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REMOTE TEACHING ACTIONS IN SYNCHRONOUS PHYSICS AND CHEMISTRY CLASSES IN HIGHER EDUCATION

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ABSTRACT

This article presents the results of a research that aimed to identify the teaching actions that occurred in synchronous classes held during the Covid-19 pandemic period in 2021. The data were obtained through recordings of four synchronous classes, referring to the Physics and Chemistry Degree courses of public institutions of Higher Education in the state of Paraná, in addition to interviews with the responsible professors. The analysis of these data was conducted based on the procedures of Content Analysis, allowing the identification of actions defined a priori and emerging actions. As a result, a total of 11 categories of teaching action occurred in synchronous classes (EXE1 – Operationalize, EXE2 – Write, EXE3 – Explain, EXE4 – Respond, EXE5 – Wait, EXE6 – Interrupt, EXE7 – Points, EXE8 – Reads, EXE9 – Question, EXE10 – Listens and EXE11 – Deletes). A certain similarity was noted between the format of each of the classes, in relation to the objectives, methodology and use of technological artifacts.

Keywords: Teacher Training. Teaching Action. Science Teaching. Emergency Remote Teaching. Synchronous classes.

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INTRODUCTION

In 2020, the world found itself in a critical situation with the beginning of the Covid-19 pandemic, which radically transformed the world's collective routine. Thousands of people had to adapt and "inhabit a "virtual space that is also real" (Frutuoso; Cavalcante; Lemos, 2024, p. 16393). One of the severely affected sectors was education, and with the decree of social distancing, Basic Education schools and Higher Education institutions had to adapt their face-to-face activities to the virtual world.

To avoid further educational losses, Emergency Remote Teaching (ERE) came into force, a modality organized to offer temporary access to curricular content that would be developed in person (Hodges et al., 2020), using digital technologies that allow interaction between teachers and their students, such as the *Google Meet* platform, a tool for conducting online videoconferences, made available free of charge during the pandemic for *online classes*.

With the ERE, the classes maintained their essence of being a "set of means and conditions by which the teacher directs and stimulates the teaching process according to the student's own activity in the school learning process" (Libâneo, 1994, p. 45), but they needed to be restructured in logistical terms. The blackboard gave way to computer and *smartphone* screens, the learning space became one of the rooms in the house, and the class became known as videoconferencing.

In view of this new reality, we can question how teaching actions were developed in this new class format, so that it presented a performance equal to or close to what was had in face-to-face classes. Thus, the guiding question of this work is: "What teaching actions were carried out during synchronous classes of Physics, Chemistry and Biological Sciences in Higher Education?".

The study of teaching practice, educational practice, pedagogical practice, etc., is a central concern in the field of teacher education. In particular, the problem of the relationship between theory and practice is a perennial problem in the field (Korthagen, 2010). Perhaps for this reason, analyses of teacher education are usually so prescriptive (Passos, 2009). Fundamental authors in the area, however, have emphasized the importance of investigating through "direct and recorded observation" what teachers actually do in the classroom (Schön, 1997, p. 90), which could contribute to the realization of a "resolute critique of the normative and moralizing views of teaching" (Tardif; Lessard, 2012, p. 36).

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From such considerations the research is inserted, the results of which are reported here. In this work, we preferred to adopt the term teaching action instead of teaching practice, as this is a polysemic term (Altet, 2011). We inform that the investigation is part of a research program, whose general objective is to describe the actions carried out by teachers (teaching action), students (student action) or other actors, by "direct observation of the classroom and/or in any physical and/or virtual environment" (Arruda; Steps; Broietti, 2021, p. 237).

EMERGENCY REMOTE TEACHING IN HIGHER EDUCATION

Emergency Remote Education (ERE) was one of the social isolation measures established during the Covid-19 pandemic period. In Brazil, it was established through DecreeNo. 343, of March 17, 2020, thus authorizing the use of information and communication technologies for the temporary replacement of face-to-face classes until the end of the pandemic (Brasil, 2020).

ERE consists of a set of teaching activities developed with the help of technologies, but which follows the molds of face-to-face education. This type of teaching is marked by the geographical distance between students and teachers, and is used based on the need for rapid changes, as in the case of the Covid-19 pandemic (Antolin; Antolin, 2021).

Hodges et al. (2020) highlight three fundamental characteristics of this teaching modality: its temporary nature, the immediacy of an emergency, and the remote nature of instruction.

Regarding the temporary aspect, Emergency Remote Education is seen as a short-term solution, unlike Distance Education (DE), in which there is a solid long-standing and intentionally planned theoretical-methodological basis. Although it is also a planned modality, the ERE occurs more quickly, as its objective is to guarantee access to education in social emergency.

This factor also refers to the immediatist character of the ERE. In the case of the Covid-19 pandemic, which took place very quickly, due to the considerable advance of the disease around the world, Emergency Remote Learning was an initiative developed in the short term to meet the needs of millions of students as quickly as possible.

Finally, Emergency Remote Teaching, as the name suggests, takes place remotely, that is, via learning and videoconferencing platforms. This characteristic promoted not only access to education, but also ensured social isolation during the pandemic period.

