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Abstract

As schools worldwide were forced to close due to the COVID-19 pandemic in early 2020, they struggled to switch to online education. Using Japan's nationwide administrative data, we examine the impact of schools' ICT equipment and teachers' IT skills on the provision of online classes, communication with students' families, and teachers' working hours during and shortly after the closures. To isolate supply-side effects, we exploit differences in ICT resources between public elementary and junior high schools using a municipality-level fixed effects model, the level at which ICT resources are decided. We find that basic ICT equipment was critical to implementing online classes, but IT skills were not. Furthermore, we observe no effect of ICT resources on schools' communication with families. However, IT skills were associated with teachers' working hours. In particular, weak IT skills resulted in a higher percentage of teachers working overtime.

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1. Introduction

In the early days of 2020, the COVID-19 pandemic forced many schools around the world to close, resulting in a widespread children's learning loss (UNESCO 2021). During these closures many countries turned to online education. Related studies have predominantly focused on the demand side, investigating how students' family backgrounds influenced access to remote/online education and the associated educational access gap (Andrew et al., 2020; Bacher-Hicks et al., 2021; Grewening et al., 2021; Ikeda and Yamaguchi, 2021; Akabayashi et al., 2023). However, many countries also faced supply side issues in providing high-quality online education given schools' information and communication technology (ICT) resources, namely ICT equipment and teachers' IT skills. Only a small number of studies have examined how school ICT resources affected the provision of online learning during the pandemic (Dincher and Wagner, 2021; Akah et al., 2022).

The first reason for this gap in the literature is the lack of data. Very few countries have systematic data on schools' ICT resources or educational practices during the pandemic. The second reason is the difficulty of separating the demand and supply sides of both ICT resources and access to online education. It is likely that schools in wealthier areas where demand for high-quality education might be higher are better equipped and staffed by more highly qualified teachers, making the effects of the supply side difficult to identify. An equally important concern is the overwork of teachers, as even schools with top-level ICT equipment and skilled staff cannot effectively provide online education if teachers are overwhelmed.

The aim of this paper is to examine how ICT resources at school affected the online education provision and teachers' working hours during the early stages of the pandemic using data on Japanese public elementary and junior high schools, the compulsory stage of schooling in Japan. Public schools in Japan are operated by local boards of educations (BoE), who also allocate major resources across schools, including ICT, following strict legal procedures. During the pandemic-induced school closures in Japan, most teachers did not switch to remote work, making ICT equipment available at school highly relevant. Notably, among developed countries, Japan has a very high availability of high-speed Internet connection (OECD 2020a), yet the use of ICT in education in schools is largely lacking (OECD 2020b, 2020c). During the school closures in the first wave of the pandemic, only a small portion of schools provided live online classes and other forms of digital education. Japan is also a country where teachers commonly work unusually long hours (OECD 2019), a problem that could be alleviated by better working conditions. Therefore, improving the supply side issues should be a priority in promoting access to online education and teacher welfare in Japan.

Whether ICT technology can improve teachers' teaching styles and thereby children's learning outcomes has been a central issue in education policy in recent years. Many studies have empirically investigated how policies providing computers to students or incentivizing ICT equipment purchases have affected students' learning, yielding mixed results. Angrist and Lavy (2002) conducted the first study formally examining the effects of funding for educational computers in Israeli schools, suggesting that an increase in teachers' computer use has no effect or a negative effect on children's learning. Goolsbee and Guryan (2006) analyzed the effect of Internet access investment subsidies in US public schools, concluding that, while there was a significant increase in Internet access at treated schools, students' test scores were unaffected. Machin et al. (2007) examined the effect of a change in policy rules allocating ICT funding to public schools, suggesting that there was an improvement in English and science but not in math outcomes. Using a randomized trial, Barrow et al. (2009) found that assigning computer-aided instructions improves pre-algebra and algebra test scores. Bass (2021) examined the effect of eligibility for ICT vouchers for public schools in California, finding a significant effect of voucher use on student achievement. Most recently, Lomos et al. (2023) using 2018 data from secondary schools in Luxembourg, a country with ample school ICT resources yet a relatively low ICT use in classroom practice, reported that teachers' technological knowledge is an important predictor of ICT classroom use. These studies examined the effects of ICT facilities on learning *at school*; however, during the COVID-19 school closures, the effective use of ICT at school was crucially important to providing instruction and supporting learning for students *at home*.

Early in the COVID-19 pandemic, Dincher and Wagner (2021) surveyed German elementary and secondary school teachers, finding that at-school ICT infrastructure did not predict the use of online teaching tools during school closures, while teachers' technical affinity did. The setting of this study is close to our paper; however, the initial level of ICT resources in Germany was vastly different from Japan, allowing Dincher and Wagner (2021) to focus on teachers' attitudes specifically. Furthermore, their paper does not attempt to separate the role of supply-side factors at school from the demand-side factors such as the characteristics of students and families. Nevertheless, Dincher and Wagner (2021) and Lomos et al. (2023) show that teachers' IT skills likely play an essential role in the impact of school ICT equipment on both at and out of school learning.

Moreover, school ICT equipment is expected not only to facilitate students' learning but also to improve teachers' work efficiency. In a typical school environment, principals and teachers hold discretion over how the benefits of improved productivity provided by additional ICT resources are distributed. For example, teachers may react to additional ICT resources by reducing time and effort spent preparing classes.[1] It is important to consider the distributional effects of a productivity increase when interpreting why previous studies on the effects of in-school ICT use produced mixed results. However, only a limited number of studies have directly assessed the impact of ICT resources on teachers' efforts at school (Bulman and Fairlie, 2016; Escueta et al., 2017).

In this study, we use a dataset combining several sets of government administrative data collected in 2020 from the entire Japanese public school system: a survey about school ICT resources; a survey about public schools' response to the COVID-19 pandemic; and a survey about teachers' overtime work. The combined dataset includes information about schools' ICT equipment, teachers' IT skills, length of school closures, types of remote education and communication channels with students' families during school closures, and teachers' overtime hours during the closures and in the following months at a municipality level for both elementary and junior high schools. Utilizing a municipality-level fixed effects model, we exploit the variation in schools' ICT resources within each municipality to isolate the supply side effect. Due to the centralized nature of resource allocation, the variation in within-BoE's ICT resources is likely related to BoE's budget implementation process. In addition to this empirical analysis, we conducted an online survey of public elementary and high school teachers to further the understanding of our results.

By presenting this research, we contribute to the growing literature covering pandemic-related school closures by simultaneously investigating the effect of school ICT resources on both the provision of online education and the choice of communication channel with students' families while also examining teachers' working conditions during and after school closures using Japanese data. Our results shed light on the distributional effects of ICT resources on both students and teachers, allowing causal interpretation. To our knowledge our paper is the first to comprehensively examine these topics.

Our results show that, during school closures, better ICT equipment was more relevant than teachers' IT skills to the provision of online education, but neither had any effect on communication with students' families using live online tools. However, weak teacher IT skills resulted in a higher percentage of teachers working extra hours, especially extreme amounts of overtime in the months following the reopening of schools. These results suggest that the impact of various ICT resources differs between students and teachers. A bottleneck to implementing online education in Japan was created by a shortage of ICT equipment, the distribution of which is determined at the municipal level but was not contributed to by teachers' IT skills. However, the persistent overwork of teachers in Japan may be due to a lack of IT skills at the individual level. Therefore, the effect of ICT resources is multi-dimensional and policy makers should be aware of

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[1] Reducing teachers' work hours should not necessarily be viewed negatively. In a society like Japan where teachers' hours of work are the longest among developed countries (OECD 2019), the stagnant use of ICT at public schools resulting in unappealing working environment may have created a difficulty in recruiting high-quality teachers. Additionally, Hojo (2021) showed that class size, in Japan typically large, is associated with teachers' overwork and their level of stress.

the importance of matching appropriate policy tools to their targets.

2. Data and setting

At the end of February 2020, shortly before the spring break, Japanese schools were ordered to close to prevent the risk of community transmission of the COVID-19 virus, first confirmed in Japan in January 2020. Many schools reopened at the beginning of the new school year, starting on April 1st, 2020, and closed again after a state of emergency was declared for Japan's most urban prefectures on April 7, 2020. The state of emergency was extended to all prefectures on April 16th, 2020, and lifted in waves from mid-May to late May 2020, prompting schools to reopen. This was the only period of pandemic-related mandated school closures in Japan. During this period, the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) implemented a series of surveys asking BoEs nationwide to report the details of school closures for the public schools in their jurisdiction, typically corresponding to a municipality. These details included the number of schools closed, specific steps taken to provide remote education to students, and steps taken to communicate with students' families. For the purposes of this paper, we use data collected through the Survey on Learning and Instruction during the COVID-19 Pandemic[2] as of June 23rd, 2020. According to this survey, conducted after schools fully reopened, the average length of school closures reported by BoEs was 24.6 school days for public elementary schools and 24.5 school days for public junior high schools. The percentage of BoEs reporting that live online classes were held in their district during the closures was 8.1% for elementary schools and 8.9% for junior high schools, and the percentage reporting the use of live online tools to communicate with students' parents was 9.4% and 10.3% for elementary and junior high schools, respectively. However, the survey asks only a binary question whether online education was implemented in a BoE at all, it does not inquire as to its extent. We come back to this point later in Section *4.3*.

Regarding schools' ICT equipment, public school resources are customarily determined by the school founding body, the local BoE. BoEs are highly sensitive to an equal provision of resources and teacher assignments to each public school of the same level, elementary or junior high. However, the weights placed on school levels might differ across municipalities. MEXT annually collects information on public schools' ICT resources, specifically ICT equipment and teachers' IT skills, through the Survey on ICT in School Education[3], of which we use the 2019 school year iteration, collected as of March 1st, 2020. While the survey results provide information about each public school separately, we aggregate the data on a BoE level to correspond with the data regarding the pandemic response. Across BoEs nationwide, 67.4% of elementary schools and 68.2% of junior high schools were equipped with high-speed (over 100 Mbps) Internet, and 83.6% of elementary and 83.5% of junior high schools were equipped with Wi-Fi. The average number of presentation devices capable of projecting digital materials (projector, digital whiteboard, digital TV) per regular classroom was 0.96 for elementary and 0.75 for junior high school. In order of elementary schools and junior high schools, the percentage of schools equipped with commercial digital instructional materials for teachers such as premade lesson presentation slides, was 57.4% and 64.3%. Digital textbooks for students were available in 9.5% and 10.0% of schools, and 76.5% and 77.1% used management software. Finally, 65.7% and 66.2% of schools had a set information policy regarding internal information.

The same survey also inquired about teachers' IT skills in four categories with four subcategories each, rating all teachers on a scale of "lacking," "mostly lacking," "mostly proficient," and "proficient" for each of the 16 items. The first category, A, is labeled as teachers' ability to use ICT for class preparation, grading, and administrative tasks. Taking the average across A-1 to A-4 subcategories, the BoE average of teachers considered as proficient in skill A was 43.4% for

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[2] Shingata Korona Uirusu Kansensho no Eikyo wo Fumaeta Gakushu Shido nado ni kan suru Jokyo Chosa (MEXT)

[3] Gakko ni okeru Kyoiku no Johoka ni kan suru Chosa (MEXT).

elementary schools and 46.9% for junior high schools. 1.2% of teachers in elementary and 1.8% in junior high schools were rated as lacking. Skill B is described as teachers' ability to teach classes using ICT. For elementary schools, 26.9% of teachers were considered proficient in skill B and 3.6% lacking, with these numbers for junior high schools standing at 27.3% and 5.8% respectively. Skill C is the ability to teach students to use ICT. 29.0% of elementary school teachers were rated proficient and 3.6% lacking in skill C, while 28.8% and 5.9% of junior high school teachers were rated as such. Finally, skill D is described as the ability to instruct students in the knowledge and attitude needed to utilize information. For elementary school teachers, 36.1% were deemed proficient in skill D and 1.6% lacking. For junior high school teachers, 34.3% were rated proficient and 2.6% lacking. As the relationship between underlying ability and the A-D categories and subcategories is unknown, we use principal component analysis over all 16 items and schools, then separate by school level before collapsing data to a BoE level to reveal the difference in overall IT skills for proficient and lacking ranks. For the purposes of our analysis, we standardized the IT skill indices to have a mean of 0 and a standard deviation of 1. Table 1 contains the summary statistics of the variables discussed so far.

Next, to examine how ICT resources affected teacher's workload during school closures and in the months after reopening, we use data collected through the Survey on Reform of Working Conditions in Schools by the Local Boards of Education[4] for years 2019 and 2020.[5] For each month from April to August, MEXT asks BoEs to report the percentage of school staff in their respective districts working 0 to 45, 45 to 80, 80 to 100, and over 100 overtime hours per month. The survey does not distinguish between types of staff; however, as staff is predominantly made up of teachers, we consider the data to be representative of overtime hours worked by teachers specifically. As Japanese teachers are known to work long hours, we use the 2019 data to establish the baseline rate of overtime. From here, we summarize the categories provided into two variables, one showing the percentage of teachers working over 45 hours of overtime and another over 80 hours of overtime, a threshold recognized by the Japanese Ministry of Health, Wealth and Labor (MHLW) as dangerous to health. Table 2 provides the averages across BoEs for elementary and junior high school teachers.

In the 2019 April-June period, around 56% of elementary school teachers worked over 45 hours of overtime and 16% worked over 80 hours on average across BoEs. In the same period, around 63% of junior high school teachers worked over 45 hours of overtime and 24% over 80 hours. In July and August, months partially overlapping with the summer break, these numbers decreased significantly. In April and May 2020, months during which mandatory school closures occurred, the percentage of teachers working overtime was similar to the summer break period for both thresholds, as all school activities were suspended. From July 2020, after schools reopened, the percentage of teachers working overtime increased dramatically; however, they did not reach pre-pandemic levels, likely because school activities remained limited to prevent infection. For all observed months and thresholds, junior high school teachers worked more overtime hours than elementary school teachers. However, the atypical situation, particularly the school closures, likely prevented schools from keeping accurate overtime records. The actual amount of overtime hours, especially in 2020, was likely much higher. Therefore, our results require a careful interpretation.

