Case report

Evgeny O. Anokhin, Gleb Yu. Aleshin*, Alexey A. Tishkin, Vladimir V. Korolev, Alexander G. Sobol, Konstantin M. Evdokimov and Alexey A. Chepiga

Not great, not terrible: distance learning of chemistry in Russian secondary schools during COVID-19

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Abstract: The COVID-19 outbreak has influenced virtually all aspects of our life, in particular, hundreds of millions of people around the world have been forced to study online. To observe the practical realization of emergency remote teaching of chemistry during the first wave of COVID-19 in Russia we gave the survey to 217 teachers and 355 students from more than 50% regions of Russia about their experience during distance learning of chemistry. 17% of students were lacking chemistry lessons at all. We compared this with the situation in Letovo international boarding school in Moscow and found relative success in terms of lessons adaptation and overall satisfaction compared to the Russia-wide survey. This might be because of the fine educational organization effort and implemented learning management system (LMS). There is a high probability of a second COVID-19 wave or any other occasion that may lead to sudden change to distance learning. Teacher community should learn from world-wide and country-wide experiences of the first COVID-19 wave to become prepared for future challenges. Those preparation measures may include implementing LMS and strategy development.

Keywords: COVID-19; emergency remote teaching; secondary schools.

Introduction

The pandemic of COVID-19 has a dramatic influence on almost every area of human activity (World Health Organization. Coronavirus Disease (COVID-19) Pandemic, 2020). Education is no exception: according to the UNESCO 188 countries around the world cancelled all lessons in schools, that affected up to 91.3% of all primary and secondary school students (UNESCO. Schools closures caused by Coronavirus (Covid-19), 2020). Closing schools is one of the most common nonpharmaceutical interventions to the pandemic (Centers for Disease Control and Prevention. Nonpharmaceutical Interventions (NPIs), 2020). In Russia schools are closed since March 23 (Over 80% of schools in Russia closed or on vacation from March 23, 2020): for the first two weeks of this period most of the schools had a vacation and after that distance learning period has started all over the country. The end of a school year in Russia is May 31st, thus Russian schools were on the emergency

*Corresponding author: Gleb Yu. Aleshin, Letovo School, Zimenkovskaya Street 3, Sosenskoye Settlement, Moscow, 108803, Russian Federation; and Lomonosov Moscow State University, Leninskie Gory, 1, Moscow, 119991, Russian Federation, E-mail: gleb.aleshin@gmail.com. https://orcid.org/0000-0002-9725-2217
Evgeny O. Anokhin, Alexey A. Tishkin, Vladimir V. Korolev, Alexander G. Sobol and Konstantin M. Evdokimov, Letovo School, Zimenkovskaya Street 3, Sosenskoye Settlement, Moscow, 108803, Russian Federation; and Lomonosov Moscow State University, Leninskie Gory, 1, Moscow, 119991, Russian Federation. https://orcid.org/0000-0002-3991-1843 (E.O. Anokhin). https://orcid.org/0000-0002-7122-5317 (A.A. Tishkin). https://orcid.org/0000-0002-8396-2162 (V.V. Korolev). https://orcid.org/0000-0001-7409-6031 (A.G. Sobol)
Alexey A. Chepiga, Letovo School, Zimenkovskaya Street 3, Sosenskoye Settlement, Moscow, 108803, Russian Federation. https://orcid.org/0000-0002-0526-0931

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remote teaching for 8 weeks in the spring of 2020, and the virus forced Russia, like many other countries, to make an experiment with the mass transition of schools to online education. Sudden disruptions in learning is actually not rare and might be happening not only due to epidemics (for example due to protests and social disruptions) as was previously noted (Potgieter, Pilcher, Tekane, Louw, & Fletcher, 2019).

