more time to study was still a factor, these students did not experience traditional higher education, which could be a reason for the lower academic success and the wider gap between low- and high-SES students. We again would like to emphasize that these considerations are made on the basis of prospective, descriptive data of academic success in a big, real-life population. The nature of this dataset does not allow strong statements about causal mechanisms underlying the observations, without further research.

Also important to mention is the possibility of assessment biases, although the university does have standards, practices, and testing systems in place. Educators had to make strategic choices that could have involved some degree of lenience at the onset of the pandemic in March 2020, followed by a potentially greater emphasis on basic competences in the assessment periods. This approach might have resulted in the improved academic success in the one-third pandemic cohort 2019–2020. However, this comment also applies to compulsory education and the full pandemic

cohort 2020–2021, in which academic success does deteriorate (to a limited extent for higher education).

Furthermore, including actual grades (e.g., GPA) as a measure of academic success was not possible here due to privacy reasons and ethical clearance, but is recommended for follow-up research. We do acknowledge that GPA is a well-established measure for assessing academic success (Richardson et al., 2012). However, York et al. (2015) advocate for future research to focus more on using alternative measures of academic success beyond GPA. Indeed, GPA does not necessarily reflect the extent to which a student successfully completes their academic year. Students with similar GPAs may differ in the consistency of their academic performance and the total credits ultimately obtained. Indeed, GPA is more sensitive than study success to individual grades across diverse courses. Additionally, study success is based on ECTS credits, a recognized standardized system within European higher education designed primarily to measure and compare academic success across higher education institutions (European Commission, 2015). Also, we are aware that the measured academic success does not result from standardized testing. For higher education studies, however, the use of interuniversity standardized exams is more difficult than in secondary education, given the unavailability of such exams in higher education.

As the pandemic was still ongoing during the academic year 2021–2022, future research (in compulsory and higher education) could focus on academic success and student characteristics by considering more different pandemic and pre-pandemic years. Including post-pandemic years will also provide added value, even more so through a longitudinal approach.

6 Conclusion

The goal of the present study was to assess the pandemic's effects on academic success from a macro-level perspective and compare them with the substantial negative impact observed in compulsory education literature. We included four pre-pandemic cohorts, one cohort that experienced one-third of their first higher education year during the pandemic, and one cohort that had their entire first year during the pandemic. We also investigated the moderating role of theoretically relevant student characteristics in the relationship between the pandemic and academic success. The observed learning losses in higher education are rather small and more limited compared with compulsory education, with minor differences over SES. Practically, awareness of the vulnerability among the low-SES students remains extremely important, and additional support is recommended.

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Declarations

Competing interests The authors declare no competing interests.

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