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Pre-university physics teaching during the SARS-CoV-2 pandemic in Croatian and Slovenian schools

I Štibi^{1,a}, M Čepić^{2,b} and J Pavlin^{2,c}

¹ *Department of Physics, J. J. Strossmayer University of Osijek, Osijek, Croatia*

² *Faculty of Education, University of Ljubljana, Ljubljana, Slovenia*

^a email: istibi@fizika.unios.hr

^b email: Mojca.Cepic@pef.uni-lj.si

^c email: Jerneja.Pavlin@pef.uni-lj.si

Abstract. In Croatia, as in Slovenia, all schools were closed on 16 March 2020 due to the SARS-CoV-2 pandemic (COVID 19). This has changed the way of teaching and thus has an impact on physics teaching, which encourages experimentation. The paper presents the results of the study on physics teaching during the pandemic in Croatia and Slovenia at the pre-university level. The data were collected using an e-questionnaire. The results show how physics was taught by 332 teachers during the pandemic and highlight the problems they faced during online teaching, focusing on experimental work. It is evident that teachers from both countries tried their best to deliver physics lessons through direct teaching as well. Moreover, they tried to include the experiments and they were very flexible about the students' obligations and much of what they learned during this time will be implemented in regular classes.

1. Introduction

In Croatia, as well as in Slovenia, on 16 March 2020, all schools were closed due to the SARS-CoV-2 pandemic (COVID 19). This has changed the teaching strategies and thus have had an impact on the physics lessons, which also encourages experimentation. In regular teaching, and especially in teaching during the pandemic, it is a question of how teachers teach and what teaching strategies they have chosen because each of them has positive and negative effects on students' learning, knowledge, attitudes, and achievements [1-3]. During this long-term distance learning everything should be transferred to distance (teaching) and digital (materials) ones. The choice which ICT to incorporate and should the teaching be synchronous or asynchronous depends on sociological to individual factors [4], but at the end students are adaptable with more or less problems [5]. From the papers it is evident that synchronous teaching and face-to face methods are more beneficial when ICT is incorporated [6]. An important task in physics lessons is to conduct experiments, which are an important part of every lesson [7]. Discussing problems and designing one's own experiments and/or conducting (collecting data) experiments, should be used in physics lessons because physics is an experimental science. Moreover, it should be used to the same extent as demonstrational experiments. Both have the aim of increasing students' motivation [8]. However, carrying out experiments is often very difficult during online teaching [9]. In this remote teaching situation, teachers have had to find alternative methods of experimental work and choose the teaching methods with the best effect [10].