During the pandemic situation teacher community and students faced emergency distance teaching, but not normal online learning (Hodges, Moore, Locke, Trust, & Bond, 2020). In this situation we have a few points. Undoubtedly, online learning is the most relevant trend of the last decades since Internet access became widely available (Broadbent & Poon, 2015). Even intellectual competitions in chemistry can be conducted in online format (Paiva, Parma, & Buffon, 2020). Interactive methods and information technologies are widely applied in chemistry teaching, including in-class education process (Bellou, Papachristos, & Mikropoulos, 2018; Prat-Resina, 2019; Sadykov & Čírnáctová, 2019). From the other point of view, it requires certain technical equipment (i.e. computer or laptop) for every single student and teacher, and not every household in developing countries can afford it. Mass transition to online can also lead to inequality in education with some students not having any lessons at all. For example, in Great Britain 71.1% of students in state schools and 27.8% of students in private ones had less than 1 lesson in a day during lockdown (Green, 2020; Weale, 2020). Finally, the most important feature of chemistry is the role of experiment in the education process (Kimel, Bradley, Durbach, Bell, & Mungarulire, 1998). That point can be crucial to the chemistry teaching process: a video of an experiment cannot fully replace one made by students themselves (Ben-Zvi, Hofstein, Samuel, & Kempa, 1976a, 1976b; Zhilin, 2013), while home-made experiments have significant limitations due to both inaccessibility of most chemicals and safety requirements (D’Ham, De Vries, Girault, & Marzin, 2004; Kennepohl, 2007).

High possibility of the COVID-19 s and the following waves (Leung, Wu, Liu, & Leung, 2020; Xu & Li, 2020) makes it especially urgent to reflect on the experience gained during this period of distance learning. Some recent reports describe the experience of education during COVID-19 pandemic (Ahmed, Allaf, & Elghazaly, 2020; Basiliaa & Kvavadze, 2020; Kogan, Klein, Hannon, & Nolte, 2020). There is no evidence that Russian experience is unique, it is more likely that this is just an example of what consequences follow from the general premises. In this communication we discuss the realization of online learning of chemistry in Russian secondary schools. Also, we highlighted one of the practices in the organization of distance learning of chemistry in Russia on the example of Letovo School in Moscow. Thus, the aim of this paper is to note the emergency remote teaching problems, to study its practical realizations and analyze best practices and treatments.

Methods

To determine the real situation at the end of the school year, three surveys were compiled using the Google Forms service. The questions of the survey can be found in the Supplementary Material.

Information about the surveys was distributed on the Internet among schoolchildren of grades 7–11 (age 13–18) and chemistry teachers participating in the Russian annual chemistry tournament (national version of International Chemistry Tournament (International Chemistry, 2020)); thus, data were collected using random sampling. This method contains systematic error (respondents without proper Internet access do not have an adequate representation), but in general it can be considered satisfactory. The last survey was conducted among Letovo international school students. Letovo school is a private school (with a grants for students that can’t pay for education), students in secondary schools have from 2 to 6 h of chemistry a week as in public Russian schools. The total coverage was about 1100 teachers and 13,000 students. According to the results, the following number of responses to the polls was collected: 355 respondents among students and 217 among teachers all over the country, and 78 respondents from Letovo school students.

In Russia there are approximately 16.5 million schoolchildren (Dmitrakova et al., 2019); it can be roughly estimated that in grades 7–11 (grades when chemistry is studied), there are about seven million of students. More than 200 students can be considered as a sufficient number of respondents. Letovo students’ poll appears to be representative as well, since only 350 students have chemistry in their curricula. Normally they have from 2 to 6 lessons of chemistry a week in a frontal teaching format. For both all-country surveys, the sample seems representative by the geographical principle (students from 46 different Russian regions of total 85 regions and teachers from 54 ones: it is more than 50 and 60% of all regions respectively) and sufficient.
Results and discussion

Russian-wide survey results

Hereby we represent the results of all-country surveys of students and teachers. According to the survey (Figure 1a), more than 80% of both teachers and students thought that the number of chemistry lessons had not increased. Particularly, more than a half of the respondents believed that this amount had not changed at all. The results are not surprising, since addition of new lessons to the curriculum in the middle of the year seems highly unlikely.

At the same time, almost half of the students noticed (Figure 1b) the increase of the amount of homework in chemistry. On the other hand, two-thirds of teachers believed that the amount of homework had not increased during the period of distance learning.

It was interesting to compare students’ and teachers’ opinions about the adaptation of practical works for distance learning (Figure 1c). They appeared to be virtually opposite: most students believed that the works had not been adapted, while most teachers believed they had been. We attribute this to the difference in

![Figure 1: Russian-wide surveys answers.](image-url)
understanding of practical works adaptation. Teachers adapt practical work by the means of including videos to online lessons while students expect real experiments. Realization of real experiments is much harder; thus, its ratio is relatively low. Our results are in agreement with previous reports about comparison of teachers’ and students’ opinion about forced using filmed experiments instead of real practical works. In these reports authors showed that both of these approaches help reach some knowledge of discipline but conducting real experiments appears to be necessary for students themselves (Ben-Zvi et al., 1976a, 1976b).