The 2019 round of the survey was its initial round and, while it inquired about several months in 2018, data for the full April-August period is available only for 2019. Additionally, not all BoEs provided data for each month, resulting in varying sample sizes, and fewer BoEs responded in 2019 than 2020. To use all the available 2020 data, we use single imputation by simple average to fill in the missing 2019 data points.

3. Empirical strategy

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[4] Kyoiku Iinkai ni okeru Gakko no Hatarakikata no tame no Torikumi Jokyo Chosa (MEXT).

[5] Unlike ICT survey, this survey is not legally mandated by MEXT, leading to a larger percentage of missing data. The wording of the relevant question also assumes digital record keeping of working hours. We find that relatively smaller municipalities are more likely to be missing; however, whether it affects our estimates based on BoE difference is not clear.

When selecting our empirical strategy, we faced three potential issues in the causal interpretation of the effect of ICT resources on remote education and teachers' overtime hours. First, schools in urban areas might be better equipped than schools in remote locations, both in terms of ICT equipment and more skilled teachers. Urban areas were also likely harder hit by the pandemic, possibly resulting in a higher demand for remote education and longer closures.[6] The fixed effects model at a BoE level allows us to address this concern, eliminating BoE-specific factors common to both elementary and junior high schools, such as the socioeconomic standing of the municipality or the degree of demand for remote education due to COVID-19. We also use a school-level dummy variable to control for level-specific effects, such as parents of older students likely having a higher income or higher demand for online education. The second concern is whether ICT resources are exogenous to the pandemic. Because ICT resources were measured before school closures, we believe this concern is negligible. Given the unexpected nature of the pandemic and the rigidities of the public school system, it is unlikely that more proactive BoEs at the time of the survey equipped schools with ICT resources in expectation of online education, which was first widely implemented in Japan during the pandemic. Third, as discussed in Section *2*, most of the data are aggregated at the BoE level, the decision-making level of school-level resources allocation, making BoE the unit of our analysis. It is therefore possible that our estimates suffer from bias due to classical measurement error. We examine these concerns in Section *4.3*.

The main underlying assumption of our analysis is that the BoE level fixed effects control for BoE characteristics that affect the provision of ICT resources common to both school levels within a single municipality, isolating the effects of the education supply side through the difference in ICT equipment and teachers' IT skills between elementary and junior high schools. This strategy is valid in identifying the effect of ICT resources on outcomes only if there is a sufficient within-municipality variation between the two school levels, and the within-municipality variations are not systematically correlated with unobserved factors that potentially affect variation in remote education and work hours of teachers. As presented in Table 1, the national average of some variables does not have a substantial variation; however, averages obscure the distribution of the variation. The within-municipality distribution reveals that the fixed effects strategy is suitable. Next, although there is no perfect way to test the second condition, we use simple linear regression to examine whether within-municipality differences in ICT equipment and teachers' IT skills between the two school levels are systematically associated with a set of municipality characteristics (population size and per capita income) and the number of COVID-19 cases in April 2020 in the corresponding prefecture. We do not confirm systematic correlation, but we further examine the validity of our assumptions in the robustness check.

To answer the question of how ICT resources affected schools' pandemic response, we employ the following model, assuming an equal effect on both elementary and junior high schools:

$$Remote\ education_{ij} = \alpha + \beta * ICT\ equipment_{ij} + \gamma * IT\ skills_{ij} + \delta_i + \mu D_j + \epsilon_{ij} \tag{1}$$

where remote education stands for the length of school closures measured in school days and dummy variables indicating the implementation of live online classes and live online communication with families in BoE i and on school level j. The term δ_i is a BoE i fixed effect, D_j is a school level dummy variable and error term ϵ_{ij} is two-way clustered at BoE and prefectural level. This model identifies the effect of the differences in schools' ICT equipment and teachers' IT skills between elementary and junior high schools within a BoE district on a common outcome.

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[6] A major limitation of COVID-19 pandemic-related research in Japan is the lack of detailed epidemiological data, as the Japanese government publishes the number of infections only on a prefectural level. While many municipalities disclose their data, these are typically metropolitan areas covering only a portion of our sample. Using a BoE level fixed effect model allows us to work around this problem and thus analyze the full national sample.

Expanding on the model in Equation (1) to capture the heterogeneous effect of the school level j, we incorporate interaction terms as shown in Equation (2):

$$Remote\ education_{ij} = \alpha + \beta * ICT\ equipment_{ij} + \gamma_0 * IT\ skills_{ij} + \gamma_1 * IT\ skills_{ij} * D_j + \delta_i + \mu D_j + \epsilon_{ij} \tag{2}$$

where γ_0 represents the baseline effect of IT skills and γ_1 represents the effect of IT skills that are additional to the school-level j.

Next, we analyze the impact of ICT resources on teachers' overtime hours during the school closures in April and May 2020 and after schools reopened for June-August 2020. In this analysis we focus on teachers' skills only and utilize ICT equipment variables as controls as teachers operate under set conditions. Equivalently to the previous analysis, we specify a baseline model (3) and a model incorporating interactions (4).

$$Overtime_{ijkt} = \alpha + \beta * ICT\ equipment_{ijt} + \gamma * IT\ skills_{ijt} + \rho * Overtime_{ijkt-1} + \sigma * Overtime\ imputed_{ijkt-1} + \delta_i + \mu D_j + \epsilon_{ijt} \tag{3}$$

$$Overtime_{ijkt} = \alpha + \beta * ICT\ equipment_{ijt} + \gamma_0 * IT\ skills_{ijt} + \gamma_1 * IT\ skills_{ijt} * D_j + \rho * Overtime_{ijkt-1} + \sigma * Overtime\ imputed_{ijkt-1} + \delta + \mu D_j + \epsilon_{ijkt} \tag{4}$$

The outcome variable $Overtime_{ijkt}$ is the percentage of teachers working over a specific number of overtime hours in month k (April-August) of year t ($t = 2020$) in BoE i and school type j. To account for the seasonality in working conditions over a school year, we also include the pre-pandemic overtime baseline $Overtime_{ijkt-1}$. As some values of $Overtime_{ijkt-1}$ are imputed, we also include a dummy variable $Overtime\ imputed_{ijkt-1}$ to account for the fact. The definition of the remainder of the terms in Equations (3) and (4) is identical to those used in Equations (1) and (2). All fixed effects models were estimated using Stata 17 *xtreg* command.

4. Results

4.1 Remote education

In Japan, where telework during the pandemic remained limited even for jobs easily performed remotely, teachers generally did not work from home during the school closures, making the analysis of at-school ICT resources relevant. Better school resources should generally contribute to children's learning, here measured by the provision of remote education, as schools cannot utilize a mode of remote education they are unable to provide.

However, our analysis focuses on the differences in the designated variables between school types on the BoE unit of observation and thus does not determine which factors contributed to the pandemic response in case the response or the provision of ICT resources was identical for both elementary and junior high schools within a municipality. We therefore find it instructive to start with a naïve specification showing overall association before presenting the results from our main specification. We display the results from Equation (1) omitting the BoE fixed effect δ_i in Table 3. Examining the results without BoE fixed effect, teachers' IT skills show the expected signs and significance. Better IT skills were linked to a higher likelihood of implementing remote education in columns (3) and (5) with weak IT skills decreasing this likelihood (columns (4), (6)) while also prolonging school closures (column (2)). High-speed internet was also associated with both longer school closures and higher likelihood of remote education. Moreover, schools better supplied with high level ICT equipment such as presentation devices in normal classrooms, commercial digital instructional materials for teachers and digital textbooks for students were more likely to adopt live online tools to hold classes or communicate with students' families. However, while omitting BoE fixed effect allows us to benefit from the original variation across school types and BOEs, it does not consider within-municipality unobserved local factors, making causal interpretation difficult. It is possible that better equipped schools are located in more urban areas, which could be harder hit by the pandemic resulting in a higher demand for remote education and longer closures. We thus for the remainder of this paper adopt the BoE fixed effects approach to eliminate common local factors, allowing for causal interpretation. The following discussion is made in this context.

Results from Equation (1) including the BoE fixed effect δ_i are displayed in Table 4. As seen in columns (1)-(2), we no longer confirm any consistent link between schools' ICT resources and the length of school closures. As schools were ordered to close, differences in school closure length likely occurred toward the end. The positive and significant estimate of the elementary school dummy suggests that other considerations were made, possibly related to students' age.

Turning to live online classes and live online communication with students' families, we find no effect of teachers' IT skills (proficiency or lack of skill) on live online classes within BOEs; rather, physical ICT equipment seemed to have enabled schools to transition to online education. The results in Table 4 columns (3)-(4) show that within BoEs, a higher percentage of schools equipped with Wi-Fi led to a higher likelihood of live online classes; however, this effect is significant only at a 10% level and not significant for live online communication with parents in columns (5)-(6). Likewise, schools better equipped with presentation devices in regular classrooms were at a 5% of significance more likely to provide live online classes to students within BOEs. Regarding teaching resources, the availability of commercial digital instructional materials for teachers increased the likelihood of live online classes and, as expected, had no effect on communication with parents. These results should be viewed within the limitations of our study, yet they paint a picture consistent with the way online education was typically depicted by the Japanese media: one teacher per empty classroom using a combination of digital presentation tools and a physical board in front of a camera.

Furthermore, utilizing Equation (2) to examine the impact of school type-specific teacher IT skills we present the results in Table 5. We do not confirm any statistically significant effect of school type-specific IT skills on remote education outcomes. We also explore the complementarity of IT skills and ICT equipment by including their interactions in Equation (1) to examine the impact on the probability of holding live online classes. We create two dummy variables each for both ICT equipment confirmed relevant and IT skills, indicating a value above the sample mean and sample median (a positive value for digital textbooks as the median value is 0) for each school type. The results are displayed in Table 6. We do not confirm any significant effect of the interaction terms, defined as the interactions of the original continuous variables, the two types of dummy variables, or their combinations. However, the variation in these dummy variables remaining in the fixed effects model is small. Albeit limited, this result suggests that the null effect of IT skills on the likelihood of online classes implementation is not caused by school-type specific factors or by a shortage of ICT equipment, possibly preventing teachers from manifesting their IT skills.

To further our understanding of these results, we conducted a survey of teachers on a web platform operated by a large Japanese education company. This platform[7] aims to provide its 73,000 freely registered users with lesson resources and opportunities to exchange ideas. We collected responses for one month in August 2022 receiving 461 valid answers. Limiting this sample to public elementary and junior high school teachers, we arrived at a sample of 424. This sample consists of 83% elementary and 17% junior high school teachers, is 60% female, with approximately equal age distribution from 20s to 50s. We believe this supplemental survey well reflects our research setting.

The survey results show that 32% of the sampled teachers conducted online education at least once during the pandemic, with over 90% of them broadcasting lessons from school. This result confirms that it is the school environment, not teachers' home environment, that should be

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[7] "Foresta Net" owned by Sprix, Ltd.
https://foresta.education/

considered in the analysis of remote education. Moreover, teachers with an experience of online classes selected presentation devices (such as projectors, digital TV, or digital blackboard) as the ICT equipment used to hold these classes, while only a small percentage responded that they used PCs or tablets only. These findings are consistent with our results. Furthermore, 25% of the sampled teachers considered presentation devices the key to a future smooth implementation of online education, in addition to basic ICT infrastructure. As this survey was conducted over two years after the initial school closures, it might not accurately reflect the conditions at the time, overstating the extent of online education. However, these findings are in line with our results, and we believe they strengthen our interpretation.

To summarize, during the early days of the COVID-19 pandemic, the differences in the pace at which schools reopened and in the provision of remote education within a BoE were likely not related to teachers' IT skills, defined as either common skill from Equation (1) or school level-specific skill from Equation (2). Rather, ICT equipment essential for accessing the Internet in a socially distanced environment, a wireless network, and the tools necessary to hold an online class (digital materials for teachers and presentation devices capable of projecting digital materials) seemed to be the factors that increased the supply of online classes. These results suggest, and a supplemental teachers' survey reinforces, that one obstacle to providing remote education during school closures was a lack of basic ICT infrastructure on the part of schools. We also confirm that using live online tools for classes and communication with students' families is different in nature, with the latter being less equipment dependent. However, considering the presence of measurement error, these results are likely lower bounds of the actual effects.

4.2 Overwork

The expected impact of ICT resources on teachers' work hours during and after school closures is not theoretically clear. Better ICT resources might enable teachers to perform their jobs, especially in cases where basic infrastructure is largely missing, possibly increasing work hours; yet teachers with better IT skills might be able to prepare for online classes more efficiently, possibly reducing the time required. It should be noted that teachers with weak IT skills might be deficient in other skills as well, lowering the relevance of IT skills specifically and creating a need for a more comprehensive approach. Further, considering the limitations of the data discussed in section *2*, the following results likely underrepresent the actual situation, suggesting that more accurate data would likely produce more significant results.

