Biochemistry teaching during a pandemic – an online teaching experience

Ensino de Bioquímica durante a pandemia – um relato de uso de tecnologias na educação

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Abstract

The present work describes an educational experience involving the teaching of Biochemistry in a high school during the COVID-19. During the online classes, we explored various tools for online education with the purpose to connect with the students and to connect the Biochemistry topics to health and exercise. We explore the tools created for this educational practice: website, media, blog, video, games, and software. The flipped classroom model was used, in which the concepts of Biochemistry teaching were connected with the student's daily life through the debate on Food and Health. Students’ feedback was collected in a non-obligatory, anonymous questionnaire. The results point out to a global satisfaction regarding the methodology and tools developed. We understand the practice here can be of use for future teaching of Biochemistry in online or hybrid situations.

Keywords: COVID-19; Health and Exercise; Game and Education.

Resumo

Neste trabalho, descreve-se uma experiência educacional no ensino médio envolvendo o ensino de Bioquímica durante a Pandemia da COVID-19. Ao longo da prática pedagógica online, variadas ferramentas foram exploradas, como: criação de site, mídia, blog, vídeo, games e software. Utilizou-se o modelo de sala de aula invertida; nela se conectaram os conceitos de Ensino de Bioquímica com o cotidiano do aluno através do debate sobre Alimentação e Saúde. O feedback dos estudantes foi obtido por meio de um questionário livre, não avaliativo e anônimo. De modo global, os estudantes relatam satisfação quanto à metodologia e ferramentas desempenhadas. Entendemos que as práticas pedagógicas aqui descritas podem contribuir efetivamente para o Ensino de Bioquímica, seja online ou híbrido, em futuras experiências pedagógicas.

Palavras-chave: COVID-19; Saúde e Exercício; Gameficação e Educação.
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1 Introduction

The Brazilian Constitution guarantees both human rights to education and health [1]. However, these rights were compromised by the Global Pandemic of the Coronavirus-19 (COVID-19). In the case of the Brazilian Population, COVID-19 brought devastating outcomes: high numbers of deaths and many other social conflicts. As a governmental strategy, school classes were suspended [2] and a new debate arose on how to secure learning without compromising health. Amongst the possibilities, many schools opt for online education. By doing so, the COVID-19 pandemic brought out the unspoken problems in education, such as the lack of access to technology and internet communication [3], the deficit in teachers’ formation in technological education, and many other issues [2,4].

The literature already reported exhaustively such issues, but the pandemic magnified and brought out new problems. Amongst which is the teachers’ decision on how who, and what to when using an online education modality. In many cases, as reported by Figueiredo [5], a replication of the traditional classroom to the online version caused a mere transfer of the existing problems. For this researcher, online education should always unite technology with a human touch; knowledge and attractiveness found in media; beauty, and playfulness. As well as the capacity to create and expand an effective bond between teacher-student, as a requirement for an educational process [6,7]. Before any kind of chosen path for education, in-class lecture, or online classroom, a teacher should know what kind of person is willing to be formed [8]. We desired this teaching experience by understanding each student as a whole person, with a personal dialogue, corroborating with the knowledge of each individual to learn more of its unique attributes, potentials, and dreams. Thus, as teachers, we aimed to construct together with the student and encourage him/her to work cooperatively, to exercise critical thinking, and encourage authorship with the concept of Biochemistry in togetherness with Health and Food.

Many authors discuss the obstacles of Biochemistry teaching. However, for this work, two main discussions are focused: i) the lack of connection to reality, and ii) the abstract thinking. Biochemistry education, especially regarding lipids, carbohydrates, and proteins is oftentimes taught partially, fragmented and disconnected to the surroundings of the student. Because of this, many students show little interest in Biochemistry because of the lack of connection to the students’ life [9]; the absence of instigating broader themes [10]; the loss of a macro view of the pathways and their implications [9]. In sum, these studies demonstrate that especially in the case of Biochemistry Teachings the connections

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of the knowledge to the student's daily life should occur, not only to captivate the student but also to allow him/her to transform one's life and society.

