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Synchronous Online Learning for Solving Physical Problems in a Team: Challenges and Opportunities

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ABSTRACT

Today's challenges make us change and sometimes, for example, in critical situations, forcefully transfer studying to digital spaces. One of the main objectives raised by educators is ensuring effective, collaborative interaction between learners and teachers or groups of learners involved in the educational process (Verstegen et al., 2016). E-learning is not an exception, there interaction and collaboration are also very important (Stadler et al., 2019). This raises a key question: how to ensure that interaction and collaboration are upheld in distance learning? To find an answer to this question qualitative case study was chosen. The case study considers the interaction and collaboration in solving physics problems. The aim of the research – to find in what ways does coherence between the Collaborative Problem Solving construct and various interactions help the teacher to strive for effective education of students during synchronous learning. Results show that cognition and practical activities are inseparable, when solving problems and cooperating in virtual environments. In addition, solving life-related problems in a virtual environment is one of the most effective ways to empower students to act. The findings of this research can be beneficial to teachers of natural sciences when striving to enhance distance learning in crisis and other extreme situations. It can also be an incentive to change attitudes towards the limitations of distance learning.

Keywords: Collaborative Problem Solving, Interaction, Online Learning, Synchronous E-Learning, Problem based learning, 3C3R PBL model

Introduction

Interaction and collaboration are considered to be one of the most effective forms of learning that are important in developing essential 21st century skills (Andreasen & Nielsen, 2013; Fung, 2017; Herayanti et al. 2019, Timonen & Ruokamo, 2021). Therefore, today the main goal of educationists is to ensure effective learning based on cooperation and interaction between learners, teachers, and all participants in the educational process (Verstegen et al., 2016). Cooperative learning creates essential conditions for learners to be active participants in learning. It is like a "rotating spiral" – practical activities of cooperative learning enable students to act, discuss, discuss, research, solve problems (Garrison, 2017), and active participation of learners in learning activities and joint responsibility for the common group work encourages them to learn cooperatively (Ruhalahti et al., 2018). This kind of learning based on active interaction and collaboration can be considered as a unique learning model for developing students' cognitive and social skills and achieving deep and meaningful learning (Timonen & Ruokamo, 2021).

However, in the context of today's challenges (pandemic and other critical situations), learning is often forced into digital spaces. It is necessary to adapt to new technologies, new solutions, new teaching and learning methods. Impactful use of IT not only occupies an important place in today's learning process, but also opens a wide range of learning opportunities (Forkosh-Baruch & Avidov-Ungar, 2019). Virtual learning environments, social networks, virtual museums, educational tours, images conveyed by surveillance cameras can be purposefully adapted for learning. However, some researchers criticize learning in the digital space both because of the social isolation of students and because of the technical problems that may arise (Kolbaek, 2018). Despite that, there is a real consensus that interaction and collaboration in the digital space must remain important elements of learning (Stadler et al., 2019), it is necessary to maintain social presence together in the digital space between learners and all participants in the educational process (Cheung, 2021). A fundamental question arises: how to organize learning in the digital space so that it is based on interaction and collaboration? What forms and methods of teaching should be used to bring learning in the digital space even closer to F2F learning in the classroom? And in general, is it possible?

One of the widely used forms of learning in virtual space is synchronous learning (Kwok Chi Ng 2007; Pacheco, 2020). These are real-time lectures, webinars, live broadcasts on social networks, chats where learners have the opportunity to ask questions, complete tasks given by the teacher and are encouraged to communicate and collaborate in groups (Strang, 2013). According to researchers, real-time synchronous interaction not only promotes student engagement in the learning process, but also provides an opportunity to interpret complex learning material, while also allowing teachers to give instant feedback when interacting with students (Hrastinski, 2008; Strang, 2013; Watts, 2016, Francescucci & Rohani, 2019). Although synchronous communication tools help learners and teachers directly communicate and collaborate (Giesbers et. al. 2013), synchronous teaching is much, much more than just imagining that a "talking head" on a screen is already synchronous teaching. According to educators, the teacher's task is first and foremost careful and consistent teaching planning. Special attention should be paid not only to the selected video conferencing tools, but also to the possibilities of learning through synchronous cooperation and exercises that promote student activity (Kwok Chi Ng, 2007). Therefore, the researchers emphasize that due to insufficient attention to the intricacies of synchronous teaching planning, the lack of face-to-face (F2F) student-faculty or student-to-student communication remains a major issue in digital learning (Francescucci & Rohani, 2019). More effective ways to improve student engagement in digital learning environments are needed (Watts, 2016; Francescucci & Rohani, 2019). And for online education to be recognized as equivalent or at least close to traditional face-to-face (F2F) classroom learning, the quality of education in the digital space must be continuously improved (Palvia et al., 2018). So, there is no doubt that synchronous learning in the digital space plays an important role and deserves special attention (Timonen & Ruokamo, 2021), and planning and premeditated learning activities are a key prerequisite for effective collaborative learning (Anderson et al., 2006). However, it is still not completely clear what teaching strategies and methods to choose for synchronous teaching in digital spaces. This remains an important field of research in education (Timonen & Ruokamo, 2021). So, what teaching strategy to choose when organizing synchronous teaching?