The results using Equation (3) are displayed in Table 7. We divided the standardized coefficient estimates of the impact of IT skill indices by the average ratio of teachers working over the specific threshold of overtime hours in each month to arrive at the effect size, visualized on a timeline in Figure 1. Teacher proficiency in IT skills had only a limited impact on overtime hours in terms of statistical significance controlling for the pre-pandemic amount of overtime. Proficiency, however, decreased the percentage of teachers working overtime for nearly all months and thresholds with a notable exception of August 2020, a month typically reserved for a summer break. Focusing on the significant effects, 1 standard deviation improvement in IT skill proficiency would result in 14% decrease in teachers working over 80 overtime hours in May 2020 and 4.7% decrease in July 2020. Both months were transitional—from closures to in-person classes for May and to summer break with supplementary classes for July—suggesting a beneficial role of IT skills when adapting to a changing situation. However, the impact for April, the month with the most dramatic transition, is not statistically significant.

Conversely, the effect of the overall lack of IT skills was more pronounced after schools reopened, especially in the over 80 hours of overtime per month category. During school closures, in April 2020, the lack of IT skills at a 10% level of significance increased the percentage of teachers working over 45 hours of overtime 3.7% per standard deviation, but had no impact on the percentage of teachers working over 80 overtime hours. For all months after reopening, the lack of IT skills had a statistically significant impact on extreme overtime, increasing the percentage of teachers working over 80 extra hours per month. The effect size of 1 standard deviation deterioration in IT skills stood at 6.9% and 5.7% for June and July respectively and 24.1% for August 2020, confirming again how unusual August 2020 was compared to the typical year. As the percentage of BoEs reporting implementation of live online classes during school closures stood at just 8–9%, working hours during closures in most BoEs would likely not have been spent preparing or providing online education, thus lowering the importance of IT skills as defined by MEXT. However, even in BoEs that did not provide online classes, teachers were tasked with compensating for learning loss incurred during closures when students returned to classrooms furnished to some degree with ICT equipment, making IT skills pertinent. Regardless of significance, the direction of the effect of lack of skills is positive for all overtime thresholds and all months, meaning more teachers working overtime.

Investigating the role of school level-specific IT skills using Equation (4), we again present the results on a timeline in Figures 2 and 3 by school type. Equivalently to the preceding analysis, the estimated impact of lack of skills is statistically significant in more instances than proficiency. As an elementary school-specific effect, teachers being proficient in IT skills in general reduced overtime at both thresholds, although the effects lack statistical significance. Conversely, a lack of associated IT skills significantly increased the percentage of teachers working over 45 hours in all months except August and those working over 80 extra hours in April and May, likely reflecting the difficulty of providing education to very young students during a sudden pandemic outbreak. For junior high schools, proficiency showed a similar trend to elementary schools, decreasing work hours but largely missing statistical significance. Compared to elementary schools, the significant detrimental effect of lack of IT skills materialized later, as it was concentrated largely in the post-closure period, especially for the over 80 overtime hours category. This result is consistent with the above interpretation that IT skills, especially the lack thereof, are more relevant when teachers actually teach.

The teachers' survey provides anecdotal evidence as to how the lack of IT skills affected teachers' overtime work. For example, after schools reopened, teachers were required to get accustomed to providing online education utilizing existing ICT equipment to prepare for possible subsequent closures. As this demand came shortly after reopening, when schools were expected to conduct face-to-face classes comparable to the pre-pandemic period, it might have heavily altered teachers working hours. Teachers also cited insufficient BoE provided IT training and a lack of IT support, limited to only several days a month. Additionally, teachers were required to set up devices newly provided to students, create their Wi-Fi profile settings or install required software, while simultaneously following information security regulations, securing students' privacy and teaching students how to use ICT devices appropriately. These new duties were on top of the usual workload. Therefore, especially in the months closely following the school closures, teachers likely spend more time in schools to complete these tasks, and the lack of IT skills might have severely affected the time required to do so.

Overall, our analysis, which likely underestimates the actual effects, suggests that overtime hours are associated with a lack of teachers' IT skills rather than proficiency, again demonstrating the importance of removing supply side bottlenecks, with the supplemental teacher survey supporting these findings. We also confirm a heterogeneous effect of IT skills based on school level and timing, indicating the complex nature of the pandemic response. Nevertheless, it is important to stress that IT skills might be representative of a broader skill set, making a possible intervention difficult to design. Additionally, our results suffer from limitations due to data restrictions and the consequently adopted empirical strategy, and more research into the topic is needed to help alleviate the burden teachers in Japanese schools face.

4.3 Robustness check

To address the potential concerns raised in Section *3* regarding the validity of our approach, we run a series of checks to investigate the robustness of our results. This follow-up analysis, which also uses the fixed effects framework, systematically confirms our results.

To start with, we investigate the first concern, that is, the validity of the BoE-level fixed effects approach in addressing unobserved common local factors that simultaneously influence both ICT resources and the schools' response to the pandemic. We adopt two approaches—splitting the full sample into subsamples of interest and adding interaction terms.

First, our BoE-level fixed effects approach assumes that the within-BoE difference in outcomes is uncorrelated with unobserved municipality-specific factors once the differences in schools' ICT resources are controlled for. However, this assumption might not hold universally. One possible case is the difference between urban and rural areas. The demand for ICT resources in junior high schools might be higher in urban areas as opposed to rural areas possibly due to competition with private junior high schools that are typically located in urban areas. Private schools are generally better equipped than public schools, possibly skewing the local demand for ICT resources or remote education at public schools in favor of one school level. To address this concern, we divide the sample based on an urban or rural location and the presence of private junior high schools. First, an urban location indicator is assigned to BoEs in municipalities designated as cities and city districts, and rural location is assigned to the remaining BoEs (towns, villages, and unions of villages), thus roughly splitting the sample in half. Second, although the BoEs that house at least one private junior high school, representing less than 20% of the sample, are typically urban, we consider this analysis separately. For remote education outcomes, the results displayed in Tables A1 and A2 in Appendix closely resemble the main ones for all subsamples. The only exception is the negative impact of presentation devices in regular classrooms on live online communication with parents in the subsample of BoEs with private junior high schools. However, considering the sample size and the remainder of the results, we do not regard it as a concern. Regarding overtime analysis, the results are presented in Tables A3-A6 in Appendix. We find that while the effects of both proficiency and lack of IT skills largely retain their signs in all subsamples, the effect of lack of skills was generally more pronounced in rural areas and correspondingly in areas without private junior high schools.

Second, in all our models, in addition to a BoE i fixed effect δ_i, we also include a school-level dummy variable D_j. However, as the state of emergency was declared and ended on a per-prefecture basis, the local response might not be identical across prefectures. If prefectures placed varying weights on school levels in terms of prioritizing online education, the omitted heterogeneity in between-school-level differences across prefectures would be correlated with the outcomes, violating our assumption on the common school-level dummy. To filter this potential effect, we include school-level and prefecture dummy interaction terms in Equations (1) and (3) for remote education and overtime analysis, respectively. The addition of these interaction terms does not qualitatively alter the results of either of these analyses, as presented in Tables A7 and A8 in Appendix, supporting our assumption about D_j. Although it is not possible to completely prove the validity of the BoE-level fixed effects approach, a series of robustness checks provided above suggest that the potential concern with our approach largely does not seem to affect our main results.

Next, we focus on the second concern raised in Section *3*—the potential endogeneity of ICT resources. To assess the robustness of the link of ICT equipment to remote education outcomes, we replaced the 2020 ICT equipment variables in Equation (1) with their 2019 levels.[8] Possible endogeneity of the 2020 level would likely create a positive bias in the effect of ICT equipment on the use of remote education as a BoE with a higher unobserved forecasting ability would have in expectation of the educational disruption equipped schools better by the survey date of March 1, 2020. The results presented in Table A9 in Appendix for the available variables are consistent with the main results, supporting our interpretation that the challenge to implementing online education in Japan was insufficient physical ICT equipment. Although neither the model specification nor the within-BoE difference is identical to the 2020 ICT equipment level analysis, we do not confirm a systematic positive bias. The effect of significant variables in the original analysis is larger for the 2019 level of presentation devices, retaining statistical significance, and is smaller for digital instructional materials for teachers, which is now not significant.

Regarding the analysis of overtime hours, we use the 2019 level of ICT equipment as controls in Equation (3), obtaining practically identical results to the main ones, as displayed in

[8] The 2018 school year wave of the Survey on ICT in School Education collected in March 2019 contains most of the ICT variables utilized in the main analysis, except for the prevalence of Wi-Fi and digital textbooks for students.

Table A10 in Appendix. After controlling for 2019 ICT equipment, we find that the effect size of IT skills is on average 0.35% points smaller than that for 2020 ICT equipment controls, having unchanged direction and one marginal result losing significance. These results suggest that the concern about the possible endogeneity of 2020 ICT equipment is unfounded.

Additionally, for overtime analysis, we looked further into the past, setting 2019 overtime as the outcome and 2018 overtime as the baseline in Equation (3). Schools with under normal circumstances chronically overworked teachers could have better ICT resources to help with the workload, possibly creating a counteractive correlation in the effects of interest. If work hours during the pandemic were subject to a large unexpected exogenous demand shock with the school ICT resources fixed, we expect the effect of teachers' IT skills on overtime to be generally larger than that in normal times. The 2018 overtime data were collected retrospectively in the 2019 wave of the Survey on Reform of Working Conditions in Schools by the Local Boards of Education; therefore, they cover a shorter period (April–June) and a larger percentage is missing. In this restricted analysis, as presented in Table A11 in Appendix, the 2019 school year IT skill index had a minimal impact on overtime hours, controlling for the 2019 school year level of ICT equipment. IT skill proficiency lowered the percentage of teachers working extreme overtime in April 2019, and the lack of skills had no effect. These results indicate that the 2019 estimated effect size is slightly larger than that of 2020 only for April and IT skill proficiency. Moreover, for 9 out of the 12 coefficient estimates, both levels of IT skills changed the ratio of teachers working overtime by less than 1%. These results lend support to our assumption of the exogeneity of the 2020 level of ICT resources in the main analysis. Furthermore, they strengthen our interpretation of the main findings that IT skill proficiency is advantageous in transitional months (school year beginning), and a lack of IT skills worsens teachers' working conditions in times of crisis.

Finally, as we raised as a third concern in Section *3*, one of the major limitations of our analysis is the use of data aggregated at a municipality level. As our implicit decision model is based at school and teacher levels, using municipality-level data likely leads to a typical classical measurement error bias. To gauge the extent of this bias in our main results, we run the analysis using Equations (1) and (3) on a subsample of municipalities containing a single junior high school. The results presented in Tables A12 and A13 in Appendix are similar to those of the main ones. Focusing on estimation coefficients of the variables statistically significant for the full sample, we find that in the restricted sample, the effect sizes are generally larger by factors of 1.1–2. While the characteristics of these small BoEs might also be reflected in the effect size differences, we confirm the presence of measurement error bias in the main results, which is as expected. Although the extent of the influence of this bias seems relatively minor, our estimation results should be interpreted as the lower bounds of the true effects in terms of the size of the effect. It should be noted that not finding a statistically significant effect of an ICT resource might not mean that this resource is ineffective in "absolute" terms, as our results provide guidance on "relative" importance in the presence of measurement error bias. Our results suggest that among the broad range of ICT resources, teachers' IT skills are relatively less important than ICT equipment in enabling remote education provision, while the former is important for reducing working overtime.

In summary, we address the potential concerns related to our analysis and the validity of our results by conducting a series of robustness checks utilizing several approaches. We confirm that our main results are robust.

5. Conclusion

The COVID-19 pandemic forced schools in many countries, including Japan, to close, turning to online education. Many studies analyzing school closures have focused on the demand side, as investigating the impact of the supply side on the provision of remote education is challenging due to the lack of appropriate data and the difficulty of separating the effects of the supply and demand sides.

The percentage of Japanese boards of education reporting the implementation of online classes during school closures in their municipality stood at less than 10% nationwide. The aim of this paper is to, using a municipality-level fixed effects model, empirically isolate the effect of the supply side, specifically schools' ICT resources determined at the BoE level, on the provision of online education and teachers' work hours using a dataset combining several sets of governmental data collected in 2020 from the entire public school system. The unique point of our analysis compared to the currently available literature is that we simultaneously investigate the effect of school ICT resources on both the provision of online education and the choice of communication channel with students' families while also examining the working conditions of teachers, who generally continued coming to school during and after the closures, using nationwide administrative data from Japanese public elementary and junior high schools on a municipality level. Under the assumptions discussed in section *3*, our results allow for causal interpretation of the effect of ICT resources on both students and teachers.

We find no significant effect of teachers' IT skills, whether proficient or lacking, on the provision of live online classes. Rather, physical ICT equipment, such as Wi-Fi access, presentation devices in regular classrooms, and commercial digital instructional materials for teachers, seemed to have enabled schools to transition to online education, suggesting that there was a technological bottleneck to implementing online education in Japan. We also confirm that live online communication with students' families is less equipment dependent than online classes. Moreover, we find that teachers' extra work hours are associated with a lack of IT skills, while the beneficial effect of IT skill proficiency is weak. Additionally, we identify a heterogeneous effect of IT skills on teachers' overtime by school level and timing, likely reflecting the complex nature of the pandemic response. A supplemental survey of public elementary and junior high school teachers lends support to our results.

These results suggest that the impact of different ICT resources differs between students and teachers. The obstacle to implementing online education in Japan on the supply side was schools' inadequate basic ICT equipment, determined at a municipal level, not teachers' IT skills, developed at an individual level. However, the persistent overwork of schoolteachers in Japan may partially be a consequence of a lack of IT skills. Therefore, the effect of ICT resources is multi-dimensional, an important point to consider when drafting a relevant policy.

However, our results have several limitations due to data availability and structure limiting our empirical strategy options. Although we used a wide array of variables assessing schools' ICT equipment and teachers' IT skills collected in a governmental survey, it is possible that other school resources and teachers' skills that are correlated but not directly measured may also be relevant in determining remote education practices and teachers' work hours. Likewise, it is possible that some measures that do not vary much between school levels within a municipality and would thus not be considered in our analysis may affect both outcomes. It is also clear that our results are specific to the context of the public school system during the early stages of the COVID-19 pandemic in Japan, which lagged in ICT use for education. More research is needed to generalize our findings to a broader context of other societies and circumstances.

