Social tie formation of COVID-19 students: evidence from a two-cohort longitudinal study

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Abstract
The COVID-19 pandemic and the consequent move of higher education to online courses has disrupted the learning paths of many students. Social network data were collected from two cohorts of students, those starting their higher education in normal conditions in 2017 and those starting in 2020 during the pandemic. The findings showed that students in the 2020 cohort reported making fewer connections at the beginning of the first semester and developed significantly fewer connections during the first semester. Female students lost the relative advantage they had compared with male students in developing new connections. Based on our findings, and because of the importance of social connections made during the first year of study, the 2020 cohort will need considerable support in catching up with previous cohorts. The findings provide strong support for the assumption that online studies offer limited possibilities in building social connections compared with on-campus education.

Keywords Social networks · Higher education · COVID-19 · Online classes · Higher education experience

Introduction
Social networks, in particular friendship networks, matter for students in higher education (Felten & Lambert, 2020; McCabe, 2016). Having more connections with fellow students has been shown to lead to better performance (Baldwin et al., 1997) and for first-year students, connecting with similar students is important for their retention (Wilcox et al., 2005). Recent research on Swiss students during the COVID-19 lockdown has, however, shown that students reported fewer interactions with students, and their mental health deteriorated compared with reports by the same students before the lockdown (Elmer et al., 2020). This could potentially have serious implications for higher education, as students
who started their education during the pandemic do not have the same social capital as those starting their studies on campus.

This social network analysis compares the social networks of students starting their education during the COVID-19 pandemic to social networks of students who started the same undergraduate courses 3 years earlier in a normal on-campus environment. In both cohorts, data on social ties along with some background information (such as gender, grade point average, and age) was gathered 1 week after the beginning of the school year and then again in the middle of the second semester of studies. The number of ties each cohort has at these two points in time are compared together with formation of new ties. The findings indicate that the students starting their undergraduate degree program during the pandemic have fewer connections and their social network did not develop over the first few months of studies the way that the social network of students starting the same degree programs 3 years earlier did. Because of this, university administration staff and teachers need to take into account that students who started their education during the pandemic might not have the same peer support as previous cohorts as outlined in the discussion.

**Literature review**

**Social networks in higher education**

The use of social network analysis is useful in a wide variety of social settings. The social network perspective encompasses “theories, models and applications that are expressed in terms of relational concepts or processes” (Wasserman & Faust, 1994, p. 4). This approach has been applied to online social networks and social media sites, but it is not limited to such platforms. Rather, it is characterized by the assumptions that individuals, who are sometimes referred to as “actors” or “nodes” in the network, are interdependent, and that this interdependence can be understood by examining their relationships with other individuals, which are sometimes referred to as “connections,” “ties,” or “edges” in the network. Social networks have been shown to have important implications for information transfer (Baer, 2010; Granovetter, 1973) and research in higher education show that the number of connections students have are important for their performance (Baldwin et al., 1997). There are also indications that informal connections are the most important in facilitating students’ advancement (Hommes et al., 2012). Interviews with first-year students further indicated that connecting with similar students is important in preventing “drop out” (Wilcox et al., 2005). The results of a long-term study of social networks among higher education students indicated that early connections are important throughout the time of study (Kossinets & Watts, 2009). Building social connections in the first year of study thus seems important.

Previous findings showed that in developing their social networks, students who entered with larger networks tended to create more connections than those who began with a smaller network (Zander et al., 2018). Students with larger networks at the beginning of their studies were further found to be more likely to keep their connections (Cho et al., 2007) and increase their network (Zander et al., 2018). Conversely, research has also shown that students at the margins of social networks, despite having fewer connections, were found to be more likely to create more connections (Cho et al., 2007). Although these findings could be seen as being in conflict, the inconsistency could also reflect the fact that the focus of the above research was on the two ends of the spectrum with regards the size
of social networks. In other words, it could be that both well-connected students with large networks and marginalized students with small networks are more likely to create new connections than students with average-sized networks.