At the same time, to learn Biochemistry, the student must develop abstraction and imagination to understand molecular interactions and biochemical pathways [11]. These pathways, molecular shapes, and interactions can be hardly represented on the blackboard. For instance, being unable to understand the 3-D shape of a molecule can compromise the student's ability to see how two molecules join and unjoin in a biochemistry pathway; thus, to grasp the role that such small molecules can have in the body's well-being. However, this can be facilitated using online education tools like, simulators that allow students to: (i) rotate a molecule 3-D and notice its active sites; (ii) simulate the interaction amongst different molecules; (iii) see the molecule inside its pathways; (iv) grasp a broader view on how these small molecules cause the body well-being [12, 13].

This study demonstrates a Biochemistry teaching experience in a high school during the COVID-19 pandemic and analyses the students’ perceptions. We asked how a flipped classroom with the aid of an online theme classroom website would help to teach biochemistry in an integrated way with students’ lives.

2 Framework and Context

2.1 Online Education

Online education is marked by the presence of the Digital Technology of Informatics and Communication [14]. It has grown with the outcome of new devices and forms of social technological interactions. This interaction between man and technology caused a profound transformation in society [15] and its relationships to a point where generations have been separated as digital natives or not natives. Online education allowed a higher facility to obtain information and new contexts for learning [16]. Despite the abundance of supply in the form of websites, apps, e-books, etc., demand for human connection in the process of learning is still needed.

To merge technology and teaching without losing human touch is a struggle in today’s classroom. Teachers require formation to master the technological improvements, understand better their native digital students, and act in the new contemporary school. At the beginning of the XXI century, authors like Thompson, Bull [17] pointed out principles and acts to guide the formation of teachers in this era of Online Education, amongst which are: (i) being infused into the entire teacher education program; (ii) being introduced in
context; and (iii) to experience innovative technology-supported learning environments in their teacher education program. Researchers pointed out the lack of formation of the professors in online education sometimes causes a dichotomy in the articulation of theory and practice [18]. This lack of articulation led to a replication of the traditional classroom in the online version [5]. Thus, future teachers require in their formation the knowledge of online education to be able to use this tool in consonance with the established goals, and knowing why? how? to whom?; because the use of technology is not neutral [19].

Distance Education was introduced in Brazilian schools in 1980. By that time, the main goal of public politics was to assure equal access and prepare for global changes. At the same time, the existing law is used to stimulate curiosity to form students with critical thinking and capable of understanding the role of man in nature [20, 21]. Digital inclusion was obtained by creating infrastructure and teacher-student access to the internet and computer [22]. Since 1980, troubled scenarios arouse and, despite efforts, researchers observed:

i. School's appropriation of technology lacked the same dynamism as the fields of science and telecommunications [22].
ii. Discrepant access to technology because of the continental size of Brazil and its economic inequality.
iii. Disadvantages of the poorest could be observed not only for the less quality of equipment or complete lack of it; internet access; study area and resources.
iv. The ability to learn online is hampered by students’ inability to focus for many hours. Online education should account for biological limitations.
v. Autonomy is a requirement to study online, yet many students were unable to guide themselves in an online study.

These listed problems imply the political consequences of the use of technology in education. During the COVID-19 pandemic, the same problems were intensified since education was available only in the online format. We understand that new times require new strategies, as during the pandemic education should accomplish the struggles facing many students in their personal lives, such as the death of family members, unemployment, economical struggles, lack of a study area, need to supervise siblings while having classes, and many other particular situations like depression and anxiety.

The use of technology and online education should require the human touch to capture the tired student [5], especially in the case of COVID-19. Online education should not be used as a tool to make learning faster, rather open new spaces to learn and use the
globalized platform as an open strategy. Espíndola, Reses [4] explore educational alternatives, like online museums, simulators, games, movies, comics, and online models for biological processes. These alternative tools allow the student to learn by doing or exploring, to solve problems, and become a protagonist in his/her learning process [4, 23].