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The implementation of ERE in Higher Education demanded a restructuring of pedagogical practices and methodologies to meet the requirements of this new format. Each institution developed its regulations, according to the local context and needs, based on official documents published by Brazilian government agencies.

It was necessary to adapt the teaching plans to these virtual formats. Based on the guidelines of Opinion No. 9/2020 of the National Council of Education, synchronous and asynchronous activities were the main academic practices adopted in Higher Education during the pandemic. Synchronous classes are forms of simultaneous communication, in which all participants access the same virtual videoconferencing platform at the same time to communicate with each other in the form of *lives* (Arruda, 2020). Synchronous classes were a way to maintain some characteristics of face-to-face teaching, in which teachers performed their job of transmitting disciplinary content to groups of students, and these, in turn, could interact with each other and with teachers. Some positive points of this format, pointed out in the research by Flores et al. (2021), were the teacher/student and student/student interaction, in addition to the possibility of immediate clarification of doubts and monitoring of the performance of activities.

In turn, asynchronous activities do not require the simultaneous participation of students and teachers (Arruda, 2020). They consist, therefore, of recorded classes, support materials and exercises that are shared on digital platforms and can be accessed at any time. This flexibility allows for greater involvement of students with the curricular contents, promoting greater reflection on what is presented in these materials (Antolin; Antolin, 2021).

The asynchronous classes enabled some advantages during the ERE. Flores et al. (2021) highlight the development of autonomy, commitment, and responsibility on the part of students, by promoting to them the possibility of "better management of time, effort, and work discipline; greater participation of students, without distracting elements; be enhancers of research/collaborative work; greater ease of learning control" (Flores et al., 2021, p. 15). For these arguments to be valid, it is also up to teachers to develop a series of actions that result in synchronous and asynchronous classes with a positive impact on the learning process of these students.

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TEACHING ACTIONS IN REMOTE CLASSES

The class is a moment that aims to provide the students' learning, and for it to occur, some planning and organization are necessary (Santos; Inforsato, 2011), tasks that are extremely complex. Tardif and Lessard (2012) also point out that the teacher works with a human collectivity and is still subject to the objectives of the school programs, which entails that he develops a set of actions during his classes, which go beyond the simple transmission of specific content and provide his students with learning not only in the classroom, but throughout their lives.

Teaching actions can be understood as the practices carried out by the teacher during his classes, related to knowledge, teaching and learning in the classroom (Arruda; Steps; Dias, 2017). Based on the social assumption that the relationship with knowledge is a "form of relationship with the world" (Charlot, 2000), we can consider these practices as those that involve the teacher's relations with the school world, where curricular knowledge and relationships with students, administrators and other actors (human and non-human) who are part of this environment are considered (Dias et al., 2017), aiming to achieve the proposed educational objectives. The effectiveness of teaching actions is directly related to the intentionality of these acts, to the teacher's ability to reflect on their practice, the constant improvement of their pedagogical skills, and to the adaptation, according to the needs of each context.

The implementation of Emergency Remote Teaching, as a way of serving students during the Covid-19 pandemic, required education professionals to quickly adapt to this new scenario, demanding a set of actions by teachers that maintained the nature of interactions in the classroom, but also adapted to the new reality of remote teaching. Some particularities that can characterize teaching actions in remote classes were identified in Rhea's research (2022). Through the analysis of interviews with eleven Mathematics teachers who taught in Higher Education at the beginning of the ERE, the author identified categories of actions carried out in two specific moments of remote classes: Poscenium – related to what teachers did before and after classes, and Execution – which refers to what teachers did during classes.

The actions detected in the research and that constitute the Poscennium were: Self-form, Acquire, Organize, Elaborate, Send, Communicate and Evaluate. They have characteristics related to the planning and preparation of classes, as well as to the evaluation of the performance of students and teachers themselves.

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The moment called Execution was composed of the following categories of action: Operationalize, Write, Explain, Respond, Wait and Interrupt, which describe the teaching practice in the classroom. Both the actions of Poscênio and those of the Executa moment also occur in face-to-face classes, but are composed of micro-actions (acts that have certain similarities and that, aggregated, form the categories of actions) more specific to the remote context, requiring teachers to resort to digital resources to carry out their academic activities with students.

Supported by the theoretical references presented here, and having as data sets recordings of synchronous classes held in Higher Education during the ERE and interviews with the responsible professors, we propose in this work to carry out a survey of the teaching actions that occurred in these classes.

METHODOLOGY

This work consists of a qualitative research, as it aims to identify the teaching actions carried out during synchronous classes in Higher Education for the Teaching Degree courses in Physics and Chemistry, at the beginning of Emergency Remote Teaching. Qualitative investigations act in the search for an understanding of human behavior, exploring different representations of the subject in question (Gaskell, 2002). According to Bogdan and Biklen (1994, p. 70), qualitative researchers:

> [...] try to understand the process by which people construct meanings and to describe what these meanings consist of. They resort to empirical observation because they consider that it is as a function of concrete instances of human behavior that one can reflect more clearly and deeply on the human condition.