Social networks in higher education have been found to have a dual connection, as they are both connected to study relationships (instrumental) and friendship (support) (Fjelkner-Pihl, 2022b; McCabe, 2016). The distinction between these is however not always clear as research has shown that friendship ties that evolve into study relationships have been found to be particularly important for students’ success (Stadtfeld et al., 2019). Research on complex social ties that cover both friendship as well as connections related to studies further indicate that they often overlap (Fjelkner-Pihl, 2022a, 2022b; McCabe, 2016). McCabe (2016) finds that students’ social networks differ in that some students have a tight network, where the connections are both related to study and friendship, whereas other students compartmentalize these connections or even “sampled” them in individual connections. McCabe findings do however indicate that the support is greater in the tight networks and those who sampled their connections did not seek support from their network.

The size and growth of social networks are however not the only thing that matters. Social networks do need to change and adapt as students progress in their studies. Wang et al. (2018) showed that connections with other students with negative attitudes toward their studies could have a negative impact on a student’s own attitudes. It is therefore important for students to build supportive connections and shed those that do not support their education (Rios-Aguilar & Deil-Amen, 2012). Losing ties that are not beneficial might, however, not be as easy if the student is in a tight network (McCabe, 2016).

There is limited amount of research on social networks in online courses in higher education. Research has shown that students centrally located with higher number of connections did better than students with fewer connections (Cho et al., 2007). However, there are indications that the networks created in online courses are limited to the course and do not extend to longer term relationships when teachers stop initiating activities (de Lima & Zorrilla, 2017). Thus, even if students have managed to build some connections in their online courses during the COVID-19 pandemic, these connections might not be strong enough to carry over into subsequent academic years.

Given the lack of connections in online education the question remains whether higher education institutes can support connections between students. Research has shown that making large classes seem smaller fosters connection between students (Hommes et al., 2014) and two experimental studies indicate that groups created by the university can influence social networks (Boda et al., 2020; Rientes & Nolan, 2014) although the effect might diminish over the academic year (Boda et al., 2020). The limited long-term effect might, however, be explained by students acknowledging that interventions help but that they only keep those connections that “work” for them (Fjelkner-Pihl, 2022a).

Higher education during the COVID-19 pandemic

Most previous research has been on emergency online teaching during the COVID-19 pandemic. Students felt that studying online increased workload and required more self-discipline than a traditional setting (Gelles et al., 2020). The attitude of students might further be important in how well prepared they were to deal with the move to online courses (Alqahtani & Rajkhan, 2020). Student groups were also affected differently by the transfer to online teaching during the pandemic. Female students were increasingly burdened by domestic duties, whereas male students reported having more free time.
When it came to online teaching male students were, however, less satisfied than female students (Flores et al., 2021).

Research on the effects of the COVID-19 pandemic on social networks has shown that students reported fewer connections during COVID-19 compared with reports by the same students before the pandemic. Under the assumption that social interactions should typically be relatively constant over the course of study, this finding suggests that the pandemic affected social networks, even of students who had opportunities to build face-to-face connections before all classes were moved online (Elmer et al., 2020). This is in alignment with research on work during the pandemic as comparison between network activities before and during the pandemic when people were working from home, showed that connections became more siloed and static during the pandemic (Yang et al., 2021).

The purpose of the present study is to examine the development of students’ social networks during the pandemic compared with that of students who started the same studies 3 years earlier, during what we now refer to as a normal situation in higher education. Comparing the social networks of students that were forced into online education to those of traditional students at the same university could yield important insights into how online education might lead to different patterns in making connections. We further believe that understanding the development of social networks of students in an online program is also important, as it is likely that the pandemic will result in increased offerings of online courses, as both academic staff and students have gained experience in and understanding of the possibilities of online education.

Method

Research context and participants

The research was conducted at the University of Iceland, a comprehensive public university with around 15,000 students. Compared with the rest of the world, Iceland was not as severely affected by COVID lockdown. With the exception of a complete lockdown during the first wave of the COVID-19 pandemic in spring 2020, the campus remained at least partially open for most of the school year from 2020 to 2021. Although subject to strict regulations, teaching in small groups was possible, and most departments prioritized splitting first-year classes into smaller groups and offering first-year students the possibility of coming to the campus at least once a week. However, many students were reluctant to come to campus, and there was a strong demand by students that exams should be held online to limit the risk of contracting COVID-19. Hence, few students used this opportunity to connect with their fellow students.