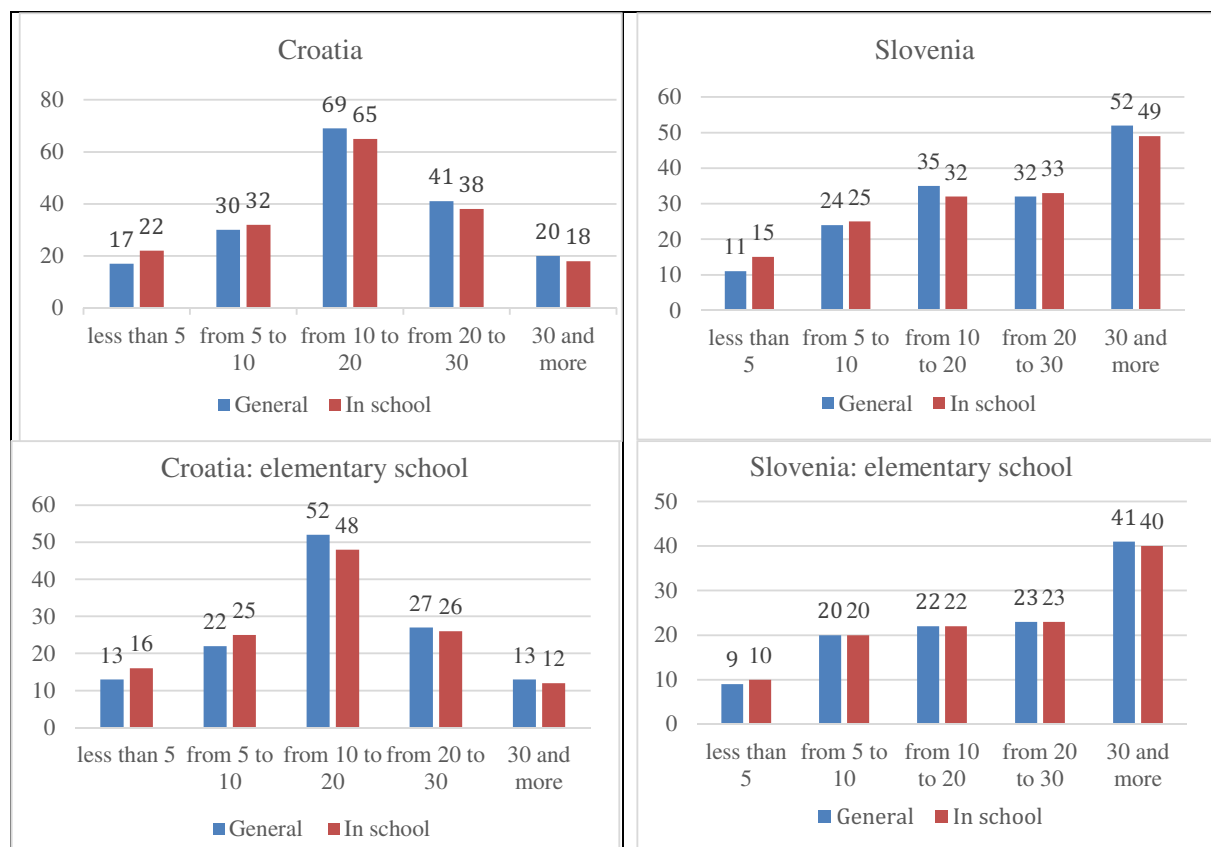
2. Research question and methodology

The pandemic era aroused curiosity in physics education research. Therefore, the following general research question was set: *How does COVID 19 quarantine affect physics teaching, especially experimental work, at the pre-university level in Croatia and Slovenia?*

The online questionnaire (instrument) on physics teaching in Croatian and translated into Slovenian was prepared. It has 5 parts: general data, conducting physics teaching during the pandemic, experiments in physics teaching, sociological component and exchange of experience. Filling in the questionnaire was all anonymous and voluntary, and when answers were collected, all of them were coded for the purpose of statistical analysis.

2.1. Sample

The questionnaire was completed by 178 Croatian and 154 Slovenian teachers (of whom about 65% for Croatia and 74% for Slovenia teach in elementary schools and about 72% are females in both countries). In Croatia, as in Slovenia, 13% of teachers are younger than 30 and older than 60. From Figure 1 it is evident that the majority of Croatian teachers who filled in the questionnaire have from 10 to 20 years of teaching experiences. In Slovenia the situation is a little different, more than 50% of the teachers have been working in the school for 20 or more years.



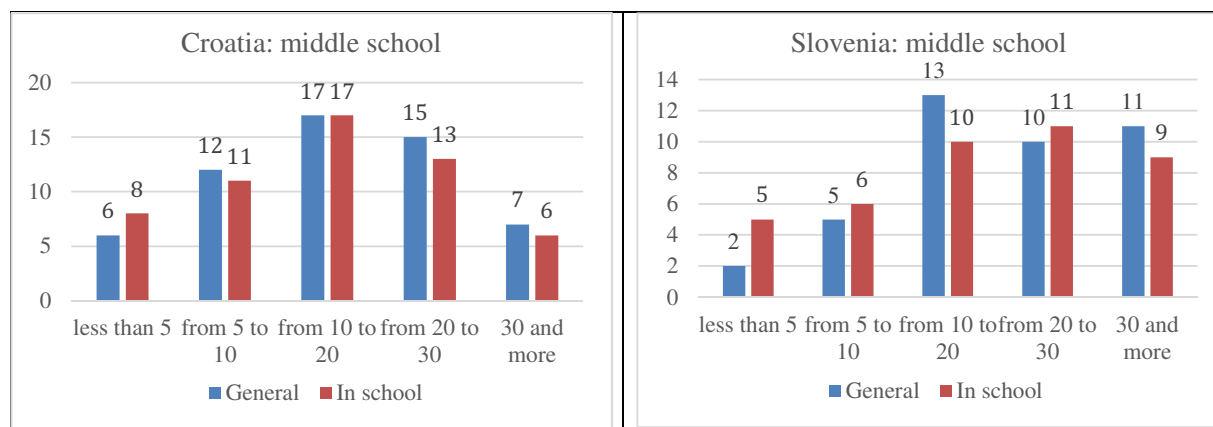


Figure 1: Length of teaching service of physics teachers, on the y-axis is a number of physics teachers.

Teachers from Croatia were mostly from the town schools (52%), and 19% from the rural places, and others are from suburbs, islands and district schools. In Slovenia 48% of teachers are from town schools, 35% from the village schools and 16% from suburbs. This could be very important when we will talk about results for experimental work (before and during the pandemic).

Subjects they teach are: only physics (44% for Croatia, and 25% for Slovenia), physics and mathematics (27% for Croatia and 51% for Slovenia). Others are teaching computer science, technical science, or other science subjects (like chemistry and biology) and vocational subjects.

61% of the teachers in Croatia and 73% in Slovenia think that their school is well or very well equipped.

The self-assessment of ICT level usage of physics teachers is shown in Figure 2. Croatian physics teachers self-assessed their ICT knowledge commonly by using most of them in some advanced or all advanced functions, whereas Slovenian colleagues self-assessed it by using basic or some advanced functions. Slovenian physics teachers less often use social networks, or just in basic functions.