The research data consisted of recordings of synchronous classes given by three professors who worked during Emergency Remote Education in Higher Education, plus interviews conducted in remote format. To collect these data, a Free and Informed Consent Form was sent to the teachers, which contained the information pertinent to the study[4].

The remote classes, analyzed here, were taught for the Degree courses in Physics (one twinned class, equivalent to two classes) and Chemistry (two classes), in Higher Education Institutions in the state of Paraná. In order to maintain the confidentiality of the

[4] We inform that data collection for this research was carried out in January and February 2021, during the term of the project "The teaching and learning of Science and Mathematics in the classroom and in informal environments" (2016-2022), approved by the Ethics Committee of the State University of Londrina (CEP/UEL), CAAE number 57663716.9.0000.5231.

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participants' identities, we chose to encode them using the letter P followed by a natural number in ascending order, according to the order of the interviews. Chart 1 presents information about the classes analyzed.

Table 1. Information about the remote classes analyzed

Teachers	*Areas*	*Types of classes*	*Duration of classes*	*Class topics*	*Disciplines*
P1	Physics	Synchronous	1h31min32s (two lessons)	Lorentz Transformations for Velocity	Modern Physics
P2	Chemistry	Synchronous	36min58s (one lesson)	Reflection on Learning	Fundamentals of Chemical Education 2
P3	Chemistry	Synchronous	46min20s (one lesson)	Biodegradable and Non-Biodegradable Materials	General Chemistry 2

Source: The authors.

As a method of analysis of synchronous classes, Content Analysis (CA) was used, a set of techniques applied to the field of communications, which aims to describe the content of the messages transmitted (Bardin, 2011). This type of analysis can be applied to various documents, forms of cultural communication (books, films, music, etc.), interviews, words, among others.

Based on this framework, the corpus was initially delimited, composed of the recordings of the classes provided by the participating teachers. Next, a floating reading was carried out, aiming to get to know this *corpus*, in order to move on to a process of deconstruction of it, delimiting units of coding or registration (words, phrases, excerpts, descriptions, etc.).

As a next step, we sought to categorize these units according to their degree of similarity of meanings. In this way, the categories represent remote teaching actions, and these are formed by subcategories, called microactions, which divide each of these actions (Rhea, 2022).

We used as a reference for the codification of the actions the research developed by Rhea (2022), presented in the topic "Theoretical Framework" of this work. For this article, we have adopted only the actions that fall under the "Execution" moment, considering the recordings of synchronous classes as essential data.

Thus, the categories of teaching action received the EXE coding followed by a numeral and a verb that represents the action. As an example, we cite the EXE1 category – Operationalize. For micro-actions, it is added with the code Sn. The sub-index n

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represents a sequence of letters, and the micro-actions were organized in alphabetical order. Thus, we take as an example the microactions EXE1Sa – Open camera, and EXE1Sd – Conversation with students.

We also emphasize that some categories of action present in the framework were not identified in this research, and that throughout the analysis, categories of action emerged that are not found in the adopted framework. We therefore chose to continue the numerical sequence of Rhea's (2022) codification, so that the emerging actions were numbered from the last category they presented. Regarding the microactions, we took the liberty of rewriting them according to what was observed in the recordings of the classes.

RESULTS AND DISCUSSIONS

The analysis of the synchronous classes allowed the identification of the following categories of *a priori actions*: EXE1 – Operationalizes, EXE2 – Writes, EXE3 – Explains, EXE4 – Responds, EXE5 – Waits, EXE6 – Interrupts.

The EXE1 action category – Operationalize, is defined by Rhea (2022) as a set of micro-actions that seeks to organize the remote class environment, such as turning cameras and microphones on and off, checking messages in the *chat,* and talking to students. The microactions in this category of action are shown in Chart 2. In it, the first column shows the microactions identified in the synchronous classes analyzed, and columns 2, 3 and 4 indicate which of them occurred in each of these classes.

Table 2. Microactions related to the EXE1 – Operationalize action, found in synchronous classes

Microaction	*Physical Class (P1)*	*Chemistry Class (P2)*	*Chemistry Class (P3)*
EXE1Sa – Open Camera	X	X	X
EXE1Sb – Accesses		X	X
EXE1Sc – Share/Unshare Screen	X	X	X
EXE1Sd – Student Chat	X	X	X
EXE1Se – Microphone Off	X		
EXE1Sf – End recording	X	X	X
EXE1Sg – Closes Camera	X		
EXE1Sh – Record class	X	X	X
EXE1Si – Turns on microphone	X	X	X
EXE1Sj – Performs commands	X	X	X
EXE1Sk – Save File	X		
EXE1Sl – Slide Swap	X	X	X
EXE1Sm – Checks message in *chat*	X	X	

Source: The authors.