The participants in the study were students in the School of Social Science and the School of Engineering and Natural Sciences, which are the two largest schools at the university. These two schools offer a broad range of study programs to a large student population. The students’ initial participation in the study was at the beginning of their first semester. We then followed the same participants as they progressed through their studies. The first cohort of participants began in the fall of 2017, well before the onset of the COVID-19 pandemic. Because the 2020 cohort began their studies in the middle of the pandemic, we decided to replicate the study in order to collect data for a comparative analysis.
Data collection

The initial data collection was conducted during the first semester in September 2017 and 2020, 1 week after the beginning of the school year. Another wave of the data collection was conducted in February of the following year during the second semester. In the 2017 cohort, the data collection was then followed up by additional data collections in October during the third semester. The final wave of the data collection occurred in May during the sixth semester, near the end of the study program. Because corresponding milestones have not been passed in the 2020 cohort, comparison will only be made between the first two data points.

Data on student social networks were collected using a purpose-built survey tool, which was integrated into the student management system. This tool allowed the students to start typing a name and then select a student from a drop-down menu of all students registered in the respective schools. The collected data were divided by school, as the students could only name students in their own school, which led to two data sets based on the same survey. In each wave, students were prompted to name up to seven students, but they were allowed to list as many as they wanted. In the waves that were conducted after students had begun their university study activities, the students were asked to name the fellow students that they spent time with during their studies or in social activities. The first wave, however, was conducted at the very start of their studies, during their orientation programs or the very first course sessions that students attended, so time spent during studies or social activities was not applicable. In this wave, the students were therefore asked to name the students they knew best at the beginning of their studies. The procedure was identical for both cohorts.

Through the survey tool, we also asked students whether they had translocated before starting their university studies. Other covariates, including grade point average (GPA) on a 0–10 scale (range in data: 5 to 9.99), age (range in data: 18 to 59), and gender, were retrieved from the student management system. For two participants, gender was missing or non-binary. Because of the very low fraction (0.4% of responses), we omitted these observations because a statistical analysis of this group was not feasible. For the 2020 cohort, we also included, in the second wave, open questions on students’ experience of the online learning during the pandemic.

To obtain consistent data on ties in the first and second semesters, as well as on new ties between the semesters, we utilized only responses by participants who responded in both waves of the data collection. After the exclusion of missing or incomplete responses in either or both waves, there were 203 observations in the 2017 cohort of 1252 enrolled students. In the 2020 cohort, there were 248 observations of 1887 enrolled students. When comparing the participating student groups to the ones that did not participate, we found that students with higher GPA and younger students were somewhat more likely to participate but the difference was similar in the two cohorts. In both cohorts, female students were more likely to participate but even more so in the 2017 cohort.

For certain types of network analysis, a low response rate can be of concern, since analyses of social networks are known to be sensitive to missing data. In the following analysis, however, the focus is on comparing the two cohorts. With similar response rates and composition of students in two cohorts, any potential bias due to low response rate should be at place in both groups resulting in relatively unbiased comparison between them. In this case the response rates are similar, but female students were more likely to answer in the first cohort as stated above. It was therefore decided to investigate how robust our findings are to the difference in gender proportions in the cohorts.
To accomplish this, we used an adapted bootstrapping approach, where we produced 500 datasets where we had randomly removed data from female students from the 2017 group to make the gender proportions equal in the two cohorts. We then calculated the average number of ties in these produced datasets and compared to our results and found that the largest difference was less than 4%. We therefore concluded that the effect of the difference in gender proportions in the two cohorts was minimal and used all 451 observations in the analysis.