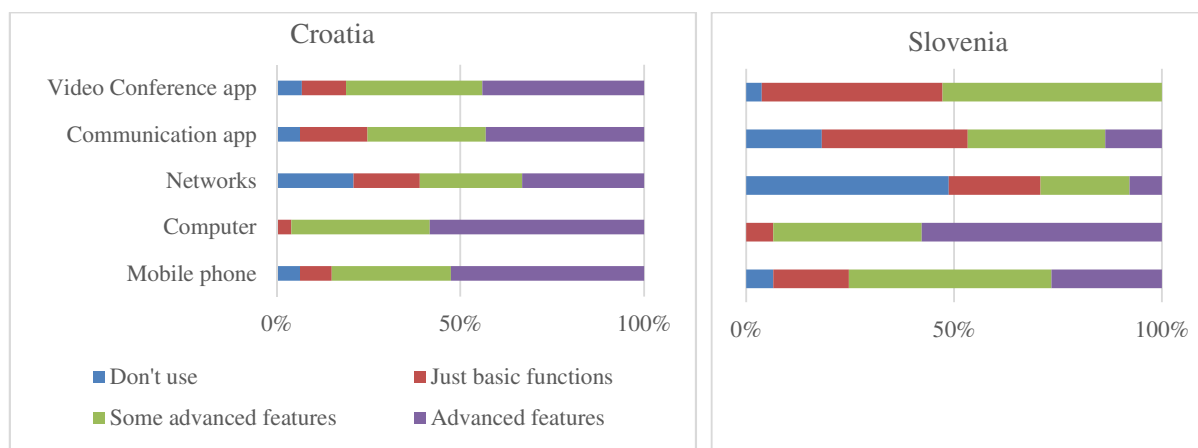


Figure 2: Self-assessment of ICT use by Croatian and Slovenian physics teachers.

2.2. Data analysis

Anonymity of the data was guaranteed for research purposes when processing the data. The data was collected in Microsoft Office Excel and statistically processed in SPSS. Basic statistics were used to describe the distribution of the individual variables. Descriptive statistics were used to describe the data.

3. Results and discussion

Croatian and Slovenian teachers are confident that they taught physics during a pandemic in the same level of detail as in the regular classes, as shown in Figure 3 and Figure 4.

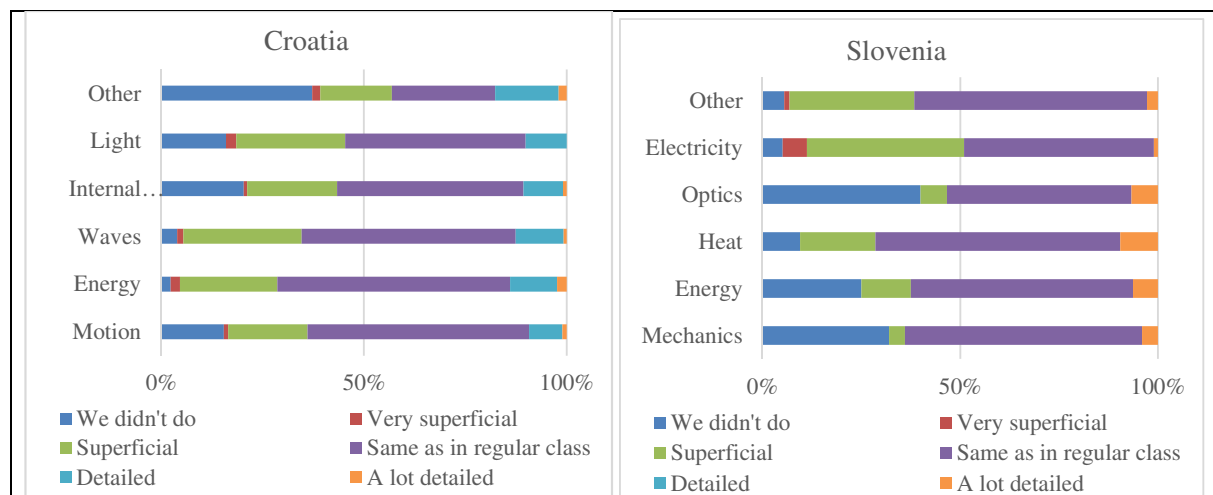


Figure 3: Topics taught by physics teachers and how detailed: elementary school.