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Declarations of interest

None.

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Table 1: Summary statistics–remote education practices and ICT resources

Variable	ELEMENTARY SCHOOL				JUNIOR HIGH SCHOOL			
	Mean	**SD**	**Min**	**Max**	**Mean**	**SD**	**Min**	**Max**
School days closed (N = 1711) June 2020								
Total days closed	24.570	10.304	0	61	24.466	10.308	0	61
Remote education practices during school closures (N = 1693) June 2020								
Live online class	0.081	0.273	0	1	0.089	0.285	0	1
Live online communication with family	0.094	0.292	0	1	0.103	0.304	0	1
IT skills (N=1711) March 2020								
IT skill index (Proficient)	-0.016	0.975	-2.217	4.388	0.016	1.025	-2.217	4.388
IT skill index (Lacking)	-0.200	0.757	-2.049	7.153	0.200	1.160	-10.226	9.526
ICT resources (N=1711) March 2020								
High-speed internet	0.674	0.431	0.0	1.0	0.682	0.444	0.0	1.0
Wi-Fi	0.836	0.336	0.0	1.0	0.835	0.348	0.0	1.0
Presentation device	0.958	0.425	0.0	3.0	0.745	0.506	0.0	5.0
Digital instructions	0.574	0.447	0.0	1.0	0.643	0.440	0.0	1.0
Digital textbook	0.095	0.230	0.0	1.0	0.100	0.257	0.0	1.0
Management software	0.765	0.392	0.0	1.0	0.771	0.399	0.0	1.0
Security policy	0.657	0.431	0.0	1.0	0.662	0.449	0.0	1.0

Table 2: Summary statistics–ratio of staff working over 45 or 80 overtime hours a month

	ELEMENTARY SCHOOL					JUNIOR HIGH SCHOOL				
Month	**N**	**Mean**	**SD**	**min**	**max**	**N**	**Mean**	**SD**	**min**	**max**
					> 45 HOURS					
Year 2020										
April	1,220	0.182	0.197	0.0	1.0	1,220	0.186	0.219	0.0	1.0
May	1,227	0.115	0.174	0.0	1.0	1,227	0.131	0.206	0.0	1.0
June	1,280	0.471	0.214	0.0	1.0	1,280	0.574	0.229	0.0	1.0
July	1,268	0.421	0.224	0.0	1.0	1,268	0.583	0.228	0.0	1.0
August	1,203	0.072	0.138	0.0	1.0	1,203	0.205	0.202	0.0	1.0
Year 2019										
April	1,220	0.546	0.180	0.0	1.0	1,220	0.644	0.165	0.0	1.0
May	1,227	0.545	0.181	0.0	1.0	1,227	0.642	0.165	0.0	1.0
June	1,280	0.558	0.188	0.0	1.0	1,280	0.650	0.172	0.0	1.0
July	1,268	0.390	0.205	0.0	1.0	1,268	0.531	0.203	0.0	1.0
August	1,203	0.041	0.093	0.0	1.0	1,203	0.109	0.154	0.0	1.0
					> 80 HOURS					
Year 2020										
April	1,220	0.028	0.097	0.0	1.0	1,220	0.034	0.107	0.0	1.0
May	1,227	0.013	0.077	0.0	1.0	1,227	0.018	0.083	0.0	1.0
June	1,280	0.084	0.131	0.0	1.0	1,280	0.158	0.168	0.0	1.0
July	1,268	0.066	0.129	0.0	1.0	1,268	0.183	0.180	0.0	1.0
August	1,203	0.007	0.059	0.0	1.0	1,203	0.027	0.072	0.0	1.0
Year 2019										
April	1,220	0.149	0.165	0.0	1.0	1,220	0.255	0.193	0.0	1.0
May	1,227	0.138	0.164	0.0	1.0	1,227	0.250	0.192	0.0	1.0
June	1,280	0.158	0.189	0.0	1.0	1,280	0.259	0.211	0.0	1.0
July	1,268	0.076	0.149	0.0	1.0	1,268	0.166	0.182	0.0	1.0
August	1,203	0.009	0.051	0.0	1.0	1,203	0.026	0.103	0.0	1.0

Table 3: Effect of ICT resources on remote education–linear regression

Dependent Variable	School days closed		Live online class		Live online communication	
Explanatory Variables	(1)	(2)	(3)	(4)	(5)	(6)
Elementary school	0.258	0.808***	-0.0124	-0.0183**	-0.0100	-0.0153*
	(0.220)	(0.298)	(0.00857)	(0.00796)	(0.00847)	(0.00869)
Teachers' IT Skill						
IT skill index – Proficient	-0.389		0.0107*		0.0155***	
	(0.453)		(0.00565)		(0.00566)	
IT skill index - Lacking		1.444***		-0.0136***		-0.0104**
		(0.393)		(0.00364)		(0.00492)
School ICT Equipment						
High-speed internet	3.051***	2.856***	0.0228**	0.0241**	0.0263*	0.0267*
	(0.823)	(0.790)	(0.0112)	(0.0113)	(0.0138)	(0.0143)
Wi-Fi	-0.580	-0.289	0.0235	0.0223	0.0152	0.0157
	(1.127)	(1.072)	(0.0168)	(0.0172)	(0.0197)	(0.0202)
Presentation device	-0.528	-0.320	0.0307*	0.0310*	0.0206	0.0231
	(0.983)	(0.967)	(0.0167)	(0.0170)	(0.0188)	(0.0191)
Digital instructions	0.349	0.430	0.0215	0.0203	0.0304*	0.0290*
	(0.844)	(0.837)	(0.0149)	(0.0148)	(0.0152)	(0.0155)
Digital textbook	-1.791	-1.844	0.0431*	0.0437*	0.0441*	0.0447*
	(1.204)	(1.190)	(0.0242)	(0.0241)	(0.0256)	(0.0254)
Management software	3.317***	3.249***	0.00217	0.00129	0.000285	-0.00191
	(1.146)	(1.095)	(0.0180)	(0.0179)	(0.0176)	(0.0172)
Security policy	-1.360**	-1.229**	0.0129	0.0122	0.0226*	0.0223*
	(0.607)	(0.576)	(0.0127)	(0.0126)	(0.0120)	(0.0123)
Constant	21.57***	20.92***	0.00236	0.00713	0.0172	0.0197
	(2.367)	(2.349)	(0.0243)	(0.0246)	(0.0204)	(0.0210)
BoE FE	No	No	No	No	No	No
Observations	3,422	3,422	3,386	3,386	3,386	3,386
R-squared	0.045	0.062	0.013	0.013	0.013	0.012

Notes: Estimation results from linear regression. Robust standard errors clustered at municipality and prefecture level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4: Effect of ICT resources on remote education–linear fixed effects model

Dependent Variable	School days closed		Live online class		Live online communication	
Explanatory Variables	(1)	(2)	(3)	(4)	(5)	(6)
Elementary school	0.102**	0.0942**	-0.0110	-0.0118	-0.00982	-0.00869
	(0.0384)	(0.0399)	(0.00834)	(0.00862)	(0.00710)	(0.00735)
Teachers' IT Skill						
IT skill index - Proficient	0.00461		0.000248		0.00380	
	(0.0162)		(0.00494)		(0.00454)	
IT skill index - Lacking		-0.0188		-0.00219		0.00373
		(0.0311)		(0.00336)		(0.00440)
School ICT Equipment						
High-speed internet	-0.179*	-0.175	-0.0205	-0.0202	-0.00964	-0.0102
	(0.106)	(0.106)	(0.0250)	(0.0249)	(0.0295)	(0.0291)
Wi-Fi	-0.0427	-0.0422	0.0294*	0.0295*	0.0277	0.0276
	(0.0801)	(0.0795)	(0.0161)	(0.0160)	(0.0169)	(0.0171)
Presentation device	0.0133	0.0112	0.0209**	0.0206**	0.00623	0.00739
	(0.0410)	(0.0403)	(0.00954)	(0.00898)	(0.00951)	(0.00908)
Digital instructions	0.00673	0.00469	0.0312*	0.0310*	0.00549	0.00579
	(0.109)	(0.110)	(0.0155)	(0.0155)	(0.0136)	(0.0137)
Digital textbook	0.105	0.104	-0.0220	-0.0220	-0.0185	-0.0192
	(0.182)	(0.182)	(0.0252)	(0.0252)	(0.0215)	(0.0214)
Management software	0.0889	0.0848	-0.0102	-0.0106	-0.0170	-0.0162
	(0.0595)	(0.0605)	(0.0328)	(0.0330)	(0.0335)	(0.0341)
Security policy	-0.0814	-0.0810	-0.0117	-0.0117	0.0349	0.0358
	(0.102)	(0.101)	(0.0302)	(0.0304)	(0.0303)	(0.0307)
Constant	24.58***	24.59***	0.0608	0.0616	0.0698*	0.0674*
	(0.143)	(0.142)	(0.0369)	(0.0378)	(0.0353)	(0.0364)
BoE FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,422	3,422	3,386	3,386	3,386	3,386
R-squared	0.007	0.007	0.008	0.008	0.005	0.005

Notes: Estimation results from linear fixed effect model at BoE (municipality) level. Robust standard errors clustered at municipality and prefecture level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 5: Effect of teachers' IT skills on remote education–linear fixed effects model with interactions

Dependent Variable / Teachers' IT skills	School days closed	Live online class	Live online communication
Proficient			
Elementary γ_0	-0.0191	-0.00590	-0.00506
	(0.0301)	(0.00866)	(0.00467)
Junior high $\gamma_0 + \gamma_1$	0.0246	0.00536	0.0112
	(0.0326)	(0.00548)	(0.00684)
Lacking			
Elementary γ_0	0.0450	0.00539	0.0105
	(0.0375)	(0.00739)	(0.00701)
Junior high $\gamma_0 + \gamma_1$	-0.0367	-0.00438	0.00177
	(0.0351)	(0.00372)	(0.00449)

Notes: Coefficient estimates from Equation (3) with j = 0 for elementary school and j = 1 for junior secondary school. The estimated coefficient on junior high school, $\gamma_0 + \gamma_1$ is produced using Stata command "lincom" for the respective linear combination of coefficients. Robust standard errors clustered at municipality and prefecture level in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 6: Effect of ICT resources on remote education–linear fixed effects model with interactions

Dependent Variable	Live online class													
	Skill continuous ICT continuous		Skill continuous ICT mean		Skill mean ICT continuous		Skill mean ICT mean		Skill continuous ICT median		Skill median ICT continuous		Skill median ICT median	
Explanatory Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Teachers' IT Skill														
IT skill index - Proficient	-0.00176		0.00162		0.00349		0.00481		0.00237		0.00388		0.0134	
	(0.0140)		(0.00994)		(0.0345)		(0.0231)		(0.00901)		(0.0323)		(0.0190)	
IT skill index - Lacking		0.00146		0.00348		-0.00878		-0.00354		-0.00130		-0.00369		-0.0137
		(0.00945)		(0.00841)		(0.0228)		(0.0198)		(0.00818)		(0.0240)		(0.0185)
School ICT Equipment														
Wi-Fi	0.0292*	0.0301*	0.0137	0.0143	0.0303	0.0258	0.0133	0.0109	0.0157	0.0165	0.0344	0.0319*	0.0225	0.0187
	(0.0169)	(0.0162)	(0.0179)	(0.0175)	(0.0201)	(0.0177)	(0.0214)	(0.0192)	(0.0157)	(0.0154)	(0.0216)	(0.0170)	(0.0198)	(0.0167)
Wi-Fi * IT skill index - Proficient	0.00256		0.00142		-0.00340		-0.000432		-0.000321		-0.00938		-0.0139	
	(0.00750)	-0.000537	(0.00698)		(0.0179)		(0.0206)		(0.00700)		(0.0152)		(0.0165)	
Wi-Fi * IT skill index - Lacking		(0.00584)		-0.00350		0.00816		0.00695		-0.000459		-0.00269		-0.00246
				(0.00945)		(0.0162)		(0.0194)		(0.00704)		(0.0128)		(0.0156)
Presentation device	0.0211**	0.0207**	0.00459	0.00491	0.0223	0.0162*	0.00924	0.000490	-0.000795	-0.000797	0.0144	0.0178*	-0.00746	-0.0125
	(0.00994)	(0.00918)	(0.00917)	(0.00907)	(0.0176)	(0.00870)	(0.0143)	(0.00898)	(0.0102)	(0.0101)	(0.0191)	(0.00904)	(0.0155)	(0.0131)
Presentation device * IT skill index - Proficient	-0.00468		-0.00619		-0.00377		-0.0110		-0.00403		0.0128		0.0133	
	(0.0110)		(0.00831)		(0.0285)		(0.0186)		(0.00746)		(0.0250)		(0.0176)	
Presentation device * IT skill index - Lacking		0.00306		0.00246		0.0117		0.0109		0.00854		0.00538		0.0240
		(0.00737)		(0.00817)		(0.0161)		(0.0158)		(0.00730)		(0.0191)		(0.0202)
Digital instructions	0.0311*	0.0309*	0.0167	0.0165	0.0322**	0.0376*	0.0185	0.0243	0.0234*	0.0229*	0.0382**	0.0415*	0.0336**	0.0332*
	(0.0164)	(0.0161)	(0.0121)	(0.0118)	(0.0144)	(0.0206)	(0.0113)	(0.0159)	(0.0131)	(0.0130)	(0.0150)	(0.0216)	(0.0150)	(0.0176)
Digital instructions * IT skill index - Proficient	0.00768		0.00342		-0.00265		-0.00396		0.00288				-0.0197	
	(0.0115)		(0.0110)		(0.0229)		(0.0192)		(0.0114)				(0.0212)	
Digital instructions * IT skill index - Lacking		-0.00948		-0.0125		-0.0165		-0.0184		-0.00969	-0.0152	-0.0235		-0.0234
		(0.00781)		(0.00949)		(0.0181)		(0.0164)		(0.00689)	(0.0235)	(0.0198)		(0.0184)
Observations	3,386	3,386	3,386	3,386	3,386	3,386	3,386	3,386	3,386	3,386	3,386	3,386	3,386	3,386
R-squared	0.009	0.009	0.005	0.005	0.008	0.009	0.005	0.005	0.005	0.006	0.009	0.011	0.006	0.009