Although the global picture is mainly positive, one should be aware of the situation when distance learning is reduced to homework and self-education. This is totally unacceptable and requires intervention in the organization of the educational process and this may lead to overall failure of distance learning.

Our survey indicated that 17% of respondents had no distance chemistry lessons at all (Figure 2a) which might be extrapolated to 1.2 million of students (of seven million students studying chemistry in Russia).

The surveys showed high levels of involvement among the students who attended distance learning. 53% of respondents replied that they had actively participated in most lessons. Teacher survey confirmed that with 40% of respondents marking more than half of the active students on lessons.

Fifty five percentage of students believed that their grades during distance learning did not change and 35% of students noticed improvement (Figure 3a). It is surprising to see that 79% of teachers say that average grades of students have increased during distance learning, including 26% who say they have significantly increased. As possible explanations we can suggest subjectivity of teachers’ perceptions about average grades, informal governmental recommendation for a more loyal assessment during distance learning, and influence of students cheating during online assessment.

The overwhelming majority of both students and teachers told that online learning was “much worse” or “slightly worse” compared to full-time study (Figure 3b). The number of teachers who are satisfied with the quality of distance learning is at the level of statistical error (1 answer out of 217). This amount is bigger among students, about 10–15%.

At the same time, the subjective opinion (Figure 3c) regarding distance learning (“whether you like it or not”) is higher than could be expected from the quality assessment. Almost half of the students told about online format either neutrally or positively. Among teachers this format is rather negatively evaluated (more than 70%). Such a difference for various sides of the educational process may appear due to the attitude regarding the educational process. For students it is quite usual desire to work less during classes. So, distance format seems to put less pressure on students.

Some students noticed more simple learning of the content using distance lessons records, others told, that reducing the amount of lessons allowed to prepare for competitive chemistry events.

**Figure 2:** Russian-wide surveys answers.
(a) Involvement of students during chemistry online lessons, (b) involvement of study groups during chemistry online lessons.
According to the surveys more than 70% of teachers and students did not have any implemented LMS during distance learning period (see Supplementary Material, Figure S1). Only 20% used Google Classroom in their lessons.

**Letovo school practice**

As an element of comparison, we can consider the experience of switching to a distance format for teaching chemistry at Letovo international school in Moscow.

Letovo is a boarding school with students from all time zones of the Russian Federation (from GMT+2 at Kaliningrad to GMT+12 at Kamchatka). The transition to quarantine measures began during the spring holidays (March, 15–March, 22), so the students had already left the boarding at the moment. The school extended the vacation time by one week in order to better prepare for the distance learning format. During this period Letovo deployed some new educational tools as well as adapted the learning management system (LMS) implemented earlier.

During usual full-time classes LMS Canvas (Canvas, 2020) was routinely used: normally teachers upload lesson materials, curriculum, hometasks, tests, instructions and other materials. Students also use it to do
homework and review past material in everyday education process. Thus all students and teachers had already been familiar with this system before the beginning of distance learning. Normally it was used as an educational resource that complemented classes in chemistry, all students could view educational materials and contact the teacher remotely.

The school decided to use the Zoom platform for online lessons (Morgan, 2019). The IT department of the school developed a system generating scheduled video conferences with restricted access. Thus, the problem of zoom bombing was solved and the problems associated with insufficient experience in using technology both among students and teachers were minimized. In addition, the school decided to reduce the duration of lessons: from 40 to 30 min in order to reduce the length of school day due to the presence of students from different time zones. In the case of classes that are held in pairs (two lessons in a row), the second lesson was reserved for students to work independently to minimize computer use during the school day to meet governmental health regulations.