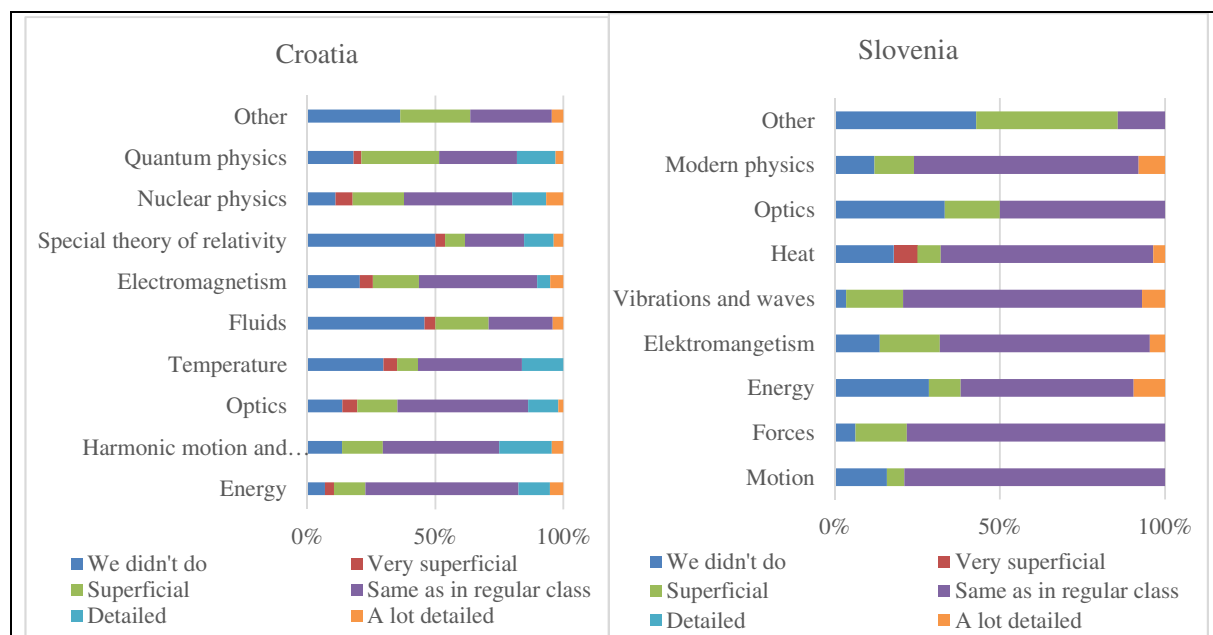


Figure 4: Topics taught by physics teachers and how detailed: middle school.

Commonly used experiments are demonstration experiments and so called “cook-book” style experiments which are focused on content knowledge, mainly because of the organizational aspect, rather than focusing on the learning process [8,11]. But during the pandemic more than half of the teachers in both countries reported that they conducted no experiments or only rarely (Figure 5). From Figure 6 and Figure 7 it is evident that the types of experimental work that prevailed before the pandemic were demonstration experiments, laboratory exercises, and hands-on experiments. During the pandemic, this moved to conducting experimental work via ICT, videos, and images of the experiments. The only type of experiments that were conducted in equal frequency before and during a pandemic were home experiments.

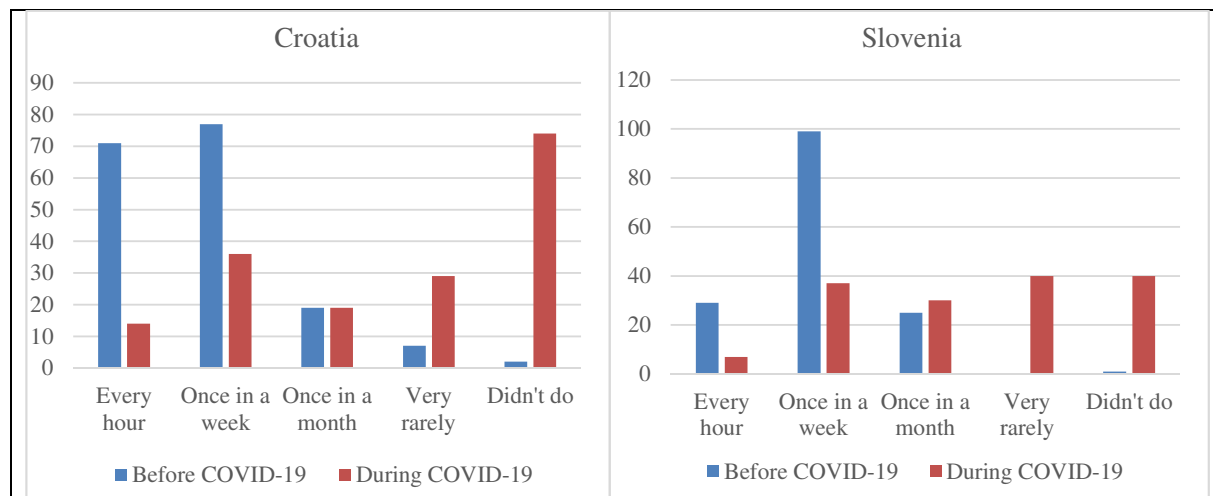


Figure 5: Conducting physics experiments before and during COVID-19 pandemic in Croatia and in Slovenia.