Notes: Estimation results based on fixed effect model at BoE (municipality) level. Robust standard errors clustered at municipality and prefecture level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 7: Linear fixed effects model–teachers' overtime hours

PANEL A	**April 2020**		**May 2020**		**June 2020**		**July 2020**		**August 2020**	
Overtime threshold	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Teacher ratio	0.184	0.031	0.123	0.015	0.522	0.121	0.502	0.125	0.138	0.017
IT skill index	-0.000446	-0.00184	0.000215	-0.00233**	-0.00552	-0.00294	-0.00447	-0.00592*	0.00272	0.000855
Proficient	(0.00421)	(0.00185)	(0.00451)	(0.00105)	(0.00512)	(0.00385)	(0.00549)	(0.00344)	(0.00448)	(0.00147)
Effect size	-0.24%	-5.91%	0.17%	-15.23%	-1.06%	-2.43%	-0.89%	-4.75%	1.96%	5.05%
Observations	2,440	2,440	2,454	2,454	2,560	2,560	2,536	2,536	2,406	2,406
R-squared	0.035	0.017	0.059	0.030	0.332	0.320	0.534	0.525	0.462	0.154

PANEL B	**April 2020**		**May 2020**		**June 2020**		**July 2020**		**August 2020**	
Overtime threshold	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**
	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Teacher ratio	0.184	0.031	0.123	0.015	0.522	0.121	0.502	0.125	0.138	0.017
IT skill index	0.00691*	0.000571	0.00364	0.00122	0.00337	0.00834**	0.00401	0.00714**	0.00880*	0.00470*
Lacking	(0.00370)	(0.00138)	(0.00338)	(0.000928)	(0.00443)	(0.00355)	(0.00456)	(0.00281)	(0.00472)	(0.00260)
Effect size	3.75%	1.83%	2.96%	7.97%	0.65%	6.90%	0.80%	5.73%	6.36%	27.75%
Observations	2,440	2,440	2,454	2,454	2,560	2,560	2,536	2,536	2,406	2,406
R-squared	0.038	0.016	0.061	0.027	0.332	0.324	0.534	0.526	0.464	0.162

Notes: Estimation results from linear fixed effect model at BoE (municipality) level. The outcome variable is the ratio of teachers working over a given overtime hours threshold in each month. Teacher ratio shows the mean of the outcome variable. IT skill index standardized to mean 0. Other control variables are "High-speed internet," "Wi-Fi," "Projector," "Digital instructions," "Digital textbook," "Management software," "Security policy" and the lag of the outcome variable with a dummy variable indicating imputed value. Robust standard errors clustered at municipality prefecture and prefecture level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Figure 1: Effect of teachers' IT skills on overtime–elementary school

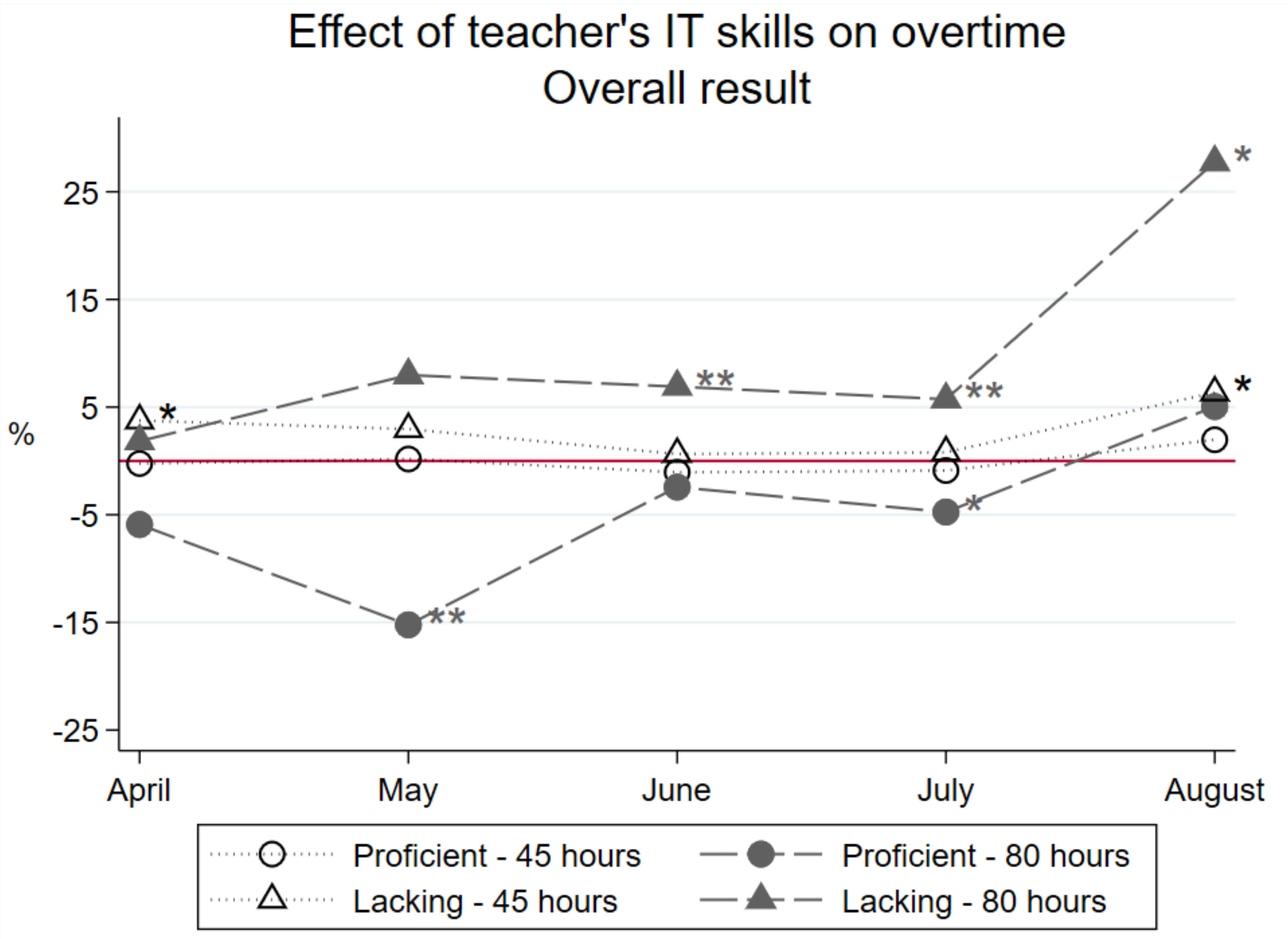


Figure 2: Effect of teachers' IT skills on overtime–elementary school

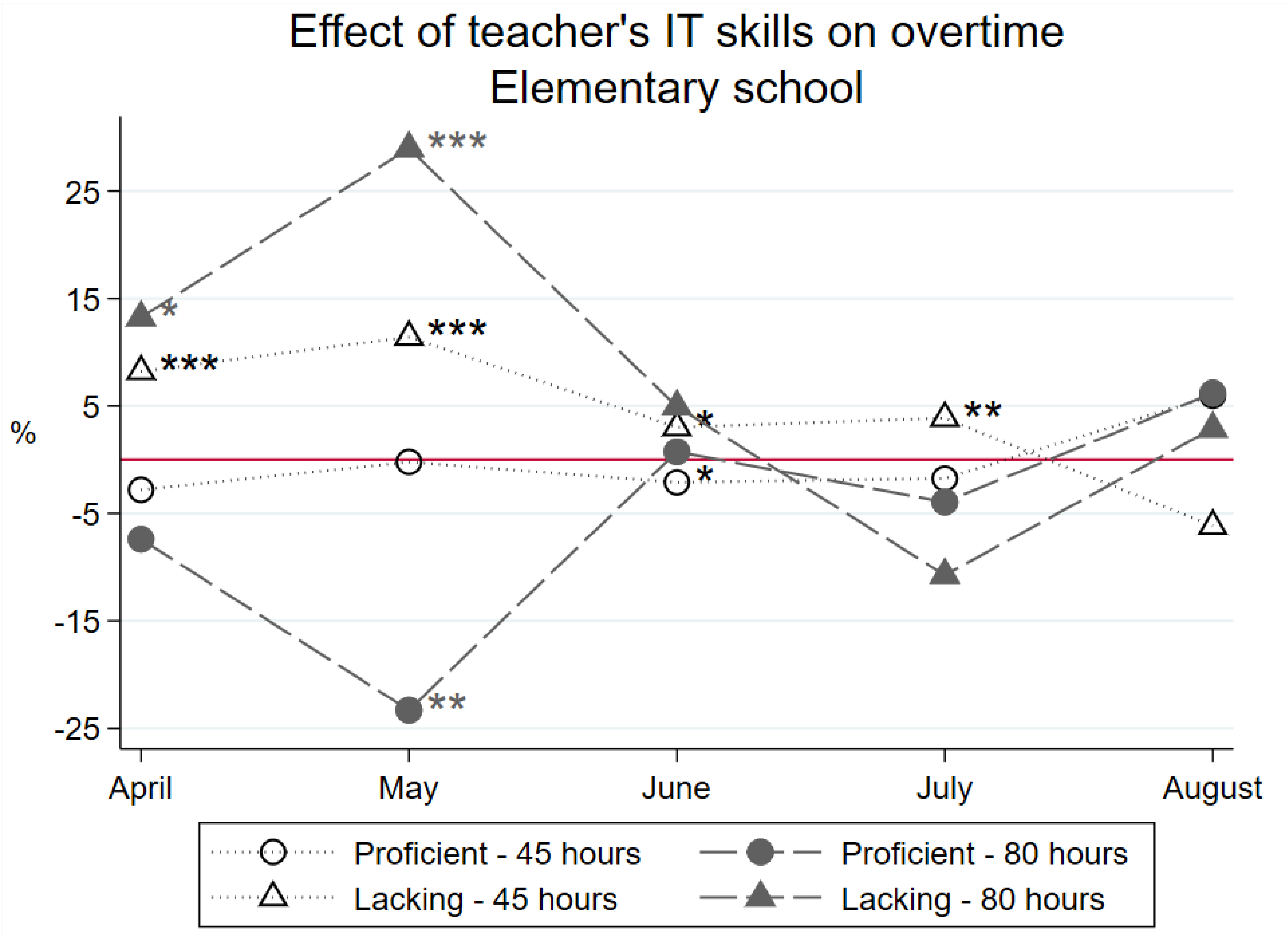
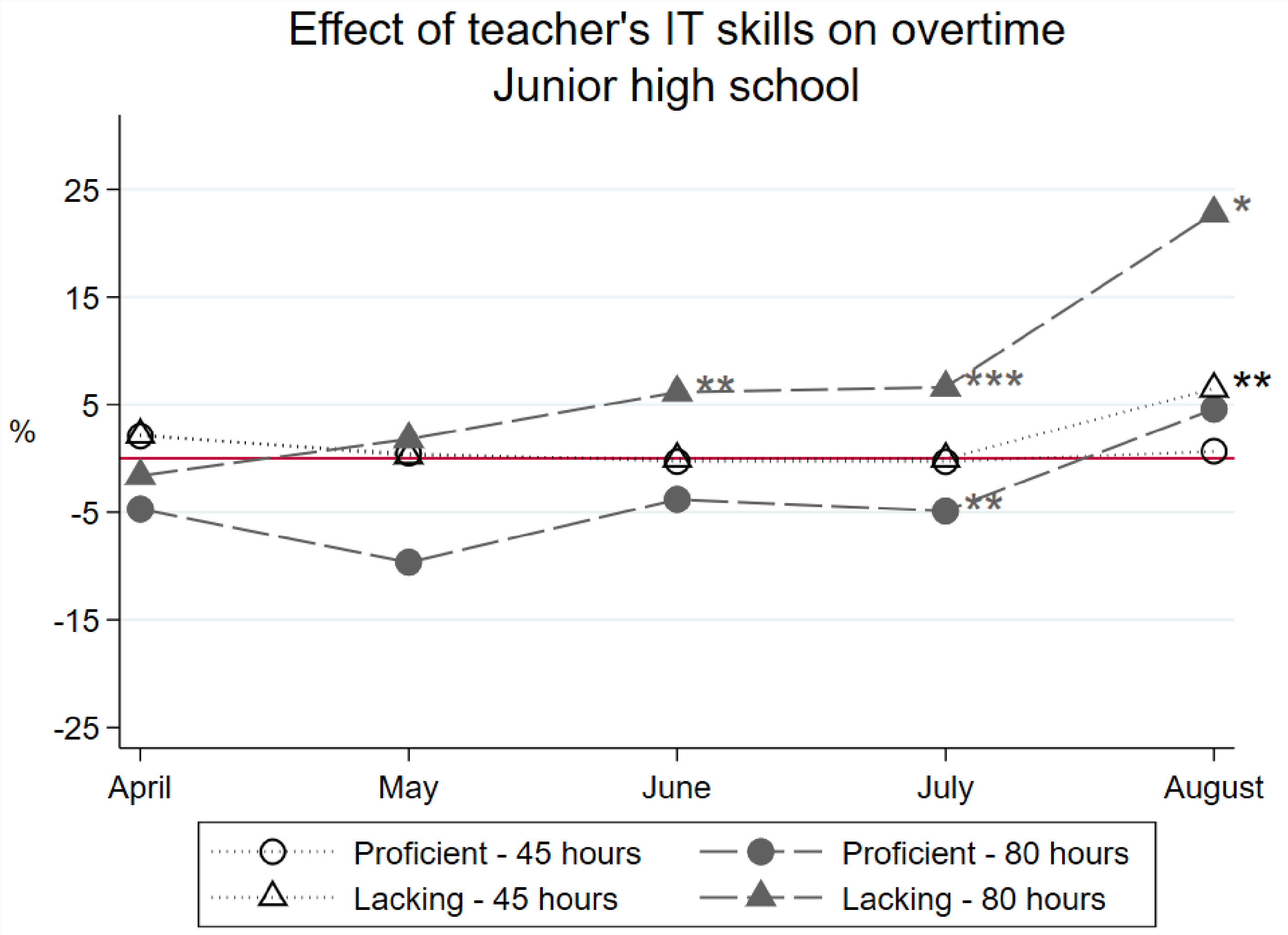