2.2 Biochemistry Education

Biochemistry is present in all Biology and daily life. However, it is very often limited to a simple isolated subject and taught from a fragmented and anthropocentric point of view. The fragmentation is a consequence of resuming Biochemistry to its cycles and not integrated to how and why and biological evolution. The anthropocentric side is because many of the examples used are merely humans not connecting to the other living beings. Both the fragmentation and the anthropocentric view corroborate the loss of wholeness. According to Matta and Neto [24], the fragmentation arouses deep in the formation of future teachers. Many times, the biological knowledge and classes, such as Biochemistry, are detached from didactic pedagogical training, when in fact both competencies are required abilities in the future teaching career.

Amongst the aims of the Brazilian Educational Laws is to form a person with a critical mind able to investigate, understand the role of man in nature, and transport the biological knowledge to act in society as a whole [20]. Mata and Neto [24] point out that, especially to the Biochemistry subject, this aim is many times unachieved. For Niebisch and Souza [9], one reason is the lack of connections and application to students’ lives.

The strict use of textbooks causes Biochemistry classes to become tedious and unattractive [9]. Much because the student cannot grasp the dynamic of the biochemical processes and the context in which they occur, as they lack abstractive thinking. The use of metaphorical analogies also leads to confusion. Conjointly, the teacher’s approach should be cautious and understand the high school student’s background to allow them to clearly understand the subject, as mentioned by Espíndola and Giannella [23].

To overcome the challenges found in Biochemistry teaching in High Schools, we consider that the main concern has to be how to promote connection with the student’s daily life. In the literature, there are several examples: topics like cycles of oxygen, carbon, and nitrogen can be taught regarding their implications for the ecosystem and living beings [24]. The subject of lipids could be united with oil/soap production-consumption and the environmental problems [24], but also intriguing questions and aspects of living beings can be brought up, like the different types of food, metabolism, and energy amongst species [24], and photosynthesis, ecosystems, and strategies to survive in various places.
The struggles debated by researchers in the field of Biochemistry education arouse various strategies for contextualized learning. Amongst them, we point out the use of information and communication technologies (ICT) for several reasons. First, promoting better visualization of molecules and their cycles in an integrative way is crucial to overcome the abstraction gap. By using 3-D models, the students gain the advantage to understand the relationship of structure and function [25]. Free tools like Rasmol, PyMol, and Protein Data Bank (PDB; www.pdb.org) are available to accomplish this goal [25]. More recently, the use of Constructor was described as a useful tool to visualize the Biochemistry in the biological processes [23].

Another use of technology in Biochemistry is the online construction of mind maps [4, 24]. Investigation and construction of mind maps are amongst the solutions pointed out by Matta and Neto [24] to promote active learning. It involves the collective construction, modeling, and evaluation in metacognitions processes of learning [26]. This could be relevant to allow the student to think together as future citizens since it stimulates links between different contents and social contexts. A STSE (Science-Technology-Society-Environment Approach) approach is also useful to allow critical thinking to be achieved in the case of Biochemistry subjects [24].

Games are an important tool when teaching Biochemistry with an ICT approach because it allows students to learn to work with conflict, cooperation, rules and improve their motivation as a whole [27]. One strategy to be considered in Biochemistry teaching is the use of games as a way to promote learning in a fun, interactive, and practical way. Espíndola and Giannella [23] show that the creation of a Learning Management System was successful for a teaching experience to undergraduate students. For the case of a school, an online space could be achieved with the use of a flipped classroom [10] together with a Constructor [23]. The use of technology allows the student to interact with the knowledge before the classroom. Also, with the use of practice questions [4], the students are oriented to think about relevant issues pointed out by the teacher. Moreover, such strategies guarantee stronger student feedback [10, 23]. The use of games also allowed students to learn to work with conflict, cooperation, rules and improve their motivation as a whole [27].

Even in a COVID-19 pandemic, with a strong pedagogical foundation, an online teaching experience produces interesting outcomes. Although aspires to the pandemic end, new approaches to teach Biochemistry using online tools should be continued, especially the aid of an online website platform. These strategies assure the pedagogical potentialities of ICT in a teaching-learning experience.