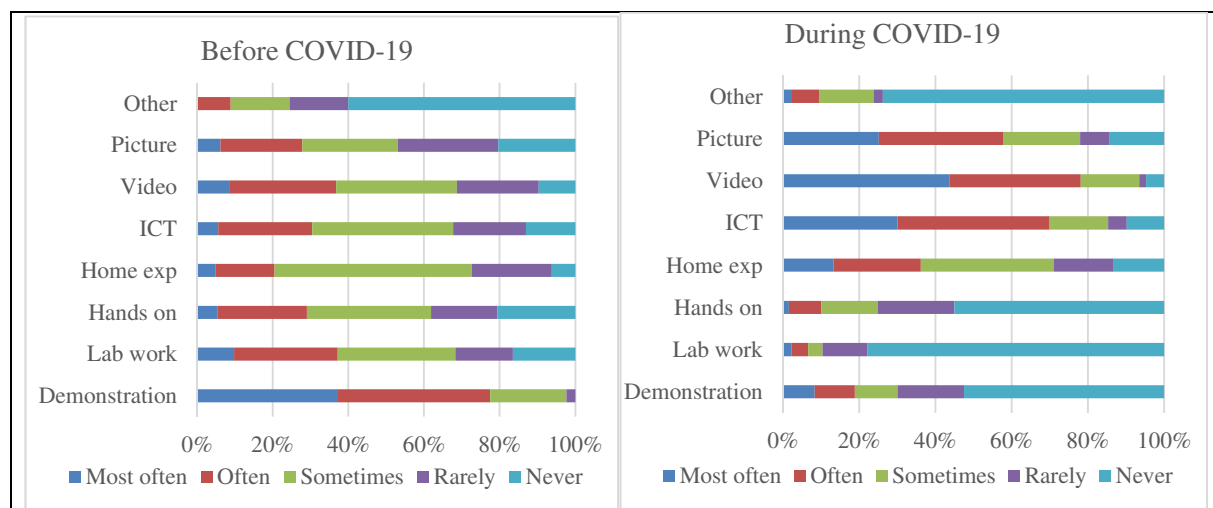


Figure 6: Types of experiments that teachers conducted before and during the pandemic: Croatia.

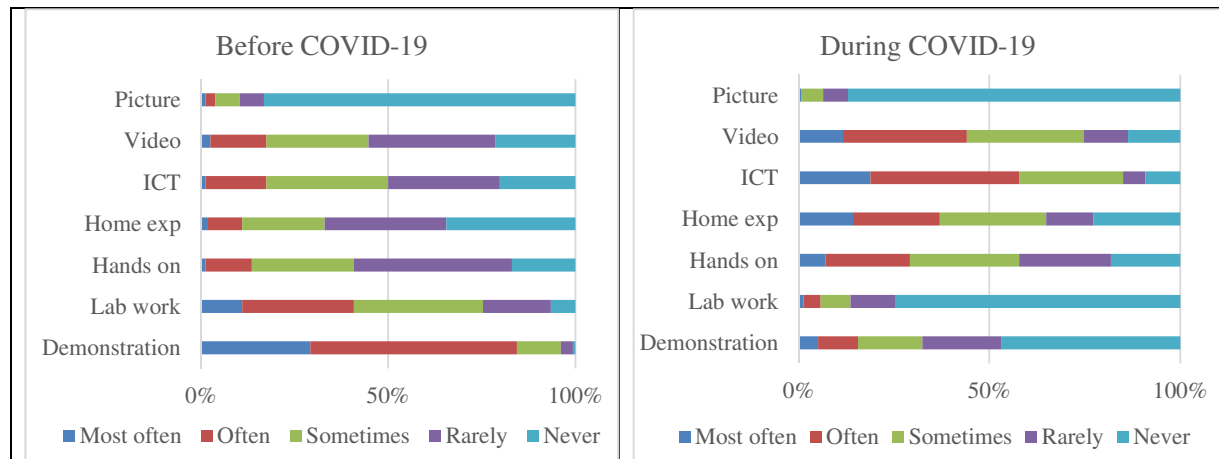


Figure 7: Types of experiments that teachers conducted before and during the pandemic: Slovenia.

Analysis of the data, separately for elementary and high schools for both countries, shows that the types and frequencies for experimental work are the same as in general for each country.

One of the differences between the countries is the schedule: 74% of Croatian teachers reported that they had physics lessons in the same time slot as in regular classes, while 44% of Slovenian teachers did it that way.

Students' participation in some form of teaching is different in Croatia and Slovenia: about 48% of Croatian teachers said that students were not obliged to participate in lectures, videoconferences and direct communication with them, but other types of communication (e-mail, chat, ...), and other homework were obligatory for almost all of them. However, Slovenian teachers reported that any kind of student participation was optional, even compulsory homework and assignments (Figure 8).