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The first microaction, EXE1Sa – Opens camera, was dismembered from the "camera/microphone" microaction found in the literature used as a reference (Rhea, 2022), due to specific situations that did not occur in all classes observed. Thus, EXE1Sa – Open camera represents the act of teachers accessing the camera of their computers or cell phones through one of the tools of the videoconferencing platforms used in synchronous classes. The teachers left the camera open so that the students could see them throughout the explanations and for better interaction during the meetings. In EXE1Sb – Accesses, teachers command to allow students access to remote classrooms.

The next micro-action, EXE1Sc – Shares/unshares screen, marks the dynamics of presenting the screen during the synchronous class, so that students could view the material prepared by the teacher, and of removing this content from viewing mode for the whole class, at specific times, in which teachers had to access other tabs and windows of the computer.

The microaction EXE1Sd – Conversation with students, concerns several moments of the class that are related to bureaucratic issues. One of these moments occurs before the start of classes, in which teachers welcome students, give initial messages and interact with them while waiting for everyone to enter the remote room, as shown in the excerpts:

> A little delay there on the small screen, but I think it will work. Beauty. yes, I'm going to have to close my video here, guys, because otherwise it gets really slow. If I need to say anything I remember, I come here and open my video. Endorsement? Very well. Yes, and if there is any interruption, then you send it in the chat there, give me a warning, please. Endorsement? So let's go. Yes, our third class, right, remote. (Excerpt from P1's synchronous class)
> Hello, good night Julia, how are you? (Excerpt from the synchronous class of P2)
> Hey Alisson, so if you.... Will you try to get yours back? That then there will be a vote, right? (Excerpt from the synchronous class of P2)

Another situation in which we identified this micro-action was at certain moments in the class when the teachers took advantage of the explanation to inform or request something from the students:

> And Tainara, I haven't forgotten your question as to why there is no contraction in... or why there is only contraction in the direction of motion. Yes, I didn't forget your question. (Excerpt from P1's synchronous class)
> I'll end the recording here so it doesn't get too big. (Excerpt from P3's synchronous lesson)

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In class P3, we identified a situation in which one of the students arrived late to the synchronous meeting and requested access to the room. The teacher interacted with him while waiting for him to enter the room.

> Hi, Mark, how are you? Did he come in? (Excerpt from P3's synchronous lesson)

Also part of the breakdown of the "camera/microphone" microaction (Rhea, 2022) were the microactions EXE1Se – Turn off the microphone, and EXE1Sg – Close camera, which marked specific moments in the P1 class, in which the teacher interrupts his explanation to reflect on the resolution of an exercise. This situation occurred because, while a certain exercise was being carried out together with the students, P1 notices that there are inconsistencies in the resolution, and then feels the need to carefully analyze the steps already taken. He then turns off the microphone and closes the camera to have more privacy in his reflection.

The micro-actions EXE1Sh – Record class and Sf – End recording, mark the way to create a video file to be shared with students later. In synchronous meetings, teachers used the videoconferencing platforms' own recording tool for this purpose.

One of the instruments used in the synchronous meetings was the microphone, and the EXE1S microaction – Turns on microphone, is related to the act of teachers accessing the microphone of their electronic devices to interact with students and explain the content of the classes. This microaction is also part of the breakdown of the "camera/microphone" microaction presented in Rhea's (2022) framework.

The micro-action EXE1Sj – Performs commands, refers to the moments in which teachers made use of the auxiliary tools of the programs used. The *slide* presentation *software* used by teachers had several useful commands for their execution. The most used by P3 and P4 were the brush and eraser tools. It is worth mentioning that the moments reserved for these micro-actions were concomitant with the teachers' speech and relatively short, lasting an average of 2 seconds, as they were commands accessible at a mouse click.

The micro-action EXE1Sk – File Save, occurred at a moment in P1's class, which occurred right after the unsharing of the screen in which the slides were being presented. In order to share a new tab, the teacher first saves the file of this presentation, to keep the notes that were made during his explanation. In turn, the EXE1Sl microaction – Slide exchange refers to the moments of the asynchronous class, in which the teachers

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advanced or retreated the *slides* during their explanations. They were also quick moments, as very simple shortcuts could be used, such as the arrow keys and the *mouse itself*.

The synchronous meetings provided the possibility of interaction between students and teachers, either through *chat* or microphone and cameras. The microaction EXE1Sm – Verifies message in the *chat*, confirms such interaction, being identified in classes of P1 and P2, which proved to be more dynamic, while P3 focuses on presenting and explaining the contents.

> I'm going here in the chat to look at your answers. (Excerpt from P1's synchronous class)

Teachers P1 and P2 made considerable use of the *chat* during their synchronous classes, seeking greater interaction with students. This resource was a viable alternative for both parties, as the students rarely turned on the camera and opened the microphone, which was a way to ensure their participation in class.

Regarding the EXE2 – Write action, two microactions were identified, as can be seen in Chart 3.

Table 3. Microactions related to the EXE2 – Write action, found in synchronous classes

Microaction	*Physical Class (P1)*	*Chemistry Class (P2)*	*Chemistry Class (P3)*
EXE2Sa – Writes in the notebook (manuscript)	X		X
EXE2Sb – Write on slide (computer)	X	X	

Source: The authors.