Figure 3: Effect of teachers' IT skills on overtime–junior high school



Appendix A: Additional Tables

Table A1: Effect of ICT resources on remote education–urban and rural subsamples

	URBAN						RURAL					
Dependent Variable	**School days closed**		**Live online class**		**Live online communication**		**School days closed**		**Live online class**		**Live online communication**	
Explanatory Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Elementary school	0.0505	0.0272	0.00289	0.00580	0.00371	0.00812	0.128**	0.123**	-0.0220**	-0.0233**	-0.0197**	-0.0192**
	(0.0315)	(0.0358)	(0.00828)	(0.00959)	(0.00762)	(0.00904)	(0.0583)	(0.0582)	(0.0101)	(0.0101)	(0.00842)	(0.00832)
Teachers' IT Skill												
IT skill index - Proficient	0.0320		-0.00913		-0.0110		0.000910		0.00229		0.00674	
	(0.0518)		(0.0125)		(0.0121)		(0.0248)		(0.00471)		(0.00480)	
IT skill index - Lacking		-0.0493		0.00565		0.00883		-0.0164		-0.00340		0.00322
		(0.0576)		(0.00685)		(0.00836)		(0.0396)		(0.00381)		(0.00460)
School ICT Equipment												
High-speed internet	-0.363	-0.384	0.00311	0.00620	-0.00603	-0.00147	-0.174	-0.170	-0.0229	-0.0220	-0.00993	-0.0103
	(0.319)	(0.322)	(0.0419)	(0.0418)	(0.0428)	(0.0433)	(0.126)	(0.126)	(0.0277)	(0.0276)	(0.0325)	(0.0318)
Wi-Fi	-0.245*	-0.266*	0.0302	0.0319	0.0613*	0.0644*	0.0194	0.0228	0.0309	0.0315	0.0179	0.0168
	(0.145)	(0.143)	(0.0359)	(0.0379)	(0.0312)	(0.0329)	(0.0868)	(0.0859)	(0.0192)	(0.0191)	(0.0220)	(0.0223)
Presentation device	0.0992	0.0925	0.0182	0.0191	-0.0118	-0.0105	-0.0212	-0.0235	0.0216**	0.0216**	0.0128	0.0148
	(0.0894)	(0.0900)	(0.0156)	(0.0151)	(0.0167)	(0.0166)	(0.0496)	(0.0481)	(0.0107)	(0.0103)	(0.0108)	(0.0104)
Digital instructions	-0.247	-0.260	0.0666***	0.0678***	0.0174	0.0195	0.130	0.130	0.0161	0.0158	-0.000583	-0.000795
	(0.229)	(0.243)	(0.0243)	(0.0242)	(0.0362)	(0.0359)	(0.116)	(0.116)	(0.0164)	(0.0164)	(0.0106)	(0.0112)
Digital textbook	-0.0423	-0.0402	-0.0585	-0.0579	0.00480	0.00524	0.123	0.122	-0.0162	-0.0166	-0.0196	-0.0207
	(0.285)	(0.291)	(0.0613)	(0.0612)	(0.0722)	(0.0722)	(0.202)	(0.201)	(0.0273)	(0.0271)	(0.0219)	(0.0217)
Management software	0.334	0.329	0.00698	0.00810	0.00917	0.0104	0.0710	0.0671	-0.0152	-0.0160	-0.0212	-0.0203
	(0.230)	(0.227)	(0.100)	(0.0991)	(0.108)	(0.107)	(0.0631)	(0.0646)	(0.0406)	(0.0411)	(0.0384)	(0.0391)
Security policy	0.0783	0.0928	0.0318	0.0283	0.0538	0.0494	-0.112	-0.112	-0.0150	-0.0147	0.0342	0.0358
	(0.210)	(0.210)	(0.0337)	(0.0327)	(0.0386)	(0.0383)	(0.109)	(0.107)	(0.0326)	(0.0330)	(0.0331)	(0.0340)
Observations	1,628	1,628	1,614	1,614	1,614	1,614	1,794	1,794	1,772	1,772	1,772	1,772
R-squared	0.014	0.014	0.012	0.011	0.005	0.005	0.008	0.009	0.014	0.014	0.013	0.012

Notes: Estimation results from fixed effect model at BoE (municipality) level. Robust standard errors clustered at municipality and prefecture level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A2: Effect of ICT resources on remote education–subsamples with and without private junior high school

	PRIVATE JUNIOR HIGH SCHOOL						NO PRIVATE JUNIOR HIGH SCHOOL					
Dependent Variable	**School days closed**		**Live online class**		**Live online communication**		**School days closed**		**Live online class**		**Live online communication**	
Explanatory Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Elementary school	0.0643	0.0431	0.00225	0.00118	0.0102	0.00826	0.108**	0.101**	-0.0129	-0.0137	-0.0132	-0.0119
	(0.0472)	(0.0480)	(0.0110)	(0.0109)	(0.00958)	(0.00924)	(0.0416)	(0.0424)	(0.00998)	(0.0102)	(0.00820)	(0.00846)
Teachers' IT Skill												
IT skill index - Proficient	0.0986		-0.0122		-0.00560		-0.000107		0.000721		0.00411	
	(0.0603)		(0.0160)		(0.0213)		(0.0176)		(0.00538)		(0.00457)	
IT skill index - Lacking		-0.0331		-0.00314		-0.00421		-0.0206		-0.00198		0.00468
		(0.0442)		(0.00528)		(0.0115)		(0.0331)		(0.00351)		(0.00462)
School ICT Equipment												
High-speed internet	-0.927	-0.902	0.0103	0.00198	0.0575	0.0517	-0.164	-0.160	-0.0219	-0.0215	-0.0122	-0.0130
	(0.975)	(0.987)	(0.0254)	(0.0256)	(0.0766)	(0.0760)	(0.114)	(0.115)	(0.0257)	(0.0255)	(0.0304)	(0.0298)
Wi-Fi	-0.170	-0.171	0.0191	0.0195	0.0485	0.0488	-0.0327	-0.0322	0.0310*	0.0311*	0.0265	0.0262
	(0.201)	(0.202)	(0.0235)	(0.0246)	(0.0299)	(0.0302)	(0.0843)	(0.0838)	(0.0173)	(0.0172)	(0.0188)	(0.0189)
Presentation device	-0.194	-0.190	-0.00711	-0.00853	-0.0344**	-0.0354**	0.0355	0.0324	0.0250**	0.0248**	0.0121	0.0135
	(0.178)	(0.182)	(0.0182)	(0.0190)	(0.0161)	(0.0163)	(0.0471)	(0.0458)	(0.0105)	(0.00987)	(0.0103)	(0.00971)
Digital instructions	-0.191	-0.185	0.0981*	0.0959*	0.0482	0.0466	0.0339	0.0320	0.0235	0.0233	0.00100	0.00130
	(0.206)	(0.209)	(0.0524)	(0.0524)	(0.0846)	(0.0844)	(0.107)	(0.108)	(0.0154)	(0.0154)	(0.0131)	(0.0132)
Digital textbook	-0.380	-0.439	-0.00144	0.00548	0.0119	0.0149	0.128	0.128	-0.0253	-0.0254	-0.0214	-0.0221
	(0.527)	(0.541)	(0.0536)	(0.0525)	(0.0777)	(0.0814)	(0.190)	(0.189)	(0.0264)	(0.0263)	(0.0219)	(0.0217)
Management software	0.179	0.163	-0.0362	-0.0372	-0.112	-0.113	0.0879	0.0834	-0.0104	-0.0108	-0.0130	-0.0120
	(0.225)	(0.201)	(0.0256)	(0.0245)	(0.0953)	(0.0952)	(0.0622)	(0.0631)	(0.0343)	(0.0346)	(0.0339)	(0.0345)
Security policy	0.878	0.950	0.0378	0.0382	0.0593	0.0631	-0.0944	-0.0954	-0.0123	-0.0122	0.0344	0.0355
	(0.854)	(0.862)	(0.0490)	(0.0524)	(0.0793)	(0.0923)	(0.103)	(0.103)	(0.0309)	(0.0311)	(0.0310)	(0.0313)
Observations	588	588	588	588	588	588	2,834	2,834	2,798	2,798	2,798	2,798
R-squared	0.028	0.026	0.026	0.024	0.012	0.012	0.008	0.008	0.009	0.009	0.007	0.007

Notes: Estimation results from fixed effect model at BoE (municipality) level. Robust standard errors clustered at municipality and prefecture level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A3: Teachers' overtime hours–urban subsample

PANEL A	URBAN									
	April 2020		**May 2020**		**June 2020**		**July 2020**		**August 2020**	
Overtime threshold	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Teacher ratio	0.181	0.038	0.122	0.020	0.542	0.135	0.536	0.145	0.154	0.024
IT skill index	-0.00201	-0.000847	-0.00209	-0.00301**	-0.00750	-0.00639	-0.00920	-0.000485	0.000823	0.00203
Proficient	(0.00575)	(0.00159)	(0.00548)	(0.00136)	(0.0117)	(0.00685)	(0.0109)	(0.00767)	(0.00783)	(0.00253)
Effect size	-1.11%	-2.25%	-1.72%	-14.74%	-1.38%	-4.73%	-1.72%	-0.33%	0.54%	8.37%
Observations	1,314	1,314	1,318	1,318	1,376	1,376	1,352	1,352	1,270	1,270
R-squared	0.066	0.043	0.076	0.044	0.419	0.424	0.672	0.652	0.571	0.251

PANEL B	**April 2020**		**May 2020**		**June 2020**		**July 2020**		**August 2020**	
Overtime threshold	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**
	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Teacher ratio	0.181	0.038	0.122	0.020	0.542	0.135	0.536	0.145	0.154	0.024
IT skill index	0.00320	0.000432	-0.00504	1.52e-05	0.00476	0.00684	0.00598	0.00756	0.00720	0.00343
Lacking	(0.00409)	(0.00212)	(0.00565)	(0.00114)	(0.00706)	(0.00550)	(0.00787)	(0.00641)	(0.0105)	(0.00460)
Effect size	1.77%	1.15%	-4.14%	0.07%	0.88%	5.06%	1.12%	5.20%	4.68%	14.15%
Observations	1,314	1,314	1,318	1,318	1,376	1,376	1,352	1,352	1,270	1,270
R-squared	0.067	0.043	0.078	0.037	0.419	0.424	0.672	0.653	0.572	0.253

Notes: Estimation results from linear fixed effect model at BoE (municipality) level. The outcome variable is the ratio of teachers working over a given overtime hours threshold in each month. Teacher ratio shows the mean of the outcome variable. IT skill index standardized to mean 0. Other control variables are "High-speed internet," "Wi-Fi," "Projector," "Digital instructions," "Digital textbook," "Management software," "Security policy" and the lag of the outcome variable with a dummy variable indicating imputed value. Robust standard errors clustered at municipality prefecture and prefecture level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A4: Teachers' overtime hours–rural subsample

	RURAL									
PANEL A	**April 2020**		**May 2020**		**June 2020**		**July 2020**		**August 2020**	
Overtime threshold	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Teacher ratio	0.197	0.029	0.133	0.012	0.503	0.107	0.466	0.102	0.131	0.014
IT skill index	3.01e-05	-0.00203	0.00146	-0.00194	-0.00441	-0.00162	-0.00326	-0.00693*	0.00272	0.000507
Proficient	(0.00545)	(0.00232)	(0.00598)	(0.00121)	(0.00515)	(0.00376)	(0.00614)	(0.00345)	(0.00528)	(0.00149)
Effect size	0.02%	-6.92%	1.09%	-15.67%	-0.88%	-1.52%	-0.70%	-6.77%	2.08%	3.53%
Observations	1,126	1,126	1,136	1,136	1,184	1,184	1,184	1,184	1,136	1,136
R-squared	0.032	0.030	0.068	0.035	0.287	0.247	0.437	0.399	0.383	0.123
PANEL B	**April 2020**		**May 2020**		**June 2020**		**July 2020**		**August 2020**	
Overtime threshold	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**
	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Teacher ratio	0.197	0.029	0.133	0.012	0.503	0.107	0.466	0.102	0.131	0.014
IT skill index	0.00734*	0.000544	0.00665*	0.00164	0.00335	0.00850**	0.00397	0.00637*	0.00877	0.00486*
Lacking	(0.00423)	(0.00167)	(0.00357)	(0.00107)	(0.00551)	(0.00381)	(0.00563)	(0.00375)	(0.00550)	(0.00268)
Effect size	3.73%	1.85%	4.99%	13.25%	0.67%	7.97%	0.85%	6.22%	6.70%	33.83%
Observations	1,126	1,126	1,136	1,136	1,184	1,184	1,184	1,184	1,136	1,136
R-squared	0.037	0.029	0.072	0.035	0.286	0.253	0.437	0.399	0.386	0.134