Dialogue, reflection, interaction, and collaboration are important elements of student learning (Dewey, 1916; Hmelo-Silver, 2012; Lazonder & Harmsen, 2016), therefore, to achieve integration, some educators try to integrate them using the PBL strategy. Several advantages of PBL application emphasized in the literature are the development of critical, reflective, and creative thinking (Kolbaek, 2018). Possible shortcomings are also revealed – individual problem solving may limit individuals' ability to solve a problem, or the solution method of Problem Solving may not be immediately obvious to the person seeking to solve the problem (OECD, 2010). However, if we take the view that interaction and collaboration are one of the most important parts of effective learning (Andreasen & Nielsen, 2013; Fung, 2017; Herayanti et al. 2019), and problem-based teaching encourages learners to think in solving problematic situations and to search for answers to problematic questions, it can be assumed that the organizing learning using the PBL strategy in the digital space will also encourage student interaction and cooperation among all participants in the educational process. Such learning can be referred to as collaborative problem solving (CPS), which plays a vital role in today's world (Griffin, McGaw, 2012.). CPS skills are considered critical and necessary not only in various educational contexts, but also when working in teams to improve teamwork efficiency and quality, decision-making as well as employee creativity. Such digital learning is characterized not only by collaboration (Garrison et al., 2000) but also by creating meaning, while working towards a common goal. Active participation, communication and commitment to the coaching group promotes collaborative learning (Ruhalahti et al., 2018). However, some researchers question the effectiveness of applying the CPS strategy in the digital space, arguing that CPS is not as useful for learners in the digital space as it is for students who solve problems in the F2F classroom (Kolbaek, 2018). The lack of motivation of students to solve problem situations is emphasized exclusively (Kolbaek, 2018). Another aspect that poses a challenge is the creation of a problem or problematic situation. Teachers need to be careful when creating problems and should pay attention to the level of difficulty of the problem. Easy problems lead to finding a solution without any effort, while too difficult problems can lead to frustration (Yurniwati & Dudung, 2020). So, how should problems or problematic situations be formulated and presented in the digital space so that students are motivated to be active and solve problems collaboratively?

The reflections presented in the introduction and the discussion questions raised can serve as an incentive for educationists to delve even deeper into synchronous teaching strategies, create new methodologies and look for new ways to ensure interaction and cooperation in synchronous teaching in digital spaces.

Method

How to ensure that interaction and collaboration are upheld in distance learning? To find an answer to this question qualitative case study was chosen. The case study considers the interaction and collaboration in solving physics problems.

The aim of the research – to find in what ways does coherence between the Collaborative Problem Solving construct and various interactions help the teacher to strive for effective education of students during synchronous learning.

The case is: Interaction and collaboration for solving physical problems in a team in synchronous online learning.

Participants: 15–16-year-old high school students (2 student groups of 4 students each (9th grade) and 2 student groups of 4 students each (10th grade). Students' participation in the study was voluntary – students who are interested in physics participated and wanted to solve challenging physics exercises as well as real-life problems in teams.

Research ethics

Students' participation in the study was voluntary. The research idea was clearly defined for the students, and all the procedures that would be performed during the research had been discussed. After receiving the consent of the students, a meeting was organized for their parents. During the meeting, the idea of the research, its progress and benefits were discussed. After coordinating the details, the parents of the students participating in the study signed informed consents for their children's participation. All collected data is saved to an external drive. Data is non-accessible, confidential, and protected.

Activities and their duration

MsTeams video conferencing tool was used for synchronous learning.

All learning activities for all groups were the same. Meetings with students were organized for 2 months, once a week. These were informal lessons/consultations aimed at developing cooperative physics problem solving skills and deepening physics knowledge.