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3 Educational Practice’s Description and its Implementation

3.1 Context of the teaching experience

This educational practice was strictly online following City Health Department Laws school restrictions to COVID-19 pandemic. This was the first intern teaching strictly online between UFSC (Federal University of Santa Catarina) and IFSC (Federal Institute of Santa Catarina).

The Biology classes, taught from November and December 2020, to 1st year High School students, enrolled in the “Integrated Technical Course in Electronics” at IFSC. A total of 27 students, mainly male, were enrolled yet only 23 were active.

At IFSC, classes were organized in two educational phases or moments similar to an inverted or flipped classroom model, alternating synchronous week and asynchronous week.

3.2 Website

The Biochemistry contents to be taught to high schools students were carbohydrates, proteins, and lipids. To provide a link with the student's daily life and more application [15, 24], these themes were brought as a connection with a broader transversal subject that is Food and Health. To create immersion and to connect with the students, a website called The Biology Teacher1 was created (Figure 1). Espíndola, Reses [4] cite the relevance of various forms of interaction when using online technologies for education. Because of this, our website had various spaces for the student to send feedback and interact, such as Forms and Questionnaires, a Blog, a Contact Area, and phone communication through WhatsApp.

The website included videos to add dynamics and food images in an esthetical harmonious beauty as proposed by Figueiredo [5]. Thus, producing appealing visuals to the young public. Attention was paid to the students’ comments on favorite foods and sports. The chosen images reflected their hobbies causing students to feel listened to and appreciated. Besides, the website was organized on several pages. The “Atividade Assíncrona” page guided students to the asynchronous learning phase, using text, video, diagrams, and a graded activity questionnaire.

The “Materiais Didáticos” page was designed to provide links for the students to deepen the subjects explained with further readings and contained the link to the game

“Pick your Plate” used in the synchronous learning phase [29] (Figure 2). On this page, the materials in various designs provided Biochemistry learning in multiple forms [10, 11, 24, 25].

Figure 1. The website opening and the menu with the created pages: Synchronized Activity, Didactical Materials, Learn More (Cholesterol: good or bad guy?; Myths and Truths; Biology and Art), Evaluate the Teachers, Who are we?, Contact and Blog [28]

“Saiba Mais” page included questions brought out by the students in the synchronous learning phase. For example, many students showed interest in the debate involving what type of fat to use for cooking. Because of this, the page was reedited by the addition of a new table, highlighting concepts and providing new images (Figure 3). This dynamic of Online Education in websites allows teachers to contemplate, guide, and summarize class debates. On the other hand, students appreciate being heard, and they comprehend that the website can be a collective space of many voices.

Even though biology and art are not always brought out together; an online version and website should be able to allow the students to emerge in various forms of connection. A page “Biologia & Artes” was designated to provide some links relating to the students’ hobbies: dance, music, and creative drawings.

Last on the website are the menus who we are, contact, and blog. The “Quem Somos” page had a presentation of the trainee teachers. A video with our voices and personal photos were added to create openness with the students.
A Blog page was created to contain small samples of the classes’ debates, impressions, or even topics brought on WhatsApp. A more colloquial communication was used in the form of text and the use of GIFs and emoji to promote interaction with the students. Figure 4 shows the use of videos as an engaging strategy to remember and connect with students outside the classroom. The blog was also used as a small diary to recall the students of the classes taken together and the journey established during this internship.
The website contained various forms. Besides, from the graded form, the other ones were open, anonymous, not graded, created to know the students or to better understand the repercussions of the website and the educational practice as a whole.

**Figure 3A.** The website page Learn More, “Saiba Mais: Colesterol – Good or bad guy?” B: Shows the table created to summarize the discussion and questions brought out in the synchronized class meeting [31].
The page “Avalie os Profs” contained a form where students’ feedback regarding the educational practices was obtained. This evaluation form was available during the whole teaching experience. The students’ feedback was anonymous, free of choice, open during the whole teaching process, and available at the website The Biology Teacher. A total of 15 students gave their feedback. The questions were both multiple-choice questions and open fields to provide space for free expression. This questionnaire was beforehand approved by the class professor and the Internship Responsible Professor.