Notes: Estimation results from linear fixed effect model at BoE (municipality) level. The outcome variable is the ratio of teachers working over a given overtime hours threshold in each month. Teacher ratio shows the mean of the outcome variable. IT skill index standardized to mean 0. Other control variables are "High-speed internet," "Wi-Fi," "Projector," "Digital instructions," "Digital textbook," "Management software," "Security policy" and the lag of the outcome variable with a dummy variable indicating imputed value. Robust standard errors clustered at municipality prefecture and prefecture level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A5: Teachers' overtime hours–subsample with private junior high school

	PRIVATE JUNIOR HIGH SCHOOL									
PANEL A	**April 2020**		**May 2020**		**June 2020**		**July 2020**		**August 2020**	
Overtime threshold	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Teacher ratio	0.149	0.045	0.097	0.028	0.514	0.136	0.522	0.155	0.138	0.034
IT skill index	-0.00733	-0.00207	-0.00265	-0.00444	-0.0239	-0.00461	-0.0181	-0.00119	-0.00764	-0.000110
Proficient	(0.00784)	(0.00419)	(0.00713)	(0.00311)	(0.0160)	(0.0116)	(0.0174)	(0.0114)	(0.0111)	(0.00256)
Effect size	-4.91%	-4.58%	-2.72%	-16.14%	-4.65%	-3.38%	-3.47%	-0.77%	-5.54%	-0.32%
Observations	482	482	484	484	502	502	492	492	468	468
R-squared	0.056	0.168	0.050	0.043	0.439	0.445	0.694	0.724	0.605	0.300
PANEL B	**April 2020**		**May 2020**		**June 2020**		**July 2020**		**August 2020**	
Overtime threshold	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**
	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Teacher ratio	0.149	0.045	0.097	0.028	0.514	0.136	0.522	0.155	0.138	0.034
IT skill index	0.00239	-0.00124	-0.00757	-0.00180	0.0123	0.0195**	0.00305	0.0249***	0.0218	0.00822
Lacking	(0.00622)	(0.00260)	(0.00833)	(0.00171)	(0.0116)	(0.00907)	(0.0138)	(0.00824)	(0.0134)	(0.00508)
Effect size	1.60%	-2.74%	-7.78%	-6.54%	2.39%	14.31%	0.58%	16.07%	15.81%	24.05%
Observations	482	482	484	484	502	502	492	492	468	468
R-squared	0.052	0.167	0.053	0.031	0.433	0.464	0.691	0.736	0.612	0.319

Notes: Estimation results from linear fixed effect model at BoE (municipality) level. The outcome variable is the ratio of teachers working over a given overtime hours threshold in each month. Teacher ratio shows the mean of the outcome variable. IT skill index standardized to mean 0. Other control variables are "High-speed internet," "Wi-Fi," "Projector," "Digital instructions," "Digital textbook," "Management software," "Security policy" and the lag of the outcome variable with a dummy variable indicating imputed value. Robust standard errors clustered at municipality prefecture and prefecture level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A6: Teachers' overtime hours–subsample without private junior high schools

	NO PRIVATE JUNIOR HIGH SCHOOL									
PANEL A	**April 2020**		**May 2020**		**June 2020**		**July 2020**		**August 2020**	
Overtime threshold	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Teacher ratio	0.198	0.031	0.134	0.014	0.526	0.118	0.499	0.118	0.144	0.016
IT skill index	0.000257	-0.00177	0.000444	-0.00217**	-0.00402	-0.00304	-0.00292	-0.00599	0.00348	0.000833
Proficient	(0.00443)	(0.00187)	(0.00473)	(0.00106)	(0.00493)	(0.00387)	(0.00551)	(0.00363)	(0.00465)	(0.00158)
Effect size	0.13%	-5.73%	0.33%	-15.51%	-0.76%	-2.57%	-0.59%	-5.09%	2.41%	5.22%
Observations	1,958	1,958	1,970	1,970	2,058	2,058	2,044	2,044	1,938	1,938
R-squared	0.038	0.019	0.065	0.033	0.331	0.316	0.517	0.494	0.442	0.145
PANEL B	**April 2020**		**May 2020**		**June 2020**		**July 2020**		**August 2020**	
Overtime threshold	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**
	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Teacher ratio	0.198	0.031	0.134	0.014	0.526	0.118	0.499	0.118	0.144	0.016
IT skill index	0.00744*	0.000865	0.00497	0.00159	0.00330	0.00786**	0.00471	0.00547*	0.00764	0.00438*
Lacking	(0.00403)	(0.00148)	(0.00337)	(0.000973)	(0.00463)	(0.00348)	(0.00472)	(0.00302)	(0.00462)	(0.00260)
Effect size	3.77%	2.81%	3.72%	11.36%	0.63%	6.67%	0.95%	4.66%	5.33%	0.0474***
Observations	1,958	1,958	1,970	1,970	2,058	2,058	2,044	2,044	1,938	1,938
R-squared	0.042	0.019	0.067	0.032	0.331	0.320	0.517	0.494	0.444	0.153

Notes: Estimation results from linear fixed effect model at BoE (municipality) level. The outcome variable is the ratio of teachers working over a given overtime hours threshold in each month. Teacher ratio shows the mean of the outcome variable. IT skill index standardized to mean 0. Other control variables are "High-speed internet," "Wi-Fi," "Projector," "Digital instructions," "Digital textbook," "Management software," "Security policy" and the lag of the outcome variable with a dummy variable indicating imputed value. Robust standard errors clustered at municipality prefecture and prefecture level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A7: Effect of ICT resources on remote education–school level and prefecture dummies interaction terms

Dependent Variable	School days closed		Live online class		Live online communication	
Explanatory Variables	(1)	(2)	(3)	(4)	(5)	(6)
Elementary school	0.232***	0.232***	-0.0404***	-0.0404***	-0.0357***	-0.0358***
	(0.0154)	(0.0154)	(0.00278)	(0.00277)	(0.00317)	(0.00314)
Teachers' IT Skill						
IT skill index - Proficient	-0.000862		-5.33e-05		0.00374	
	(0.0171)		(0.00492)		(0.00473)	
IT skill index - Lacking		-0.0117		-0.00233		0.00405
		(0.0282)		(0.00359)		(0.00490)
School ICT Equipment						
High-speed internet	-0.197*	-0.195*	-0.0262	-0.0259	-0.0116	-0.0121
	(0.105)	(0.104)	(0.0241)	(0.0242)	(0.0293)	(0.0290)
Wi-Fi	-0.0425	-0.0419	0.0338*	0.0339*	0.0369**	0.0364**
	(0.0944)	(0.0942)	(0.0174)	(0.0174)	(0.0178)	(0.0180)
Presentation device	0.00736	0.00583	0.0167*	0.0164*	0.00641	0.00747
	(0.0437)	(0.0440)	(0.00982)	(0.00943)	(0.00911)	(0.00884)
Digital instructions	0.0424	0.0400	0.0293*	0.0288*	0.00384	0.00465
	(0.103)	(0.104)	(0.0147)	(0.0147)	(0.0135)	(0.0137)
Digital textbook	0.0811	0.0813	-0.0219	-0.0219	-0.0184	-0.0191
	(0.183)	(0.183)	(0.0243)	(0.0243)	(0.0205)	(0.0204)
Management software	0.0420	0.0404	-0.00853	-0.00884	-0.0135	-0.0129
	(0.0808)	(0.0818)	(0.0317)	(0.0320)	(0.0319)	(0.0324)
Security policy	-0.0676	-0.0683	-0.0136	-0.0137	0.0319	0.0329
	(0.0965)	(0.0961)	(0.0307)	(0.0310)	(0.0311)	(0.0316)
Observations	3,422	3,422	3,386	3,386	3,386	3,386
R-squared	0.038	0.038	0.039	0.039	0.035	0.035

Notes: Estimation results from fixed effect model at BoE (municipality) level. School level dummy and prefecture dummies interaction terms included (results omitted). Robust standard errors clustered at municipality and prefecture level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A8: Teachers' overtime hours –school level and prefecture dummies interaction terms

PANEL A	April 2020		May 2020		June 2020		July 2020		August 2020	
Overtime threshold	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Teacher ratio	0.184	0.031	0.123	0.015	0.522	0.121	0.502	0.125	0.138	0.017
IT skill index	-0.000752	-0.00179	-8.74e-05	-0.00218**	-0.00422	-0.00188	-0.00492	-0.00670*	0.00206	0.000858
Proficient	(0.00434)	(0.00189)	(0.00454)	(0.000974)	(0.00503)	(0.00344)	(0.00560)	(0.00340)	(0.00415)	(0.00144)
Effect size	-0.41%	-5.75%	-0.07%	-14.25%	-0.81%	-1.56%	-0.98%	-5.38%	1.49%	5.07%
Observations	2,440	2,440	2,454	2,454	2,560	2,560	2,536	2,536	2,406	2,406
R-squared	0.145	0.076	0.295	0.122	0.418	0.419	0.592	0.593	0.583	0.305

PANEL B	April 2020		May 2020		June 2020		July 2020		August 2020	
Overtime threshold	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**
	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Teacher ratio	0.184	0.031	0.123	0.015	0.522	0.121	0.502	0.125	0.138	0.017
IT skill index	0.00820**	0.000658	0.00622**	0.00135*	0.00326	0.00725**	0.00493	0.00606**	0.00236	0.00237
Lacking	(0.00342)	(0.00114)	(0.00283)	(0.000787)	(0.00403)	(0.00309)	(0.00389)	(0.00287)	(0.00410)	(0.00239)
Effect size	4.46%	2.11%	5.06%	8.82%	0.62%	6.00%	0.98%	4.86%	1.70%	13.99%
Observations	2,440	2,440	2,454	2,454	2,560	2,560	2,536	2,536	2,406	2,406
R-squared	0.150	0.076	0.298	0.120	0.418	0.421	0.592	0.593	0.583	0.307

Notes: Estimation results from linear fixed effect model at BoE (municipality) level. School level dummy and prefecture dummies interaction terms included (results omitted). The outcome variable is the ratio of teachers working over a given overtime hours threshold in each month. Teacher ratio shows the mean of the outcome variable. IT skill index standardized to mean 0. Other control variables are "High-speed internet," "Wi-Fi," "Projector," "Digital instructions," "Digital textbook," "Management software," "Security policy" and the lag of the outcome variable with a dummy variable indicating imputed value. Robust standard errors clustered at municipality prefecture and prefecture level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A9: Effect of ICT resources on remote education–2019 ICT equipment

Dependent Variable	School days closed		Live online class		Live online communication	
Explanatory Variables	(1)	(2)	(3)	(4)	(5)	(6)
Elementary school	0.0920**	0.0842*	-0.0133	-0.0143	-0.0112	-0.00988
	(0.0424)	(0.0437)	(0.00922)	(0.00951)	(0.00744)	(0.00771)
Teachers' IT Skill (2020)						
IT skill index - Proficient	0.00311		0.000717		0.00398	
	(0.0165)		(0.00500)		(0.00460)	
IT skill index - Lacking		-0.0200		-0.00247		0.00404
		(0.0313)		(0.00333)		(0.00442)
School ICT Equipment (2019)						
High-speed internet	-0.139	-0.137	-0.00436	-0.00411	0.0163	0.0164
	(0.0980)	(0.0995)	(0.0251)	(0.0251)	(0.0287)	(0.0287)
Presentation device	0.0466	0.0446	0.0249**	0.0246**	0.0104	0.0110
	(0.0562)	(0.0553)	(0.0119)	(0.0117)	(0.0100)	(0.00981)
Digital instructions	-0.0131	-0.0160	0.0140	0.0137	-0.000786	-0.000166
	(0.0865)	(0.0878)	(0.0142)	(0.0143)	(0.0108)	(0.0108)
Management software	0.0643	0.0644	0.0118	0.0118	-0.0176	-0.0179
	(0.0810)	(0.0788)	(0.0331)	(0.0329)	(0.0314)	(0.0314)
Security policy	0.0200	0.0151	-0.0140	-0.0145	0.0238	0.0255
	(0.0583)	(0.0583)	(0.0250)	(0.0252)	(0.0253)	(0.0262)
Observations	3,418	3,418	3,384	3,384	3,384	3,384
R-squared	0.006	0.006	0.006	0.006	0.004	0.004

Notes: Estimation results based on fixed effect model at BoE (municipality) level. Robust standard errors clustered at municipality and prefecture level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A10: Teachers' overtime hours –2019 ICT equipment controls

PANEL A	April 2020		May 2020		June 2020		July 2020		August 2020	
Overtime threshold	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Teacher ratio	0.184	0.031	0.123	0.015	0.522	0.121	0.502	0.125	0.138	0.017
IT skill index	-0.000399	-0.00170	0.000455	-0.00222**	-0.00557	-0.00220	-0.00420	-0.00546	0.00231	0.000603
Proficient	(0.00408)	(0.00182)	(0.00437)	(0.00107)	(0.00518)	(0.00381)	(0.00548)	(0.00362)	(0.00451)	(0.00150)
Effect size	-0.22%	-5.46%	0.37%	-14.50%	-1.07%	-1.82%	-0.84%	-4.38%	1.67%	3.56%
Observations	2,438	2,438	2,452	2,452	2,558	2,558	2,534	2,534	2,404	2,404
R-squared	0.030	0.013	0.054	0.022	0.332	0.317	0.534	0.525	0.458	0.148