To avoid fatigue, classes with students lasted 30 – 40 minutes without interruption. because online synchronous learning, especially during longer sessions, requires energy and engagement (Pacheco, 2020).

Research questions

- How to formulate and present problem-based learning (PBL) tasks to encourage interaction and collaboration?
- Why does using PBL strategy during synchronous teaching promote student interaction and cooperation?
- What characterizes different interactions in collaborative problem solving in synchronous learning?
- This qualitative Case Study research was implemented in several stages:

Adaptation of research material for synchronous teaching

Creating tasks based on the Collaborative problem solving (CPS) construct (Griffin, Care, McGaw, 2012) and 3C3R PBL model (Hung, 2006).

CPS construct was chosen for several aspects:

First, when implementing the CPS construct, two or more people participate in the activities, and the successful implementation of the activities requires the cooperation of team members, sharing of problem-solving ideas, monitoring, and analyzing the problem-solving process, explaining cause-and-effect relationships, proposing strategies for solving the problem in the team (Hesse et al., 2015).

Second, in the CPS construct, the relationship between social and cognitive abilities in implementing the CPS construct is very strong (Griffin et. al. 2012). Social skills play an important role not only in solving problems together but are also a distinctive feature of many cooperative activities. Cognitive abilities, in turn, have a lot in common with classical problem-solving methods, based on which problem solvers look for answers to problematic questions and present the decisions made with arguments.

The planning and activities of the synchronous teaching were chosen according to the 3C3R model (Hung, 2006).

This 3C3R model was chosen because of its broad scope for integrating content and activities (Hung, 2006), e.g., various problematic real-life situations, the solution of which requires the interaction of learners, requires social, communicative, cognitive, and cognitive abilities.

Second, for teachers, the 3C3R model provides a conceptual framework within which they can more systematically and effectively formulate and design problems (Hung, 2006).

Third, the use of the 3C3R model provides a conceptual framework for designing PBL problems and evaluating their relevance and effectiveness (Hung, 2006).

Synchronic lessons with the students

Based on the CPS construct and the 3C3R model, tasks and activities were placed on six slides and named “Six slides principle for synchronous teaching”. The presentation of the slides is shown in the picture below (Fig. 1).

1st slide	**2nd slide**	**3rd slide**	**4th slide**	**5th slide**	**6th slide**
Problem /Challenge	The idea to solve problem	“Helping slide”	Tools	Helping content	Reflection

Figure 1 Six slides principle for synchronous teaching

Data collection and analysis

The following methods of data collection were chosen – observation, researcher’s notes, semi-structured interviews in focus groups, lesson videos, student reflections. The coding of the research participants is presented in Fig. 2.

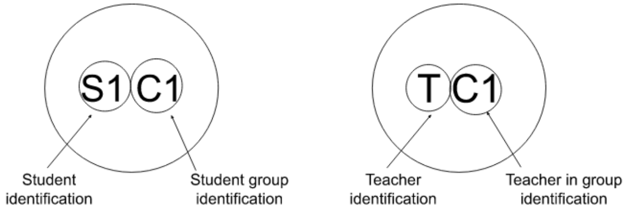

Figure 2 The coding of the research participants

All video sessions were recorded and later transcribed. MAXQDA2020 software was used for data processing. The collected data was coded and analyzed according to the distance learning model A Model of E-Learning (Anderson, 2004), the CPS construct (Griffin, Care, McGaw, 2012) and the elements of the 3C3R model (Hung, 2006). Attention was focused on the following interactions during synchronous teaching: student-teacher, student-student, student-teaching content, teacher-content. These interactions used in the study were defined according to A Model of E-Learning (Anderson, 2004).

Table 1. Interactions according to A Model of E-Learning

Interaction	Description
student-teacher	Multifaceted student-teacher communication and collaboration through synchronous delivery of learning materials, organizing discussions, F2F communication, and other real-time activities.
student-student	Learning together based on the ideas of constructivism and connectivism, promoting the cognitive process and research, helping to accumulate knowledge together based on the experience of the learning community and developing cooperation skills using technological solutions for learning in a virtual environment.
student-content	Learning opportunities using interactive tools (real-time explorations, real-time video presentations, interactive tasks, virtual labs, etc.). This interaction is focused on meeting the individual learning needs of learners (providing targeted learning support, quick feedback, orientation to further learning).
teacher-content	The process of creating and/or updating educational content (educational materials/resources, educational objects, interactive tasks) and educational activities related to the implementation of the content (research, creative tasks, etc.).