The EXE2 – Writes action concerns the ways in which teachers recorded some type of information during remote classes. According to Rhea (2022), in remote teaching there is a variety in the methodologies chosen by teachers and, consequently, for the way they 'pass' or write the content.

The microaction EXE2Sa – Write in the notebook (manuscript), represents the act of teachers making some note in the notebook. In the case of class P1, it refers to the moments in which the teacher reflects on one of the exercises proposed as an example, as there is a collective doubt about its resolution. P1 then writes in the notebook, trying to find possible solutions to the problem. P2, on the other hand, performs this micro-action at a time in class when he interacts with the students. He asks a question to one of the students and he answers in the *chat*, giving an example of overcoming a person who is now

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considered one of the richest in the world. After reading this answer, the teacher comments that he does not know such a person and, finding this fact interesting, writes down his name in a notebook to research about him.

> Do you know it? I don't know... I'll even write it down. (Excerpt from the synchronous class of P2)

The *slides* were also used by the teachers to write. The microaction EXE2Sb – Writes on the *slide* (computer), characterizes the act of teachers making notes, drawings and highlights on slides or other digital media during the explanation of content or exercises.

Another action present in the synchronous classes analyzed was EXE3 – Explica, which marks the moments of the classes in which the teachers explain about the programmed contents. In the case of synchronous meetings, this category of action was composed of three microactions, which are presented in Chart 4.

Table 4. Microactions related to the EXE3 – Explains action, found in synchronous classes

Microaction	*Physical Class (P1)*	*Chemistry Class (P2)*	*Chemistry Class (P3)*
EXE1Sa – Explains activity	X		
EXE3Sb – Explains Content	X	X	X
EXE3Sc – Explains teaching/learning objectives	X		

Source: The authors.

The microaction EXE3Sa – Explains activity, was identified exclusively in P1's class, where he presents examples and performs exercises together with the students:

> Well, so this exercise says the following: that Stanley is here at the finish line, which I'm going to call reference S. The reference frame S', the exercise says that he was also placed here at the finish line, right. Mavis' ship, it is 300 meters long. Mavis is at the bottom of her ship, she's here at the bottom. It's event 2 and here in front event 1. (Excerpt from P1's synchronous class)

The synchronous classes analyzed had as their main objective to address thematic content of the areas in question. Thus, the microaction EXE3Sb – Explains content, was present in the three classes. The excerpts below represent some moments in which these microactions occurred.

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> Okay, for us to find a velocity relationship, the idea is this: we're going to take an element of X', and we're going to take an element of t'. That is, we're going to take the differential of X' and the differential of t'. (Excerpt from P1's synchronous class)
> So what is this movement for teaching? It is a pedagogical proposal that will detach the idea of neutral science, as it is in your speech, right, that neutral science, that the more development, the more science, the more scientific, technological, you know, the more wealth, the more social well-being. (Excerpt from the synchronous class of P2)
> Yes, the solubility of most substances, yes, what happens, right, when we see a solubility curve? Solubility ends up increasing with the increase in temperature, but with oxygen this does not happen. So we can see here, right, from this graph, the solubility of oxygen in water, that its solubility will decrease as we increase the temperature. So here on this axis we have the temperature, here the solubility in milligrams per liter of water. So as the temperature increases, the solubility decreases, it is. (Excerpt from P3's synchronous lesson)

In addition to explaining the syllabus, P1 also explained the teaching and learning objectives related to his class (microaction EXE3Sc – Explains teaching/learning objectives). Being a Teaching Degree course, P1 demonstrates its concern for students to understand the content worked, to the point of having autonomy and enough knowledge to pass on it in the best possible way when they are working in the classroom:

> So we, to make it easier, always our understanding, remember that a, like, let's say my goal, right, my goal with you is that you base this knowledge very well on... the Theory of Special Relativity, to the point that you can transmit this to high school students. That is my goal with you. That's why we're always working on the foundation of the thing, right, looking very well at the references, who's who, who's against whom, is it? So that's why I'm always going to bring these cute stickers there so we can understand very well where we are. OK?! (Excerpt from P1's synchronous class)

The fourth action identified in the synchronous classes considered here was EXE4 – Respond. It was defined by Rhea (2022) as the action that represents the way chosen by the teacher to answer the students' questions during these meetings. In the present analysis, it was possible to identify a micro-action belonging to this category: EXE4Sa – Responds orally, in which the teachers used the microphone to perform such an action. Chart 5 presents the information on this category.

Table 5. Microactions related to the Responds action, found in synchronous classes

Microaction	*Physical Class (P1)*	*Chemistry Class (P2)*	*Chemistry Class (P3)*
EXE4Sa – Responds orally	X	X	

Source: The authors.

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The EXE4 – Responds action refers to the moments in which teachers answer students' questions, however, with the analysis of the recordings, we expanded this definition by adding the moments in which teachers also respond to comments from these students.