PANEL B	April 2020		May 2020		June 2020		July 2020		August 2020	
Overtime threshold	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**
	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Teacher ratio	0.184	0.031	0.123	0.015	0.522	0.121	0.502	0.125	0.138	0.017
IT skill index	0.00725*	0.000511	0.00361	0.00116	0.00360	0.00813**	0.00376	0.00743**	0.00874*	0.00495*
Lacking	(0.00370)	(0.00133)	(0.00337)	(0.000940)	(0.00438)	(0.00360)	(0.00463)	(0.00293)	(0.00479)	(0.00260)
Effect size	3.94%	1.64%	2.93%	7.57%	0.69%	6.74%	0.75%	5.97%	6.32%	29.23%
Observations	2,438	2,438	2,452	2,452	2,558	2,558	2,534	2,534	2,404	2,404
R-squared	0.034	0.012	0.056	0.020	0.332	0.321	0.534	0.526	0.461	0.158

Notes: Estimation results from linear fixed effect model at BoE (municipality) level. The outcome variable is the ratio of teachers working over a given overtime hours threshold in each month. Teacher ratio shows the mean of the outcome variable. IT skill index standardized to mean 0. Other control variables are 2019 levels of "High-speed internet, "Projector," "Digital instructions," "Management software," "Security policy" and the lag of the outcome variable with a dummy variable indicating imputed value. Robust standard errors clustered at municipality prefecture and prefecture level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A11: Teachers' overtime hours –2019 overtime hours

PANEL A	**April 2019**		**May 2019**		**June 2019**	
Overtime threshold	**45**	**80**	**45**	**80**	**45**	**80**
	(1)	(2)	(3)	(4)	(5)	(6)
Teacher ratio	0.595	0.202	0.593	0.194	0.601	0.205
IT skill index Proficient	-0.00222	-0.0134*	-0.00276	-0.0113	-0.000920	-0.00170
	(0.00806)	(0.00746)	(0.00723)	(0.00766)	(0.00839)	(0.00662)
Effect size	-0.37%	-6.63%	-0.47%	-5.82%	-0.15%	-0.83%
Observations	1,742	1,742	1,776	1,776	1,914	1,914
R-squared	0.584	0.624	0.601	0.623	0.558	0.562

PANEL B	**April 2019**		**May 2019**		**June 2019**	
Overtime threshold	**45**	**80**	**45**	**80**	**45**	**80**
	(11)	(12)	(13)	(14)	(15)	(16)
Teacher ratio	0.595	0.202	0.593	0.194	0.601	0.205
IT skill index Lacking	-0.00107	-0.000907	0.00571	0.00313	-0.00151	-0.00169
	(0.00701)	(0.00639)	(0.00644)	(0.00499)	(0.00735)	(0.00605)
Effect size	-0.18%	-0.45%	0.96%	1.61%	-0.25%	-0.83%
Observations	1,742	1,742	1,776	1,776	1,914	1,914
R-squared	0.584	0.622	0.602	0.622	0.558	0.562

Notes: Estimation results from linear fixed effect model at BoE (municipality) level. The outcome variable is the ratio of teachers working over a given overtime hours threshold in each month. Teacher ratio shows the mean of the outcome variable. IT skill index standardized to mean 0. Other control variables are 2019 levels of "High-speed internet, "Projector," "Digital instructions," "Management software," "Security policy" and the lag of the outcome variable with a dummy variable indicating imputed value. Robust standard errors clustered at municipality prefecture and prefecture level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A12: Effect of ICT resources on remote education–subsample of municipalities with one junior high school

Dependent Variable	**School days closed**		**Live online class**		**Live online communication**	
Explanatory Variables	(1)	(2)	(3)	(4)	(5)	(6)
Elementary school	0.208***	0.200***	-0.0146	-0.0141	-0.0199*	-0.0171
	(0.0645)	(0.0580)	(0.0126)	(0.0130)	(0.0102)	(0.0108)
Teachers' IT Skill						
IT skill index - Proficient	-0.00259		0.00126		0.000166	
	(0.0269)		(0.00454)		(0.00585)	
IT skill index - Lacking		-0.0239		0.00196		0.00878*
		(0.0473)		(0.00405)		(0.00520)
School ICT Equipment						
High-speed internet	-0.219	-0.212	-0.00549	-0.00601	0.00743	0.00487
	(0.158)	(0.157)	(0.0283)	(0.0279)	(0.0342)	(0.0338)
Wi-Fi	0.00875	0.0152	0.0223	0.0215	0.00410	0.00169
	(0.120)	(0.117)	(0.0212)	(0.0221)	(0.0202)	(0.0215)
Presentation device	-0.0169	-0.0217	0.0341**	0.0347**	0.0268**	0.0282**
	(0.0758)	(0.0740)	(0.0149)	(0.0146)	(0.0132)	(0.0125)
Digital instructions	0.113	0.111	0.0361***	0.0361***	0.00860	0.00945
	(0.135)	(0.135)	(0.0114)	(0.0120)	(0.0105)	(0.0110)
Digital textbook	0.152	0.153	-0.0179	-0.0181	-0.0188	-0.0191
	(0.232)	(0.231)	(0.0319)	(0.0313)	(0.0246)	(0.0243)
Management software	0.148	0.142	-0.0214	-0.0208	-0.0231	-0.0207
	(0.0982)	(0.0973)	(0.0452)	(0.0454)	(0.0476)	(0.0477)
Security policy	-0.116	-0.120	-0.0142	-0.0137	0.0369	0.0381
	(0.126)	(0.121)	(0.0365)	(0.0367)	(0.0359)	(0.0370)
Observations	1,100	1,100	1,088	1,088	1,088	1,088
R-squared	0.016	0.017	0.021	0.021	0.017	0.021

Notes: Estimation results based on fixed effect model at BoE (municipality) level. Subsample of municipalities with one junior high school. Robust standard errors clustered at municipality and prefecture level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A13: Teachers' overtime hours – subsample of municipalities with one junior high school

PANEL A	April 2020		May 2020		June 2020		July 2020		August 2020	
Overtime threshold	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Teacher ratio	0.198	0.027	0.128	0.013	0.485	0.098	0.442	0.090	0.120	0.015
IT skill index Proficient	0.00678	-0.000274	0.00611	-0.000704	-0.000151	-0.000380	0.00298	-0.00617*	0.00458	0.000883
	(0.00754)	(0.00320)	(0.00828)	(0.00138)	(0.00631)	(0.00444)	(0.00658)	(0.00363)	(0.00710)	(0.00203)
Effect size	3.42%	-1.03%	4.76%	-5.58%	-0.03%	-0.39%	0.67%	-6.86%	3.81%	5.98%
Observations	678	678	684	684	710	710	716	716	694	694
R-squared	0.060	0.040	0.096	0.045	0.299	0.241	0.405	0.369	0.335	0.128

PANEL B	April 2020		May 2020		June 2020		July 2020		August 2020	
Overtime threshold	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**	**45**	**80**
	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Teacher ratio	0.198	0.027	0.128	0.013	0.485	0.098	0.442	0.090	0.120	0.015
IT skill index Lacking	0.00807	-0.00110	0.00560	0.00176	0.00306	0.0114**	0.00407	0.0106**	0.00799	0.00501
	(0.00527)	(0.00222)	(0.00368)	(0.00136)	(0.00677)	(0.00438)	(0.00696)	(0.00431)	(0.00661)	(0.00315)
Effect size	4.07%	-4.15%	4.36%	13.96%	0.63%	11.64%	0.92%	11.78%	6.64%	33.92%
Observations	678	678	684	684	710	710	716	716	694	694
R-squared	0.062	0.041	0.096	0.047	0.300	0.254	0.405	0.375	0.337	0.139

Notes: Estimation results from linear fixed effect model at BoE (municipality) level. Subsample of municipalities with one junior high school. The outcome variable is the ratio of teachers working over a given overtime hours threshold in each month. Teacher ratio shows the mean of the outcome variable. IT skill index standardized to mean 0. Other control variables are "High-speed internet," "Wi-Fi," "Projector," "Digital instructions," "Digital textbook," "Management software," "Security policy" and the lag of the outcome variable with a dummy variable indicating imputed value. Robust standard errors clustered at municipality prefecture and prefecture level in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Appendix B: Teachers' IT skills questionnaire

1) Status of teachers' ICT utilization and guidance (teachers in charge of classes in 2019)

Skill A: Ability to use ICT for class preparation, grading, and administrative tasks

A–1 Make planned use of computers, the Internet, etc. to increase education efficacy.

A–2 Make use of the Internet and other tools to collect materials used in class or materials needed for administrative tasks, and to share information necessary to coordinate with guardians and the public.

A–3 Make use of word processing, spreadsheet, and presentation software, etc. to prepare materials such as prints or presentations used in class or documents and materials needed for class management and administrative tasks.

A–4 Make use of computers and other tools to record, organize, and evaluate students' work, reports, worksheets, and others in order to comprehend learning status.

Skill B: Ability to teach class using ICT

B–1 Use computers and presentation devices to effectively present materials and others to appropriately summarize learning contents, to clearly explain tasks and raise students' interest and curiosity.

B–2 Have students use computers, presentation devices, etc. to effectively present opinions and others, in order to share and compare opinions, ideas, and works.

B–3 Use learning software and other tools to have students perform repetitive learning tasks and other tasks corresponding to each student's level of learning for the purposes of establishing knowledge and mastering technical skills.

B–4 Have students make effective use of computer software and other tools when summarizing ideas from group discussions or collaboratively preparing reports, materials, works, and others.

Skill C: Ability to teach students to use ICT

C–1 Guide students to gain the basic skills needed to operate computers and other tools necessary to learning (character input, file management, and others).

C–2 Guide students to be able to use computers and the Internet to collect and select relevant and reliable information.

C–3 Guide students to be able to use word processing, spreadsheet, and presentation software, etc. to organize research and ideas and to summarize them in text, tables, graphs, figures, and others in an easy-to-understand manner.

C–4 Guide students to use computers, software, etc. to be able to exchange, share, and discuss ideas with each other.

Skill D: Ability to instruct students in knowledge and attitude needed to utilize information

D–1 Guide students to be able to take responsibility for their own actions participating in information-driven society, to think of and respect others, and to follow rules and manners when collecting and sharing information.

D–2 Guide students to be able to appropriately avoid antisocial and illegal behavior, online crimes, and other risks and to be mindful of their health when using the Internet and other tools.

D–3 Guide students to gain the basic knowledge of information security and to appropriately set and manage passwords to be able to use computers and the Internet safely.

D–4 Guide students to acknowledge the usefulness of computers and the Internet and encourage students' interest in utilizing them for learning and understanding their mechanism.

2) Reference for answering 1)

Skill A: Ability to use ICT for class preparation, grading, and administrative tasks

Proficient: Generally skilled in items in question.

(Example A–3: Is able to use word processing, spreadsheet, and presentation software, etc. to prepare materials such as prints or presentations used in class or documents and materials

needed for class management and division of school duties.)
Mostly proficient: Knows how to use ICT equipment in question.
(Example A–3: Knows how to operate word processing, spreadsheet, and presentation software.)
Mostly lacking: Unable to operate without receiving in-school or other training.
(Example A–3: Will know how to operate word processing, spreadsheet, and presentation software after receiving in-school or other training.)
Lacking: Unable to operate without receiving step-by-step training (including outside-school training) starting from the basics of operation.
(Example A–3: Largely does not know how to operate word processing, spreadsheet, and presentation software.)

Skill B: Ability to teach class using ICT
Proficient: Is able to use ICT in teaching activities.
(Example B–1: Is able to use computers and presentation devices to effectively present materials and others to appropriately summarize learning contents, to clearly explain tasks, and raise students' interest and curiosity.
Mostly proficient: Using practical examples and guidebooks, is able to use ICT in teaching activities.
(Example B–1: Is able to present materials and others using computers and presentation devices.)
Mostly lacking: Does not know how to teach using ICT without receiving in-school or other training.
(Example B–1: Will be able to present materials and others using computers and presentation devices after receiving in-school or other training.)
Lacking: Does not know how to teach using ICT without receiving step-by-step training (including outside-school training) starting from the basics of operation.
(Example B–1: Largely does not know how to present materials and others using computers and presentation devices.)

Skill C: Ability to teach students to use ICT
Proficient: Generally able to teach items in question.
(Example C–1: Is able to guide students to gain the basic skills needed to operate computers and other tools necessary to learning (character input, file management, and others).)
Mostly proficient: Using practical examples and guidebooks, is able to teach.
(Example C–1: Has and is able to explain the basic skills needed to operate computers and other tools necessary to learning (character input, file management, and others).)
Mostly lacking: Does not know how to teach without receiving in-school or other training.
(Example C–1: Does not know how to teach; in-school training is therefore necessary.)
Lacking: Does not know how to teach without receiving step-by-step training (including outside-school training) starting from the basics of operation.
(Example C–1: Does not know how to teach; step-by-step training (including outside-school training) starting from the basics of operation is therefore necessary.)

Skill D: Ability to instruct students in knowledge and attitude needed to utilize information
Proficient: Generally able to teach items in question.
(Example D–1: Is able to guide students to be able to take responsibility for their own actions participating in information-driven society, to think of and respect others, and to follow rules and manners when collecting and sharing information.)
Mostly proficient: Using practical examples and guidebooks, is able to teach.
(Example D–1: Using practical examples and guidebooks, is able to guide students to be able to take responsibility for their own actions participating in information-driven society, to think of and respect others, and to follow rules and manners when collecting and sharing information.)
Mostly lacking: Does not know how to teach without receiving in-school or other training.
(Example D–1: Does not know how to teach; in-school training is therefore necessary.)
Lacking: Does not know how to teach without receiving step-by-step training (including outside-school training) starting from the basics of operation.

(Example D–1: Does not know how to teach; step-by-step training (including outside-school training) starting from the basics of operation is therefore necessary.)