Due to the limitations of emergency remote teaching, the amount of practical work has been minimized. Partially practical exercises were replaced by showing video demonstrations, but several practical works were redesigned taking into account the reagents that could be found at home. For example, practical works in the seventh grade on the topic “Evidences of the chemical reactions”, in the eighth grade on the topic “Ion-exchange reactions”, in the ninth grade on the topic “Theory of electrolytic dissociation” were adapted to be held at home (see the details of this practical works in Supplementary Material Section). In all of the above-mentioned works, the common requirement was using safe reagents. The reactions were carried out in highly diluted solutions. In addition, the teacher observed the students’ practical work through video conferencing at Zoom.

Noticeably, that the most active students in the class remained at their high level of academic performance, students of average activity worsened their performance, while the most inactive students improved their results. However teachers observed that the differentiation and engagement of students during the seminars has worsened. Only the most motivated students participated in problem solving practice and skills training.

Teachers believed that work-life balance had shifted. The border between learning/teaching and personal time virtually disappeared, students used the opportunity to contact the teacher at any time convenient for them. On the contrary, the option of live class small talks between the student and the teacher has completely disappeared: the maximum level of communication is achieved only during general video conferences.

In relatively large groups of students (more than 12 people), the amount of collaboration and teamwork had significantly decreased: the practical implementation of such activities was extremely inconvenient, despite the presence of breakout rooms in Zoom. However, if students received individual tasks their involvement in lessons had increased. Individual tasks could be combined with carrying out a collective project, for example, filling in tables in teams with data in Google documents or similar services.

In extracurricular activities in chemistry work was carried out in small groups (usually less than six students). Therein, the opposite dynamics was observed: students worked even harder, uniting their efforts. As a result, overall performance of these classes improved. Distance format not only did not become an obstacle in learning for motivated students, but also provided an opportunity to develop their collaboration skills. Particularly active students interacted with each other while using online whiteboards (for example, a Zoom board, Google Jamboard, Miro).

After the end of the school year, an anonymous survey was conducted among the students of Letovo school, about 22% of students of grades 7–10 participated in this survey. Data are presented in Figure 4.

Despite the fact that Letovo school decided to reduce the duration of the lessons and transfer part of the lessons to an independent work format, most students (65%) believed that the number of lessons remained the same and only 31% of respondents noticed a decrease (Figure 4a). This result indicated that the workload on students during the distance learning format had increased compared to full-time classes. Only 4% of respondents believed that the number of lessons had increased (compared to 18% in Russia).

According to Figure 4b only 19% of Letovo school students felt an increase in homework (in Russia 46% of the students gave this answer). Apparently Letovo distance learning avoided the situation when the educational process mostly relied on self-education and homework.
Only 23% of students in Russia showed that practical work had been adapted to the distance learning format. Letovo school survey indicated much better performance towards this problem: 59% of students (Figure 4c) believed that the practical classes were well implemented in the distance format. A similar dependence was observed considering overall involvement in lessons during video conferencing: 67% of students in Russia versus 85% of students (Figure 4d) in Letovo school actively participated in such lessons. In Letovo school 80% of students (Figure 4e) responded that their grades did not decrease during distance learning (in Russia — 90%). The result is not surprising since the grading and assessment systems have not been changed.

Fifty four percentage of the Letovo students believed that the assimilation of distance chemistry learning had slightly or significantly decreased compared to full-time lessons (Figure 4f). At the same time, in Russia 65% of students gave similar answers. The general attitude of the students towards distance learning seems to be similar: in Letovo school, 28% liked this format (Figure 4g), in Russia — 33%; 50% of Letovo students versus 50% in Russia disliked the format.

Despite the overall high performance in Letovo in this particular case, distance learning yet remains a forced measure inferior to full-time education. This partly might be the case due to the benefits presented by school in full-time education that cannot be countervailed by distance learning benefits. Those include extracurricular activities, communication etc.

The main limitation of this study is survey sampling. Although the information about the survey was broadly distributed, the sampling was conducted mostly among the teachers working with students who are interested in chemistry and among participants of chemistry competitions. It is natural to assume that our results might be positively shifted from true country-wide average. But as well teachers and students may overestimate the problems caused by distance learning because of their interest.

Conclusions

In this communication we analyzed major challenges deduced from Russia-wide surveys and compared them to the experience of Letovo School distance learning. Distance chemical education during the first wave of COVID-19 pandemic in Russia went neither great nor terrible. Our survey indicates that every sixth student studying in grades 7–11 had virtually no distance chemistry lessons at all. Overall involvement of students