**Data analysis**

In addition to examining networks at single points in time, we used information about students’ social networks at two time points to identify variables regarding the formation of social ties. To identify variables related to tie formation, we calculated *new ties* as ties between a pair of students in the second wave, but not in the first. The number of new ties formed by a student was therefore not counted as simply the difference in the total number of ties between the two waves, but whether a new tie to a particular student was reported in the second wave. For example, a student with two ties in the first wave and three in the second wave could nevertheless have formed two new ties between them: one of the three ties might be an old tie (reported in both waves), one of the old ties might have been lost, and two new ties might have been formed.

In reporting descriptive statistics that compared the two cohorts and showed whether the populations differed, we applied Pearson’s Chi-squared test to the categorical variables and the Wilcoxon rank sum test to the continuous variables. Several multiple linear regression models were estimated, in which new ties were the dependent variable. The coefficients of such models are readily interpretable as estimating the effect of one variable while holding other variables constant. In the main analysis, we used ordinary least squares (OLS) for the estimation. This allows interpretation of coefficients as indicating that an increase in the independent variable by 1 unit increases the expected value of the dependent variable by the numeric value of the coefficient. In the present study, because the number of new ties implied counted data, the multiple Poisson regression would also have been appropriate, but it has the drawback that the interpretation of Poisson coefficients is much less intuitive. To confirm robustness, we performed all regressions using both OLS and Poisson. The results were equivalent in the two models regarding the statistical significance of coefficients, sign of coefficients, and direction of change in coefficients between cohorts. The results of the Poisson regression are available from the authors upon request.

All visualizations and statistical analyses were performed using the R software environment for statistical computing (R Core Team, 2021). Network manipulation and visualization were performed using the igraph package for R (Csardi & Nepusz, 2006). In other aspects of the data manipulation and analysis, we relied heavily on the tidyverse set of packages for R (Wickham et al., 2019).

**Findings**

**Descriptive statistics**

The initial descriptive statistics are shown in Table 1. They suggested that the observable characteristics of the cohorts were similar. The distribution of students in the two schools
was also similar, as were their GPAs. The percentage of male students was slightly higher in the 2020 cohort, although the difference was not significant ($p=0.07$). The percentage of students who were translocated prior to starting their university studies was also similar. This indicates that overall, the number of people students knew at the start of their higher education would be expected to be similar.

The most significant difference was in student age. The average age of students in the 2020 cohort was slightly more than 24 years, whereas the average age in the 2017 cohort was slightly under 22 years. Specifically, there was a statistically significant difference of 2.5 years ($p<0.001$) between the two groups. This finding was not surprising, as some students were older individuals who found themselves out of work because of the pandemic and chose to study rather than remain unemployed. This age difference needs to be taken into consideration in interpreting the results.

The network summary statistics are presented in Table 2, where the waves of data collected from both cohorts are shown side by side. The number of ties was much lower in the COVID-19 cohort in both the first and the second waves. In the first wave the difference in average number of ties was found to be 1.47 while in the second wave the difference was found to be 2.82. In both cases the difference was found to be significant ($p<0.001$). However, the difference in the number of ties was not as pronounced as the difference in the number of new ties formed between the waves. The 2020 cohort reported only 1.40 new ties (sd = 1.85) on average, compared with 3.54 (sd = 3.04) reported by the 2017 cohort, a difference of 2.14, which was both statistically ($p<0.001$) and substantively significant. The ratio of tie formation between the two cohorts was striking. The new tie formation reported by the 2020 cohort was less than 40% of that reported in 2018. In other words, over 60% of the relationships that first-year students could have expected to form with their fellow students in a regular year did not materialize for students who started their studies during the pandemic.