> Yes, no, maybe only the first term works. I didn't do this exercise. But perhaps only the first one will work. (Excerpt from P1's synchronous class)
> yes, J [student], I can even agree with you, but I think there is a way for us to get out of this just by using the contraction relationship. It's a matter of just understanding the following... (Excerpt from P1's synchronous class)
> [...] You can't, then you say "I don't want to see if I'll be able to handle it"... (Excerpt from the synchronous class of P2)

It should also be noted that this action was identified only in the synchronous classes of P1 and P2. The synchronous meeting of P3 proved to be a very theoretical moment, in which the teacher uses all the time to explain the content, as well as the students did not demonstrate any type of interaction via *chat* or microphone.

The fifth action defined by Rhea (2022) and identified in the synchronous classes considered was EXE5 – Waiting, representing the moments when teachers waited for something during the synchronous class. It was composed of four microactions, as shown in Chart 6.

Table 6. Microactions related to the EXE5 action – Wait, found in synchronous classes

Microaction	*Physical Class (P1)*	*Chemistry Class (P2)*	*Chemistry Class (P3)*
EXE5Sa – Waits for students to open microphone	X	X	
EXE5Sb – Waits for students to enter the remote room			X
EXE5Sc – Waits for students to write in *chat*	X	X	
EXE5Sd – Waits for students to do class activities	X		

Source: The authors.

We also chose, for this category of action, to break down the microactions "student actions" and "by access" presented by Rhea (2022) into 4 microactions, as shown in Chart 6. The EXE5Sa microaction – Waits for students to open the microphone, was identified in P1 and P2 classes, and represents the act of teachers waiting for students to activate the microphone tool to interact during synchronous meetings.

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Identified only in the synchronous meeting of P3, the microaction EXE5Sb – Waits for students to enter the remote room, occurred at a time when the class had already started. It is thought that this microaction also occurred in P1 and P2 classes, but before its beginning and since these initial moments were not recorded, we do not have data to confirm or refute this hypothesis.

The next microaction that integrates the EXE5 – Waiting action is EXE5Sc – Waiting for students to write in the *chat*. It represents the moments when the teachers waited for the students to write comments, questions and answers in the *chat*. This microaction was identified in P1 and P2 classes, which proved to be more interactive. In the case of P1, the *chat* was used several times for the students to present answers to parts of the exercises, as well as to answer questions asked by the teacher. In P2's class, the *chat* was used by the students to make comments on class topics and to answer questions asked by him.

The microaction EXE5Sd – Waits for students to do class activities, was identified in class P1. The teacher brought exercises to carry out in the classroom with the students, and at times he directed small activities for the students to solve. Thus, it was necessary to wait for them to complete and present their results. In the excerpt below there is an example of a moment when the teacher waits for the students to finish solving part of the exercise, in which he even makes a joke:

> We only have until two in the morning to stay here, huh. (Excerpt from P1's synchronous class)

Closing the categories of action defined *a priori*, the so-called EXE6 – Interrupts was identified, characterized by situations in which teachers had to stop the class for some specific reason. This category has three microactions, two of which emerged from the analysis of the recordings, as shown in Chart 7.

Table 7. Microactions related to the EXE6 – Interrupts action, found in synchronous classes

Microaction	*Physical Class (P1)*	*Chemistry Class (P2)*	*Chemistry Class (P3)*
EXE6Sa – Interrupts class to analyze exercise	X		
EXE6Sb – Interrupts class to refer to material	X		
EXE6Sc – Stops class to check access request			X

Source: The authors.

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The microactions EXE6Sa – Interrupts the class to analyze the exercise and EXE6S$_b$ – Interrupts the class to consult material, occurred during the synchronous class of P1, in a certain situation in which the resolution of an exercise ended up becoming complicated. The teacher interrupts the class to consult his notes in a notebook and, soon after, to reflect on the exercise. P3 interrupts the class and turns off the camera to have more privacy at this point.

The microaction EXE6Sc – Interrupts the class to verify access request represents the moment of the P3 class, in which one of the students tries to enter the remote room, making the request to the teacher. He then interrupts the class to attend to this student.

The actions described so far were pointed out by Rhea (2022), as previously substantiated, but access to class recordings allowed us to perceive new categories, which will be presented from now on. The first of them was called EXE7 – Point, presenting a microaction, as shown in Chart 8.

Table 8. Microaction related to the EXE7 action – Point, found in synchronous classes

Microaction	*Physical Class (P1)*	*Chemistry Class (P2)*	*Chemistry Class (P3)*
EXE7Sa – Points text/image	X	X	X

Source: The authors.

Despite being based on only one micro-action (EXE7Sa – Points text/image), this category of action was identified at various times in the synchronous classes of P1, P2 and P3, in which the teachers used the tools of a brush, laser or even the mouse, to point out certain images or texts during the explanations.

Another action that occurred in classes of P1, P2 and P3 was called EXE8 – Reads, which represents the moments in which the teachers read some type of text. It was composed of two microactions, which are presented in Chart 9.

Table 9. Microactions related to the EXE8 – Reads action, found in synchronous classes

Microaction	*Physical Class (P1)*	*Chemistry Class (P2)*	*Chemistry Class (P3)*
EXE8Sa – Reads student comments in *chat*	X	X	X
EXE8Sb – Reads Slide Content	X	X	
EXE8Sc – Read book exercise	X		

Source: The authors.