Results

The results of the study show that the tasks and activities created based on the CPS construct (Collaborative problem solving construct (Griffin, Care, McGaw, 2012) and the 3C3R problem-based learning (PBL) model (Hung, 2006) in organizing synchronous teaching using the "Six slide principle for synchronous teaching" activate all studied interactions connected by common elements (Table 2).

Observational data show that to promote interaction and cooperation-based teaching, teacher-content interaction is extremely important, not only in the initial stage of planning, creating problem situations and predicting activities, but also during the entire synchronous teaching.

Table 2. Elements connecting interactions

Slide	Description	Interaction	Connection
1st slide Content / Problem / Challenge	A contextual problem or problem situation related to the teaching content is presented	Teacher – Content Teacher – Student Student – Content	Real-life experience, problem situations, challenges with questions starting with How? Why?
2nd slide The idea to solve problem	Students present ideas on how to solve the problem.	Student – Student Student – Content	Mindmap, brainstorming, etc.
3rd slide "Helping slide"	A hint given by the teacher that directs the students to the solution to the problem	Teacher – Content Student – Content Student – Student Teacher – Student	A picture with help elements without clear instruction and exploring idea for the solution.
4th slide Tools	Teacher-provided tools for the test that will help answer the given question	Teacher – Content Student – Content Student – Student	Tools for the experiment that will help answer the given question. Tools are provided in a variety and more than necessary, which can be found at home.
5th slide Helping content / learning material	Help provided by the teacher: teaching content, description, links, etc.	Teacher – Content Student – Content Student – Student Teacher – Student	Texts, explaining, knowledge which students must connect with their experiment results
6th slide Reflection	Student and teacher reflection	Student – Student Teacher – Student Teacher – Content	Reflection, important questions like: Why? What makes you decide about it? Comment your choice, etc.

Teacher – content interaction

The problem arising from the context – a prerequisite for encouraging student activity

The observation data of the conducted research show that teacher – content interaction is a very important element of synchronous teaching. The success of the entire synchronous teaching depends on the choice of the teacher, the challenge presented, the organized activities and moderation. The context and the resulting problem situation are extremely important for students' interest and engagement in synchronous learning. For example, if the lesson took place before Christmas or another holiday, an example of a problematic situation could be the following: a family celebration, a large dinner table, laughter, shouting... Suddenly, a person chokes without speaking. How to help him? This simple problematic situation not only actualizes the problem itself, brings it closer to the students' life experience, but also encourages students to think, discuss, and explain the observed phenomenon based on the laws of natural sciences. Therefore, the biggest challenge for the teacher is to find phenomena or teaching objects from the surrounding environment that would be relevant to the students and would pose a challenge. It would be possible to model problematic situations, and after modeling the students could study them at home using the simplest tools.

Cognitive conflict – an incentive to think and cooperate

The analysis of the video material of the lessons suggests that one of the ways to promote the interaction between students is the cognitive conflict that arose during the exploration *(... But it should work, if there is a lot of air here, press it and it should push the ball out. I don't know why it doesn't work for me …)* S1C1. It was noticed that the interaction between students intensified significantly while searching for a solution to this problem.

Hints – silent aids that encourage student-student interaction

The analysis of activities in synchronous lessons revealed that after presenting a problematic situation, the teacher must be ready to give hints to the students, which would allow the students to change the direction of thinking and encourage them to look at the problem from a different angle. Observational data revealed that visual material works very well for this, e.g., pictures, diagrams, etc. All this activates the student-student interaction and helps to achieve the set goals.

Teacher – student interaction

The study revealed that teacher-student interactions based on simple agreements with students *(... Let's immediately agree that you will speak. okay? Of course, I will also talk to you, but you should talk more. OK? ...)* has a positive effect on student-student interaction. The analysis of the videos shows that the students try to stick to the agreements, get involved in the discussions themselves and try to involve others *(... S3C1, what do you think? ...)* S1C1, *(... Maybe we should try, as you said? ...)* S4C3, *(... What if we did, what you said? ...)* S2C3.