The reduction in new tie formation reported by the 2020 cohort was partially counteracted by a reduction in lost ties, as the 2020 cohort reported only 0.65 lost ties (sd = 1.21) on average, compared with 1.47 (sd = 1.81) reported by the 2017 cohort, which was a statistically significant difference ($p<0.001$). This could be interpreted as an indication that

| Table 1 | Descriptive statistics of individual-level variables |
|---------|---------------------------------------------------|
| Characteristic | 2017, $N=203^1$ | 2020, $N=248^1$ | $p$-Value$^2$ |
| Gender | | | 0.07 |
| Female | 133 (66%) | 142 (57%) | |
| Male | 70 (34%) | 106 (43%) | |
| School | | | 0.4 |
| Engineering and Natural Sciences | 124 (61%) | 141 (57%) | |
| Social Sciences | 79 (39%) | 107 (43%) | |
| Age | 21.9 (4.4) | 24.4 (7.0) | $<0.001$ |
| Grade point average | 7.23 (2.27) | 7.13 (2.23) | 0.5 |
| Translocated before starting studies | | | 0.6 |
| No | 153 (75%) | 181 (73%) | |
| Yes | 50 (25%) | 67 (27%) | |

$^1n$ (%); mean (SD)

$^2$Pearson’s Chi-squared test; Wilcoxon rank sum test
students, finding fewer opportunities for forming new ties, compensate by better maintaining their existing ties. It is worth noting, however, that because the 2020 cohort reported fewer overall ties in the first semester, the percentage of such ties lost over the course of the semester is almost the same. In 2017 students lost 55% (that is, 1.47/2.69), of their initial ties, but in 2020, students lost 53% (that is, 0.65/1.22) of their initial ties.

Overall, the findings imply that the networks in the COVID-19 cohort evolved at a significantly slower pace compared with the regular cohort and that a much greater proportion of the few ties present in the second semester were connections carried over from prior to the onset of the students’ university studies.

The findings also showed that in the 2017 cohort, the time between the first and second semesters was the period of greatest renewal of ties. Between the start of the first and second semesters, these students reported an average of 3.54 new ties (sd = 3.04), whereas between the second and third semesters, they reported an average of 1.85 new ties (sd = 1.91). Between the third and sixth semesters, an average of only 1.44 new ties (sd = 1.68) were formed. Therefore, in each subsequent wave of the survey, fewer new ties on average tended to be reported.

Figures 1 and 2 confirm the pattern demonstrated in Table 2. The difference in the number of ties was evident at the start of the first semester, but it became more pronounced in the second semester. The greatest difference in the number of new ties is shown in Fig. 3. In 2017, less than one of every ten (9.4%) students reported forming no new ties between the first and second semesters. In contrast, in 2020, 47.4% reported no new ties. In other words, almost half of the students did not report forming any new relationship at the start of the second semester. Some students formed new relationships during the pandemic, but the findings showed that the reduction occurred over the entire range. It is informative to look at the findings for a student in the 25th percentile, as shown in Fig. 3. In 2017, this somewhat socially active student would have been expected to report five new relationships; in 2020, the same student would have been expected to report only two.

Additional information about the structure of social networks and tie formation is provided in graphs of the actual networks. Figure 4 compares the networks of the two cohorts using a network graph. The figure shows four separate networks, each of which

| Table 2 | Descriptive statistics of network variables |
|---------|------------------------------------------|
| Characteristic | 2017\(^1\) | 2020\(^1\) | \(p\)-Value\(^2\) |
| Reported ties in each survey wave | | | |
| Ties in first semester | 2.69 (2.65) | 1.22 (1.74) | <0.001 |
| Ties in second semester | 4.78 (3.16) | 1.96 (2.1) | <0.001 |
| Ties in third semester | 4.63 (3.13) | | |
| Ties in sixth semester | 3.91 (3.08) | | |
| Reported new ties between survey waves | | | |
| New ties between 1st and 2nd semesters | 3.54 (3.04) | 1.40 (1.85) | <0.001 |
| New ties between 2nd and 3rd semesters | 1.85 (1.91) | | |
| New ties between 3rd and 6th semesters | 1.44 (1.68) | | |
| Reported lost ties between survey waves | | | |
| Lost ties between 1st and 2nd semesters | 1.47 (1.81) | 0.65 (1.21) | <0.001 |

\(^1\) Mean (SD)
\(^2\) The \(p\)-value for difference between means in 2017 and 2020
is formed by a different set of individuals. It shows the 2017 and 2020 cohorts of both engineering and natural science students and social science students. To allow the visualization of tie formation during the year, the ties that were reported to have formed at
the beginning of the first semester are shown in light blue, whereas new ties formed between the first and second semesters are shown in dark purple.