3.3 Synchronous Learning Phase

The synchronous learning phase taught by the trainee teachers occurred on December 8th and 9th. The class of December 8th had a longer class time than the following day. Both classes were online gathering through Google Meet. Google Jamboard made it possible to project a presentation but, at the same time, to interact with the students as a normal blackboard would allow.

The class of December 8th contained three main moments: i) outline and introduction to Health and Food; ii) Myths and Truths on the Biochemistry of Lipids, Carbohydrates, and Proteins; iii) a Travel and Food where the game “Pick your Plate” occurred.

First, during the introduction and outline, several questions were presented for a warm-up debate: “What is health?”, “Why do we eat?”, “How does exercise matters on health?” During this debate, many students asked about mental health and stress. A more global perspective was brought up due to the high tension many felt in their personal and familiar environment during the COVID-19 pandemic.

The second moment, an active methodology allowed the student to reflect on the Biochemistry Myths regarding carbohydrates, lipids, and proteins. The open atmosphere allowed the students to feel comfortable expressing their questions and doubts. Personal
and familiar habits were brought to the discussion, especially regarding the daily choices of lipid consumption, like coconut oil, pork fat, and margarine.

The third moment was a fun hour when students were invited to travel to an online museum, “Smithsonian Institute”. At the museum, they would play “Pick your Plate”. The game was presented by the trainee teachers as a MasterChef Edition and the goal for the participants was to prepare healthy meals around the world. The class played together choosing the dishes as a whole. Instead of time, the amount of money was the limiting variable for food creation. Health could be seen using the game nutritional table as well as the salt, fat, and sugar percentages. The game was played in Spanish. When a translation was needed, it was made by trainee teachers.

The use of the game “Pick your Plate” is an excellent choice to take advantage of the online educational strategy. The game allowed the students to have a dynamic online class, where the topics related to Biochemistry were brought together with a global understanding that food is also associated with economic value and cultural aspects. They were invited to think about health parameters and their variation from country to country because they are established by each nation; about the differences in breakfast, lunch, and dinner around the world, because of the cultural cuisine influences. The fun and motivating environment allowed the student to better understand how the food choices implicated in the total daily income of salt/fat or sugar varied from country to country. In some cases, some variables were absent, as shown by the game, because it was not a variable considered by the national health department.

In sum, it presented an important debate on the choice we make to feed and nourish the body. In addition, the understanding that health is a multivariable concept, and diets restricting certain food groups, like no carbs at all, can be harmful. Class ended with a wrap-up of the debates, an overview of important concepts, such as beauty, body image, health, culture, global food footprint, and economical value. Indications to the next day’s activities were also presented.

The December 9th class, lesser in time, contained three main moments: i) to wrap up the debates and recapitulate the main concepts on Biochemistry; ii) the added table at the “Saiba Mais” page was presented and answers were given to the questions regarding the Biochemistry of lipids; iii) the asynchronous learning phase was presented. To better guide the student for this autonomous moment of learning, a presentation was made to show the activity, goals, the simulator “Eat and Exercise” from Phet Colorado, and explained how to manipulate the tools; iv) finally, the graded questionnaire was presented and explained together.
3.4 Context and Asynchronous Learning Phase

The asynchronous learning phase taught by the trainee teachers occurred on December 15th and 16th. Though there were no online gatherings, student-teacher communication, question answering, and reminders occurred through WhatsApp.

The Simulator “Eat & Exercise” from www.phet.colorado.edu [32] was used in a Portuguese version. The “Atividade Assíncrona” page made it possible for students to guide themselves to the activity and easily manipulate the simulator. The chosen simulator connected the concepts of carbohydrates, lipids, and proteins to daily life. It allowed students to understand how heart health depends on diet and exercise and how the Body Mass Index (BMI) depends on weight and height; estimate the number of calories needed for basic human body survival; the number of calories each food provides and the number of calories burned by exercise; relate the basic needs of the human body to the age of the individual; create a regime with diet and exercise, etc.