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Throughout the three synchronous classes considered here, it was possible to notice the interaction of teachers with students via *chat*. Usually these moments were generated by the professors themselves, who instigated the participation of the students, asking questions or asking them to make comments. To maintain this interaction, the teachers read the messages sent in the class *chat*, corresponding to the microaction EXE8Sa – Reads comments in the *chat*.

> Calm, professor. All right for now. Beauty. (Excerpt from P1's synchronous class)
> Oh, the JV [student], he also replied, he said that... is... that the equation provides education, we can have more and more people generating wealth and fewer and fewer people in a precarious situation. (Excerpt from the synchronous class of P2)

The teachers also used *slides* to present the syllabus, and in some situations they read part of the information contained in them, as a way to complement their explanation, which characterized the emergence of the EXE8Sb microaction – Reads content on *slide*.

> It is the study of the interrelationships between science, technology and society, so CTSA constitutes a field of work for academic research and public policy. (Excerpt from the synchronous class of P2)

The microaction EXE8Sc – Reads book exercise characterizes the moment of the synchronous class of P1, in which one of the students raised a question about a certain exercise and, to answer the question, the teacher read this exercise by consulting the textbook.

> Two atomic clocks are carefully synchronized. One of them remains in New York while the other is on the plane that... When the plane returns, the total time interval measured is 4 hours. What is the difference between the time interval measured between the two clocks and which one indicates the shorter time interval? Suggestion: Since u is much smaller than c, you can simplify by using a binomial series. (Excerpt from P1's class)

The action category EXE9 – Question is related to the act of teachers questioning students about certain subjects in class. It is composed of a micro-action: EXE9S_a – Question about the theme of the class, as presented in Chart 10.

Table 10. Microaction related to the EXE9 action – Question, found in synchronous classes

Microaction	*Physical Class (P1)*	*Chemistry Class (P2)*	*Chemistry Class (P3)*

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EXE9Sa – Question about the content of the class	X	X	

Source: The authors.

The microaction EXE9Sa – Question about the content of the class, refers to the questions raised by the teachers during the explanation of the content. They used this artifice to promote interactive moments with students, either via *chat* or microphone.

> Now I'm going to ask you a question, and I want you to answer it for me there in the chat. Take a pen, a pencil, and I'm going to ask you the following question: how far away, oh, the diagram helps the question well, is it? What is the distance from – I'm going to call Mavis here – from the point, the origin t equals zero, to t' equals 5 seconds, what was the distance traveled by Mavis? Let's call this XM to differentiate from this X here. So, how much is XM worth? Come on, I want to know from you, it's not asking that in the exercise. I want to know. (Excerpt from P1's synchronous class)
> And A [student], tell me what do you understand with this equation, when you read it? (Excerpt from the synchronous class of P2)

The recordings of the classes indicate that, even with the action of asking questions made by the teachers, the students were still apathetic, with few who answered. The answers given by the students, for the most part, were via *chat*, but situations were identified in which they used the microphone to do so.

The action category EXE10 – Listening, comprises the act of teachers paying attention to what students said via microphone. It occurred in classes of P1 and P2, as shown in Chart 11.

Table 11. Microaction related to the EXE10 action – Listening, found in synchronous classes

Microaction	*Physical Class (P1)*	*Chemistry Class (P2)*	*Chemistry Class (P3)*
EXE10Sa – Listens to student response/comment on microphone	X	X	

Source: The authors.

When questions were raised about the contents or exercises during classes, some students spoke up by opening their microphones, and the teachers paused their speeches to listen to their answers or comments.

In class P1, the students used the microphone at the time of proposing exercises, exposing their ideas and doubts for their resolution.

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> Ah, professor, I did it by Mavis' reference, in this case 0.8c times 5 seconds that passed. (Excerpt from P1's synchronous class)

In the case of the synchronous class of P2, the students participated, through the use of a microphone, in two situations: at the beginning, when the teacher directs the class through questions, and, at the end, when an opportunity for discussion about the importance of the topic addressed is opened.

> That science generates technology, and then technology generates wealth, and wealth social well-being. (Excerpt from the synchronous class of P2)
> Wow, for sure [laughs]. It's very important, I think you think outside the box, if for me... I started to do a self-analysis from when I was a student, you know. That it really wasn't like that, and I went to high school, I did the three years at night, which at the time I worked, so it's even more lowland, right. You literally don't think, you just copy, deliver, and look that I studied at a reference school, so even so, it was very complicated, right. So, thinking in this sense, as a teacher I say that it is a... A great challenge. Right. (Excerpt from the synchronous class of P2)

Concluding the survey of teaching actions during synchronous classes, we identified the category called EXE11 – Erases, which comprises the moments when teachers performed the act of removing information on the *slides* that would no longer be necessary for the class. Chart 12 presents the microactions that make up this category.

Table 12. Microaction related to the EXE11 – Erase action, found in synchronous classes

Microaction	*Physical Class (P1)*	*Chemistry Class (P2)*	*Chemistry Class (P3)*
EXE12Sa – Deletes annotations on the *slide*	X		

Source: The authors.