The teacher's "withdrawal" and "timely return" are prerequisites for students to interact

Monitoring data shows that the teacher's unexpected "retraction" *(... For three minutes I'm offline ...)* TC3, *(... it's your decision ...)* TC1 disturbs students, but at the same time it activates student cooperation, helps students get more involved in independent problem-solving activities, encourages sharing of ideas. And the teacher's "timely return" and showing that he was interested in the students' decisions *(... What are you doing? What did you come up with? ...)* TC1, *(... Tell me, very interesting ...)* TC4, *(... How unexpected ...)* TC2 encourages interaction even more. The teacher's "withdrawal" and "timely return" are effective means to keep students active during synchronous teaching.

Do it together with the students – keep the intrigue

The research data show that the presence of the teacher with the students, involvement in their research activities, arouses the interest of the students

(... And you, the teacher, will you wait until we are done and do it after or? ...) S3C1, *(... I'm doing the same as you... we'll see how well we succeed ...)* TC1 During this kind of interaction, students feel relaxed, trust emerges, all members of the group try to get involved in the activities, and the desire to look for even better options for solving the problem also appears *(... But, here, it is possible to come up with more ...*) S2C3, *(... maybe I'll think a little more ...)* S4C4.

Student – student interaction

Delve deeper, share and be a team member...

The results of the study revealed that the interaction between students when planning activities according to the presented model is exceptional. Students strive to be important team members. Before sharing something with the members of their group, they first delve into the topic, read the material presented, individually analyze the problem and only then start discussions *(... I think our team's tactics are quite good, first we each individually looked at what we think about it, what we know, what we understand, then we discuss ...)* S4C3 *(... In the beginning, we looked individually at what we know and can solve and then we talked, discussed ...)* S3C4, *(... we checked our knowledge, we said our opinion ...)* S1C1 The students identify the need for individual analysis of the problem as one of the very important things *(... I think it is very important to clarify what you want to say, because if you only come up with thoughts and attack other people for theirs and say maybe yes maybe so. Then, there will be such a long discussion ...)* S2C2. Here you can also see the students' responsibility for the team's overall activities *(... If you formulate the answer clearly to yourself, what you want to say, those discussions happen very quickly somehow ...)* S1C2 Research data also revealed that when working in a team, students are open to listen, accept the opinions of other team members and negotiate *(... I think you just need to listen to each other... be able to accept it and say your opinion ...)* S3C3, *(... often while making a decision we either state ours, listen to others, change our minds, or we just agree ...)* S2C1. Such students' reflections suggest that being together is very important to these students.

A cohesive team – an essential step towards successful collaborative problem solving

The research revealed that the composition and size of the team is also very important to the students *(... If we had more people, maybe it would be more difficult or if there were fewer people, maybe it would also be too difficult ...)* S4C1, *(... now that is the optimal amount – the relationship is pleasant and communication is easy ...)* S1C1, *(... what is important is which group and which people you are with ...)* S1C4. Observational data revealed that to solve a problem in team cooperation, students often discuss several solutions to the problem, which help to find the answer. Therefore, it is necessary that the work in the team goes smoothly *(... you* *just need a non-confrontational team that functions properly in solving problems ...)* S3C4. In a cohesive team, when someone from the group gives his answer, he is listened to *(... I think the most important thing is to listen, to be able to listen ...)* S1C1, *(... we listen to other ideas...Very, very, very good thing)* S2C2, and when examining possible ideas for solving the problem, all group members look for compromises and a final solution *(... You look for compromises and you don't think that your answer is the right one ...)* S3C1, there is a discussion if necessary *(… When there is actually a discussion and either common solution is reached or the answer is found during practice, you can compare whose answer was correct ...)* S1C1. So, being in a cohesive team means being part of a team.

"Fear of making mistakes..." or "We learn from mistakes..."?

The research revealed that in a harmonious team, not being afraid to make mistakes *(... it is important to understand that you can make mistakes …)* S1C1, *(… and I decided that maybe I could do it without them, I failed. I had to try it and find out who is right and who is wrong. ...)* S3C1 and acknowledgement of the ideas proposed by other team members to solve the problem *(... I didn't think of that... How did you come up with such a good idea? ...)* S3C4 is one of the prerequisites for implementing successful interaction and solving problems in a team. All this can only be achieved through mutual respect *(... Mutual respect is needed. If there is the understanding that there is nothing terrible to make a mistake here ...)* S3C2, *(... no one judges you for making a mistake here, everyone says that everything will be fine ...)* S4C1. Mutual respect and learning without fear of making mistakes are prerequisites for deep, interactive, and collaborative learning.