As shown in Fig. 4, the network of students in engineering and natural sciences is more clustered in both cohorts. However, the figure shows that the 2020 network was decreased compared with the 2017 cohort. Several findings should be noted. First, there was a much greater number of “social isolates” in the second cohort (i.e., people with no connections, which is illustrated as gray dots with no lines to other dots in Fig. 4). Second, the dark purple lines show new ties, which are scarce. Third, there was less evidence that existing relationships were complemented by new relationships or that existing groups were expanded. Instead, the findings indicated a bifurcation. On one hand, there were groups with existing ties that did not add new ties between the waves of data collection. On the other hand, there were groups that consisted of only new ties. It is possible that these groups were formed online. If so, they could be evidence of a split between new online relationships that were formed as a result of coursework and older in-person relationships without overlap.

As is evident from the above, in particular from Table 2 and Fig. 3, there was a large difference between the social networks of the two cohorts, especially in terms of new ties formed during the semester. However, it is important to rule out as far as possible that this difference was not caused by a third variable. For example, because the 2020 cohort was slightly older, it is possible that these older students were less inclined to form and maintain ties. Therefore, in Tables 3 and 4, we report the results of multiple linear regression models in which new ties were the dependent variable.

In Table 3, we show the difference between the cohorts regarding the maintenance of new ties when other key variables were considered. The coefficient estimate was negative at $-1.89 (p < 0.001)$. The negative and highly statistically significant coefficient estimate indicated that after controlling for all covariates, students in the 2020 cohort formed 1.89
fewer new relationships between the two waves of data collection, which was close to the raw difference of 2.14 shown in Table 2. The variance inflation factor (VIF) for the 2020 cohort variable was only 1.05, and the highest VIF (for the Engineering and Natural Sciences variable) was 1.14, indicating that multicollinearity is not an issue in this model.

The estimates for the other covariates are also worth discussing. Regarding gender, female respondents formed on average 1.23 more ties than the male respondents did ($p < 0.001$) across these two cohorts. Tie formation declined with age, but the decline was slight; only 0.04 fewer ties were formed per additional year of age ($p = 0.017$). Those who translocated before starting their studies tended to form more new ties, as did students who had high GPAs. Students in the engineering and natural sciences also formed more ties, which was consistent with the results shown in the network graph in Fig. 4.

The coefficient estimates shown in Table 3 were pooled across cohorts, which was relevant in determining whether the cohort difference persisted when control variables were included. However, they did not provide any insight into whether the predictors of new tie formation...
formation differed between the cohorts; that is, whether particular variables influenced tie formation either more or less during the pandemic compared with a normal situation. We therefore conducted a multiple linear regression model on each cohort, the results of which are shown in Table 4. As before, we calculated the variance inflation factors, and found them to be low (all variance inflation factors across both models and all variables presented in Table 4 were below 1.3) indicating that multicollinearity is not an issue in these models.

Although all coefficients were of the same sign for the two cohorts, there were some important differences. The estimate for gender was pronounced. In line with the pooled regression, the estimate for the 2017 cohort showed that female students reported significantly more new ties than the male students did. The adjusted difference was 2.13 ties (p < 0.001), indicating that after controlling for other variables, the female students reported 2.13 more new ties on average than the male students did. In the 2020 cohort, however, the gender difference was only 0.43 ties, which was not statistically significant (p = 0.073). These findings showed that tie formation was much more equal between the genders in the online setting.
The effects of age and GPA were similar across the cohorts. Although the coefficient for GPA was not significant in the 2017 cohort, the point estimate was almost the same. The difference between engineering and natural science students and social science students was smaller in the 2020 cohort.

In the 2017 cohort, students who translocated before starting their studies formed on average 1.28 more ties \((p = 0.004)\) than students who already resided in the city in which the university is located. In the 2020 cohort, this difference decreased to 0.17, which was not statistically significant. When all interactions were online, the increase in networks experienced by potentially marginalized students when they moved to a new town was not evident, which could have potentially increased their marginalization.