Through this Table, it is inferred that only teacher P1 performed the act of erasing. This is due to the objective of his class, which was to solve examples and exercises together with his students, so that the *slides* were used as spaces for this purpose. Thus, when he noticed that the *slide* was overloaded with information or needed to fix some step of the resolutions, P1 used the "eraser" feature of the presentation program:

> Let me erase a little bit that this thing here was very, very scribbling, you don't need that much either, right? (Excerpt from P1's synchronous class)

The P2 class focused on the discussion of research results, so the *slides* were used to present theoretical concepts and data collected.

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Teacher P3, on the other hand, directed the class through a traditional explanatory approach, in which the *slides* were used as support in the presentation of concepts and examples that supported his speech.

Concluding this analysis, we present in Chart 13 a comparison between Rhea's research (2022) and the categories of actions and their respective microactions identified in the analyzed classes. We chose not to use the encodings of microactions, as they differ in relation to synchronous activities.

Table 13. Comparison between the actions and microactions obtained in the literature and found in the observation of synchronous classes

Share	*Microaction*	*Rhea (2022)*	*Synchronous classes*
EXE1 Operationalizes	Open camera	X	X
	Access	X	X
	Call	X	
	Share/unshare screen	X	X
	Conversation with students	X	X
	Turn off microphone	X	X
	End recording		X
	Closes camera	X	X
	Record class	X	X
	Turn on microphone	X	X
	Performs commands		X
	File Saves		X
	Slide exchange		X
	Check message in *chat*	X	X
EXE2 Writes	Write in the notebook (manuscript)	X	X
	Write on the *slide* (computer)	X	X
EXE3 Explains	Explains activities	X	X
	Explains content		X
	Discusses	X	
	Writes	X	X
	Explains teaching/learning objectives		X
	Material	X	
	Question	X	
EXE4 Answer	Responds orally	X	X
	Answers in writing	X	
EXE5 Wait	Waits for students to open microphone	X	X
	Waits for students to enter the remote room	X	X
	Wait for students to write in chat	X	X
	Waits for students to do class activities	X	X
EXE6 Stops	Interrupts class to analyze exercise		X
	Answer doorbell/intercom	X	
	Noise	X	
	Interrupts the class to consult material		X
	Interval	X	
	Asks for commitment	X	
	Technical problems	X	
	Messages from third parties	X	
	Stops class to check access request		X

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EXE7 Points	Points text/image		X
EXE8 Read	Read student comments in *chat*		X
	Read content on *slide*		X
	Read the exercise from the book		X
EXE9 Question	Question about the content of the class		X
EXE10 Listening	Listens to student response/comment on microphone		X
EXE11 Erases	Deletes notes on the *slide*		X

Source: Authors.

In this table, the lines highlighted in blue show the microactions identified, both in the adopted framework and in the analysis of the classes. Through it, it is possible to verify that the actions defined *a priori* (EXE1 – Operationalize, EXE2 – Write, EXE3 – Explain and EXE4 – Respond, EXE5 – Wait, EXE6 – Interrupt) were also observed in the synchronous meetings. We also infer that the other actions and micro-actions obtained in the analysis of the classes derive from the access to these recordings, which presented additional information to the interviews, so that it was possible to visualize all the actions carried out by these professors throughout the synchronous meetings to which we had access. Some microactions raised by Rhea (2022) were not identified in the synchronous meetings analyzed, as they are the result of particular situations. As an example, we cite the microaction EXE6 – Answers bell/intercom, which was reported by one of the teachers interviewed by the researcher, but which did not occur in any of the synchronous classes that made up the dataset of this article.

FINAL CONSIDERATIONS

This article presents the results of a research that aimed to identify the teaching actions carried out during synchronous classes taught in Physics and Chemistry Teaching Degree courses of public institutions of Higher Education in the state of Paraná, using the methodological assumptions of Content Analysis (Bardin, 2011).

For the synchronous meetings, 11 action categories were identified: EXE1 – Operationalize, EXE2 – Write, EXE3 – Explain, EXE4 – Respond, EXE5 – Wait, EXE6 – Interrupt, EXE7 – Point, EXE8 – Read, EXE9 – Question, EXE10 – Listening, and EXE11 – Delete, of which the first 6 were defined *a priori* (Rhea, 2022), and the others emerged throughout the observations of the recordings. Each of these categories was composed of

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microactions, which presented common characteristics that allowed them to group into these sets.

It is noted that the analyzed classes presented, in general, a similar pattern, in which the professors used the technological resources of videoconferencing platforms to generate expository moments for the presentation of theoretical content and activities, as well as to ensure interaction with students (in the case of synchronous meetings).

Through the survey of these actions, we can infer that the teachers participating in this investigation sought tools and methodologies that met the needs of the students served, so that they could maintain access to education during the pandemic period, which reinforces the importance of training these professionals for the adversities of the classroom routine. We believe, therefore, that this work contributes to the reflection on teacher training, especially in relation to the new technologies that have been incorporated into society.

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