Student – content interaction

Problem tasks are an incentive to search for diverse information

Research data revealed that student-content interaction is very diverse. When solving problems, students use various sources of information *(... Read some examples ...)* S1C1, *(… you can google it... however, there are many answers on the Internet ...)* S4C1, *(... first of all I think about what the topic could be in accordance to what we have already covered and what might be related to that problem ...)* S1C1, *(... I'm looking in old notebooks ...)* S2C4, *(... I have a physics problem book ...)* S1C4. Problem-based tasks not only direct students to different sources of information, but resource management becomes one of the priorities. Students understand that they cannot limit themselves to the information found in only one information source, so before presenting their reflections, they check the information found *(... if the information does not match, then you rely on several sources and see how you can get the correct one from them ...)* S3C2, *(... it is important to check the information, because if, for example, you say something wrong, then you can steer the discussion in the wrong direction ...)* S1C1.

The lack of instruction encourages students to think

Observational data and analysis of videos revealed that the students who participated in the study have only superficial abilities to explore and experiment, in most cases students are waiting for instructions, instructions or a description of the experiment on how to perform it (... Do we use all the tools here? ...) S3C1, (... let's do it together teacher? ...) S1C1. Students find it difficult to find analogues of the observed phenomena and model them using simple tools, but these activities undoubtedly create many opportunities for students to make mistakes, look for new solutions, and re-analyze the presented material. All this only encourages students to get to know the observed phenomena better.

Discussion

There is no doubt that interaction and collaboration are one of the most effective forms of education, which is important for developing essential 21st century skills (Andreasen & Nielsen, 2013; Fung, 2017; Herayanti et. al. 2019, Timonen & Ruokamo, 2021). However, teaching in the digital space remains a problem, which is often criticized for the social isolation of students and the technical problems that arise (Kolbaek, 2018). It could be agreed that social isolation of students really exists, especially when a lecture – "talking head" is chosen for synchronous teaching, there is a real threat of monotony as a one-way of disseminating information to students (Khan et al., 2021). However, our research shows that the social isolation of students can be avoided by choosing tools that promote collaboration, such as the application of the CPS construct using the 3C3R model, because the combination of the CPS construct and the 3C3R model creates unique opportunities to promote student interaction, involve them in active and interactive learning. the process.

When talking about interactive teaching methods in virtual environments, researchers often give examples of interactive videos, various quizzes that can be part of live sessions, and teachers provide feedback or initiate discussion during each interaction (Khan et al., 2021) The idea is great if the teacher takes the role of leader and moderates the discussion. However, let's look at it from the other side, if we want the student to be in the center, and we want to bring learning in the virtual space as close as possible to F2F teaching in the classroom, shouldn't we think about strategies that would give students even more opportunities to raise new ideas, think critically and creatively, discuss, plan tests, raise hypotheses, perform "live" science experiments using tools available at home, discover and create new knowledge and apply it in practice? To implement this during synchronous teaching, as our research revealed, is it enough to use the "Six slides principle for synchronous teaching" principle?

We fully understand the limitations of our study. Therefore, it can be agreed that there is no model suitable for everyone and there cannot be because of different students, different involvement, different cultures, but it is also obvious that the principles, models, and constructs really exist. So, the goal is to find connections and integration between them and present the result to teachers for use in practice. Therefore, it is worth looking for as many models and constructs as possible, which would allow each education in different countries to choose the model that is relevant and important for the students.

Conclusions

Impactful learning in the digital space for active communication and collaboration is one of the critical issues that educators are faced with today. Our study revealed that the harmony of the CPS construct and the 3C3R model is a prerequisite for successful implementation of synchronous teaching (creating tasks, presenting them, organizing activities, etc.) in virtual environments.

We conclude that creating tasks and organizing synchronous teaching based on the CPS construct and applying the 3C3R problem solving model creates strong connections between teacher – content, teacher – student, student – student and student – content interactions. Presentation of problematic tasks during synchronous training is an incentive to search for various information, select and critically evaluate it. On the other hand, arising cognitive conflicts when faced with problems encourage students to think, delve into problem solving, cooperate and be part of a team.

In addition, the application of the "Six slide principle for synchronous learning" based on the CPS construct and the 3C3R model revealed that solving problem situations related to students' lives, exploring in real time, using simple tools at home, trusting each other, not being afraid to make mistakes and being a team member influence interaction and cooperation for successful learning.

The findings of this study may be useful for science teachers to enhance distance learning in crisis and other extreme situations. It can also be an incentive to change the way we think about the limitations of distance learning.

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