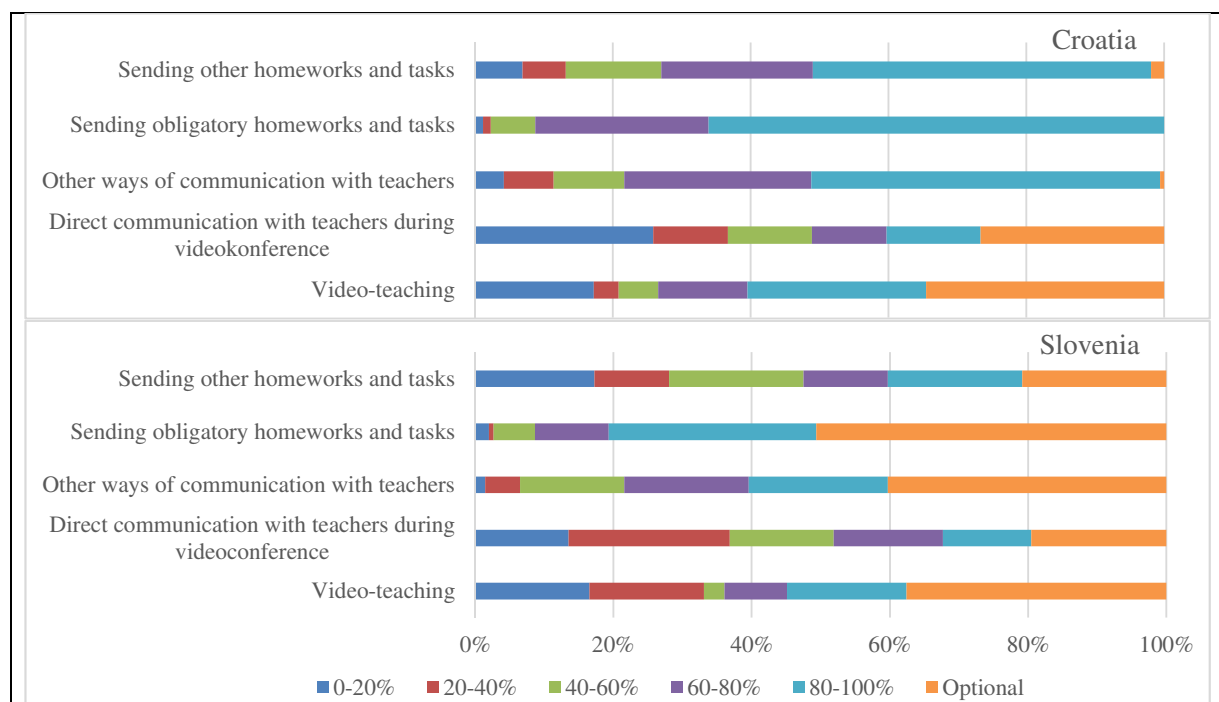


Figure 8: Students' participation in some form of physics lessons in Croatia and in Slovenia.

The most commonly used ICT for communication with students was e-mail, Zoom, Teams and Skype in Slovenia, and in Croatia e-mail, Teams, Yammer and Viber (Figure 9). Under “Others” teachers wrote: Messenger, Google Classroom, WhatsApp, Edmodo, Yitsi meet ...

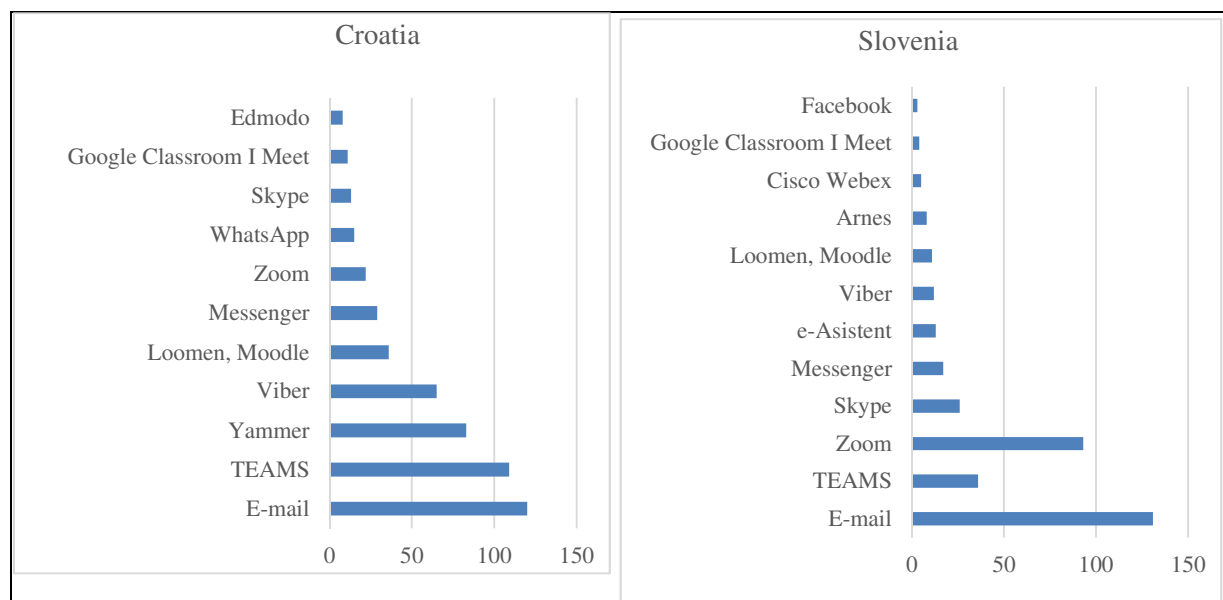


Figure 9: ICT in communication with students for the purposes of physics lesson.