The final set of analyses was conducted to determine the way in which gender patterns in tie formation were affected by the pandemic. Figure 5 shows the distribution of connections at the start of the first semester according to gender and cohort. Figure 6 shows connections at the start of the second semester according to the same categories. Both figures show that in 2017, male and female students began with a similar number of connections, but during the year, the female students increased the size of their networks more quickly than the male students did. The comparison of the 2017 and 2020 cohorts did not show striking differences in how the networks of both genders evolved, with the exception that for both genders, the reported number of ties at each point was much lower in 2020 than in 2017.

Figure 7 shows the number of new connections formed between the first and second semesters according to the same categories. The pattern indicated by the regression models presented in Table 4 is evident. Although the female students formed more new ties than the male students did, the difference was much smaller in the 2020 cohort than in the 2017 cohort.

Two open questions were included in the second wave of the 2020 survey where students could state what they appreciated and what they disliked about their online learning
experiences. The students expressed happiness with the flexibility of online classes but the most common comments regarding what they disliked were about lack of connection with fellow students and teachers with more than half of the students (138 of 248) writing comments complaining about feeling lonely. No obvious patterns were seen between the number of reported connections with fellow students and the responses to the open questions.

Fig. 6  Number of connections at the start of the second semester by year and gender

Fig. 7  Number of new connections by year and gender
Discussion

Our findings showed that students who started their undergraduate degrees in 2020 reported fewer connections than students who started their studies in 2017. This finding was consistent when we corrected for small differences in the ages of the two cohorts. This finding is in line with Elmer et al. (2020), who found that students reported fewer connections during COVID-19 than before the pandemic. We found that the differences in reported connections between the two cohorts increased after the first semester. Most pronounced was the difference in newly formed connections over the semester. Students in the 2020 cohort formed on average 60% fewer new connections than students in the 2017 cohort did in the same period. This decrease occurred despite the university’s efforts to offer first-year students the opportunity to attend classes in smaller groups on campus. This indicates that even if diving students into smaller groups has shown an effect on social connection between students (Hommes et al., 2014) this was not enough to make up for the lack of connection in online classes. Given the importance of social connection for higher education students this is concerning (Felten & Lambert, 2020).

The lack of new connections during the pandemic clearly disadvantages the 2020 cohort, as more connections to fellow students have been shown to lead to better performance (Baldwin et al., 1997), and connections made in the first-year lead to better retention (Wilcox et al., 2005). Overall, connections made in the first year of study are important for students throughout their education (Kossinets & Watts, 2009). As the development of social networks reported by the 2017 cohort showed, networking activity was the highest in the first year, and it decreased as the students’ progressed in their studies. Thus, there is considerable value in comparing two separate cohorts of students who are at the same point in their studies, one before and the other during online teaching during the pandemic.

It is noteworthy that regarding new connections, the female students lost some of the advantage they had compared with the male students before the pandemic. There were no direct indications in the data regarding why this happened, but it is possible this was an extension of findings that women in higher education faced greater stress than their male counterparts during the COVID-19 pandemic (Gelles et al., 2020). This finding is in particular interesting in light of the findings of Flores et al. (2021) that male students were less satisfied with the online teaching than female students. It is also important to note that students who translocated in 2020 to begin their studies did not build connections to the same extent as similar students in 2017, which could potentially lead to their marginalization.

Somewhat counteracting the drastic reduction in the formation of new ties for the 2020 cohort is a reduction in lost ties. This could indicate that due to fewer opportunities these students were more attentive to maintaining their existing ties. Given that these students reported fewer ties at the beginning of the year, however, this could also be due to these students only reporting their closest connections in the survey at the start of the year, unlike the 2017 cohort, who reported everyone they had known and met on campus. It is also worth noting that in the case of lost ties, a reasonable to focus on the percentage of one’s existing ties that are lost over a certain period, and that because of the fewer initial ties in 2020, the percentage of ties lost was almost identical in the two cohorts.