During the pandemic most of Croatian teachers gave 1-3 grades per student (most of them through tests or other activities that students had to do individually), and Slovenian teachers gave 1 per student (most often through tests) (Figure 10).

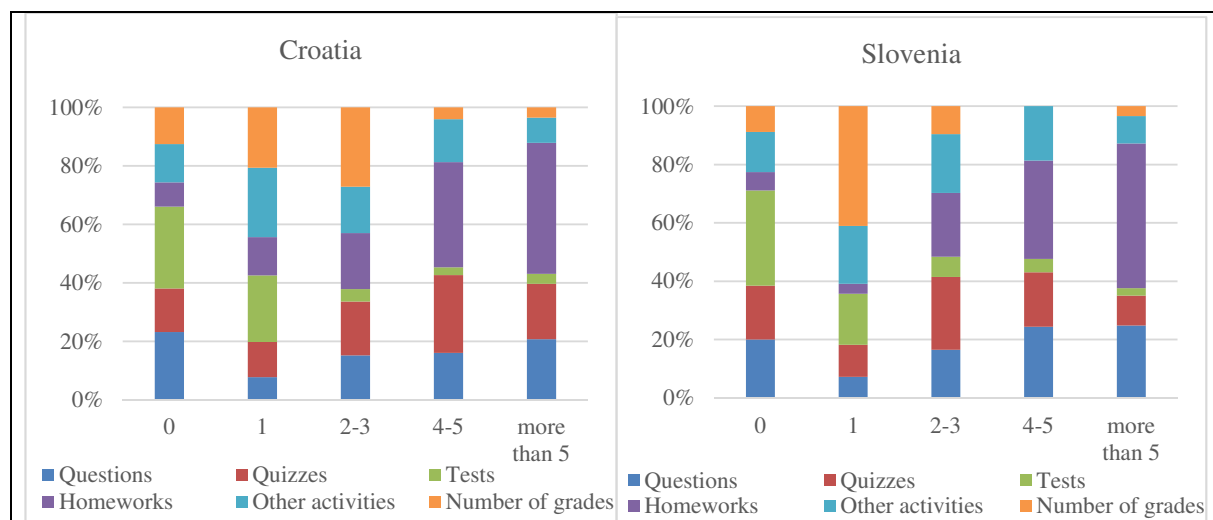


Figure 10: Assessment of physics knowledge in Croatia and in Slovenia: types and number of grades

In open answers teachers reported the many challenges of distance education related to new technologies, communication, their own challenges in teaching from home, the nature of the experimental subject, growth opportunities, designing of teaching and learning materials, etc., as shown in Table 1.

Table 1: Summary of teachers reports about experimental work, usage of ICT in the future and teaching physics in general during the pandemic COVID-19.

Croatia	Slovenia
a. Experimental work in physics lessons during pandemic: teachers' point of view	
The attitude of some teachers is that conducting experiments is difficult and complicated, especially during online teaching. Much more effort and time should be put into experiments, and since it is not advisable to watch videos, pictures and similar works where students are not directly involved in conducting them, some teachers did not conduct experiments at all. One of the teachers' explanations for the lack of experiments is that there is no equipment (the kits are left at school). Another problem that arose was the students' lack of understanding, so that conducting the simplest experiment with instructions was a problem. But many teachers tried hard to carry out the experiments despite all the problems. Those who introduced video materials (their own or from colleagues) are aware that this is not quite methodologically correct and does not encourage student motivation enough, but they state that students saw some experiments live that they certainly would not see in class. Most teachers invested effort in preparing materials for conducting experiments during direct instruction where students could participate in measurements, readings, assumptions, either directly by the teacher or through simulations. And most importantly, effort was put into designing student project assignments in the form of home experiments, with simple equipment, relying on student creativity and improvisation. To the surprise of many teachers, the home experiments went very well and were accepted by the students. It was necessary to record the experiment, explain it on the recording, write a report and a conclusion, ... This part lacked interaction with the teacher and timely guiding the students through the steps of the experiment or writing a report to make the complete project task even better. And the general attitude is that this is an unnatural way of teaching and nothing can replace the direct work in the classroom.	Most teachers had to both change the annual work plan and spend much more time planning the work. Teachers stated that they spent a lot of time on the computer and preparing the lesson materials and the lesson itself, so they lacked time for experiments (they posted videos of other colleagues' experiments via youtube links) but the vast majority allowed students to conduct experiments at home or using simulations. They spent a great deal of time on written preparations and instructions for conducting such experiments, which the teachers felt should have been much more detailed under such conditions. In addition to recording the experiments of others, they felt that by repeating them, students could master the concepts quite well. However, the choice of experiments had to be very well planned and selected, both because of the time frame for conducting and implementing them and because of the availability of materials and supplies. Some teachers are of the opinion that students are not creative enough and do not have access to supplies, but the rest are still of the opposite opinion, i.e. they are satisfied with the student projects and experimental work from home. It turned out that students were active and motivated and the vast majority completed the tasks. Maybe the reports could have been written even better, but with this kind of communication, they think it was quite sufficient and at a correct level. And in the end they are generally satisfied, and one could say happy, because together students and teachers have increased their knowledge of ICT, supported each other in this and made progress together.
b. Teaching physics during pandemic: teachers' point of view	
The teachers' thoughts started from the fact that physics lessons cannot be done online, that there is no real feedback, that it is exhausting, and that a lot	A forced educational experience, learning new teaching methods that most will use in regular classes. A very stressful and exhausting time, "wild

of time has to be spent creating and designing a lesson. A lot of energy was spent trying to motivate and activate students in this environment and it produces very little effect. Lack of ICT skills and irresponsibility on the part of students and parents make it very difficult to implement this form of teaching. Despite all this, the teachers saw the positive sides, from the teaching part to the fact that some students are more activated than in regular lessons, certain classroom activities can be done much better through ICT (quizzes, short exams, simulations of experiments). The shortcoming that the teachers saw was the grading. They believed that the grades were unrealistic, but over time the overall distance learning improved and teachers were more satisfied with the work and feedback.	pace", unpreparedness, and with learning physics both they and their students were taught ICT. Sometimes too much attention was paid to learning and mastering ICT rather than the subject material, and a tremendous amount of effort was put into preparing the working materials, preparing for the lesson was like when they first started teaching. Most of them are aware that students leave at the end of the school year without some knowledge that the initial work plan dictated, but they also feel that students actually did very well in the new environment and some excelled more than in regular classes. They are aware that contact with students was most lacking, but this was somewhat compensated for by the introduction of virtual classrooms and video conferencing. Teaching became much more individualized, resulting in much more time being spent in contact with students, correcting assignments and projects, and ultimately supporting the students themselves. Finally, there was a general lack of support from the ministry, relevant agencies and technical staff in the introduction, design and delivery of the lessons themselves.
c. Physics teachers' attitudes about use of this kind of teaching and experimenting	
The majority of Croatian teachers indicated that they will also use ICT in regular teaching, mainly in the form of homework, project assignments, short knowledge tests at the beginning of the lesson through quizzes. In addition, a lot of effort was put into creating online materials that will certainly be used later, more frequent use of home experiments and project assignments that students do on their own, but also simulations of experiments that are not available live in regular classes. For some, the deciding factor is that this kind of teaching takes a lot of time to prepare and organize, but for most teachers this is not a deciding factor. They rather rely on the fact that they have seen in their examples how students are more active, motivated and interested in the work by using additional ICT methods.	Despite all the problems and negative experiences, majority of the teachers will continue to use the distance learning methods used, from simulating experiments that do not exist directly in the classroom, videos that they consider to be excellently prepared, quizzes, initial tests via online forms (instant results), to many more project assignments and home experiments that they found very useful, interesting and motivating for the students. The delivery of the same continues to be through web services, either through email or through others. Communication apps such as Viber, etc. are also left in place due to additional instruction, sharing of materials, and ultimately solving current problems related to projects, homework, and other independent student work.

4. Conclusion

The paper presents physics teachers' self-assessment of different aspects of physics teaching during the COVID-19 pandemic from 2 countries, Croatia and Slovenia. From the research results it is evident that teachers from both countries tried their best to conduct physics lessons to a great extent through direct teaching, although this took a lot of time for all the tasks they were supposed to do and prepare before and after direct teaching. To some extent they tried to include the experiments, at least the home experiments and to some extent the practical experiments, and this was a positive part of this teaching period. Many students were very good at this part of the work, and the teachers reported that they will also implement

more of this type of experimental work in a regular classroom. They were also very flexible with student obligations during this period. The teachers reported positive and negative aspects and the challenges of this period. However, it was an educational period for all of them and they will implement much of what they learned during this period in the regular classroom. It is concluded from this research that much of what was used and learned during this time can be used to develop scenarios in similar situations that will occur in the future, and that teachers from both countries had the same problems and tried to solve them in the same way.

5. Authors' ORCID iD

Ivana Štibi, [0000-0003-4460-9451](https://orcid.org/0000-0003-4460-9451)

Mojca Čepič, [0000-0003-0951-5302](https://orcid.org/0000-0003-0951-5302)

Jerneja Pavlin, [0000-0003-1206-3650](https://orcid.org/0000-0003-1206-3650)

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