It is to some extent positive that the findings indicate that students are actually able to maintain existing ties during these difficult times. This might indicate that they benefit from the support offered by tight social connections (McCabe, 2016). It is worth pointing out, however, that in some cases it can be important to shed connections that no longer support the progress and development of the student (Rios-Aguilar & Deil-Amen, 2012). As
connections with students with negative attitudes toward school can affect a student’s own views (Wang et al., 2018), it can be important for students to adjust their social network to support their education. In light of McCabes (2016) findings that losing connections that no longer serve the student is harder in a tight knit network this might mean that students did hang on to connections that do not serve them as they did not have opportunity to make new connections. Students might have entered the university with friendship connections but might not be building up the instrumental relationships they need in connections to their studies. Relying on older ties and a more static network structure could also impact the learning environment as a whole. Yang et al. (2021) reported similar patterns for information workers, as remote work led to more static and siloed networks that can make it more difficult to acquire and share new information. Thus, the potential silver lining of fewer lost ties in the pandemic cohort is considerably less bright than it might seem at first glance.

The question remains whether the 2020 cohort will be able to catch up with the 2017 cohort as they progress in their studies or whether the lack of connections in the first year set the students a difficult path in the long term. It is important for faculty who teach these students in later years to consider that students from these cohorts might not have the same peer support we are used to students having. And as the pandemic continued to impact teaching across the world in the years following 2020, other cohorts are likely to be similarly affected. Our view is that because the situation is so dire, it is also important that higher education institutions respond effectively to the lack of connections when they welcome students back on campus, offering students plenty of opportunities to collaborate so that they can pick up at least a few connections that work for them (Fjelkner-Pihl, 2022a).

The main conclusion derived from the comparison of the formation of new social ties between the 2017 cohort and students who started their education online in the fall 2020 during the COVID-19 pandemic indicates that compared to the 2017 cohort, the 2020 cohort did not adjust their social networks. Most significantly, they formed much fewer new connections. The implication is that students in the 2020 cohort may be at a considerable disadvantage throughout their higher education. It is our belief that universities need to play an active role in helping affected students make new connections and support the evolution of their social networks, as social networks play a significant role in students’ futures.

Limitations and future research

The research reported here is limited to students in two academic fields: the social sciences and engineering and the natural sciences. Those two fields were separated into two different networks, limiting the ability of students to report cross-field connections which might have offered insights into university-wide social relationships. Further research could systematically investigate differences in the development of social networks in different fields of study, concurrently comparing online education and on-campus education. Our study was limited to one public university in Northern Europe, where the effects of the COVID-19 pandemic were not typical. It is possible that the difference between the 2017 cohort and the 2020 cohort would have been even greater in universities where all courses were taught entirely online.
Another limitation is that the university is a public university that accepts all students if they have passed grammar school tests. The findings might differ in universities with a more competitive student population. The fact that the students represented in this study were forced to learn online during the pandemic must also be considered. These students might differ from students who self-selected into an online course. Students who self-select online education might therefore approach social networks differently. However, our study aimed to compare the development of social networks between on-campus and online learning in similar student groups. By comparing the two cohorts at the same university, we were in a better position to show the effects of online learning versus on-campus learning, independent of differences in students who actively chose between the two modes of learning. As with any survey research, there is also the possibility of non-response bias if the people who participated in the survey differ systematically from those who do not participate. Because our focus is on the comparison of two cohorts, this is less of a threat because any non-response bias would also need to differ systematically across cohorts, but it cannot be completely discounted. The research is further limited in that it only relies on quantitative data where qualitative date would have added to the richness of the data (Froehlich et al., 2020).

We hope that future research will address the limitations of the present study by adding to the understanding of the development of the social networks of undergraduate students, particularly by comparing the development of social networks in online settings in diverse contexts. The findings of such research could benefit universities in developing and implementing programs and activities to help online students develop social networks to the same extent as traditional on-campus students. And as the most immediate effects of COVID-19 recede, they shed light on one of the many ways in which the pandemic has the potential to affect whole generations over the longer term.

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Declarations

Conflict of interest The authors declare no competing interests.

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