The simulator, together with the game, causes the online process of learning to become dynamic, including the asynchronous learning phase. Students began to speculate questions, such as “What would happen with my health if I don’t eat well?”, “What would happen if I don’t exercise?”, and many other variables like weight, age, gender… These questions contribute to understanding how concepts of Biochemistry are interconnected by many daily variables.

Finally, the students presented their results and answered a graded questionnaire regarding the asynchronous learning phase. A Google Form was used to create this questionnaire. The graded questionnaire made possible for students free expression (by text, video, drawing, etc.) of their impressions on the Simulator and the Class overall. Among the answers, a student represented through drawing a debate on the type of fat ingestion (oil, butter, or pork fat) and the consequences on health (Figure 5).

The student shows the table added to the page “Saiba Mais”, showing how relevant was the addition of this information for him. In the students’ images are summarized types of fats coconut, olive oil, butter, and margarine, pointing out what is healthy from unhealthy. In this presentation, a more traditional teacher with the board is used, showing how rooted is this concept of teacher-classroom representation.
4 Implementation Evaluation of the Practice and Main Results

We will discuss the contributions of the website and the educational moments implemented during this internship: the synchronous learning phase and the asynchronous learning phase, concerning the results and feedback obtained by the students through the form on the page “Avalie os Profs”.

4.1 The contributions of the Website

The creation of the website had a great repercussion in this internship because it allowed establishing a unique theme classroom. Its beauty and content brought overall joy and dynamics in such a difficult learning time at the COVID-19 pandemic.

According to the Form “Avalie os Profs”, when asked about the clarity of the content presented in the blog and video, 70% of the students considered it to be excellent or good (Figure 6) and 80% considered the produced material as appealing (Figure 7).

Both data show the importance of a theme room in the process of learning. For online education, as in the case of this experience, a website to direct and orient the students’ learning is very important, because of the excess of information online. Providing an organized space guides the learning process in an established path [33]. In comparison, it would be the same as to pioneer an untouched forest rather than to go through the same forest, but by a trail. A student reported this concept as: “The content is informative, fun to read, and easy to navigate throughout the website.” Another student quoted as:

The content is very informative, fun to read, and easy to navigate on the website. There is much important information and materials that help to better understand them, altogether everything is well signalized. (Personal font: Anonymous comment of a student given in the form “Avalie os Profs”).

Figure 5. Student answer to the Evaluation graded Form. The image shows the student on the computer screen, and the teacher is one of the trainee teachers. The image represents him explaining the Biochemistry of lipids using as an example the type of oils and fats and their impact on health.
However, online education requires internet access, and the lack of it and/or outdated computer devices hampered navigation online, as shown in the comment:

The good side is that the website has many interesting contents; the downside is that I had slow navigation because my computer is old. (Personal font: Anonymous comment of a student given in the form “Avalie os Profs” [34]).

Such a narrative can also help to explain the data found in Figure 7 (question B). Due to slow internet connection, students made use of their mobile devices and 4G networks. Some reported the lack of structure for online classes at home, that is, the absence of personal computers and the internet or the need to share the computer with other relatives. Uneven digital access remains in Brazilian education [4], and it became more visible with the COVID-19 pandemic. To rethink the debates of accessibility as proposed back in 1980 is still relevant, because of the need to guarantee this generation the right to learn despite the COVID-19 pandemic.

Another aspect of the website was that it involved the theme of Biochemistry in a broader presentation. For some students, the extra material available on the website showed to be of value, helping in this learning process as a whole. A student wrote:

“Positive points: they explain very well, interesting material, and a good number of extra files to go deeper into the subject.” (Personal font: Anonymous comment of a student given in the form “Avalie os Profs” [34]).

This points out that the existence of a theme website and extra material (with variation in form and number) are relevant in the online process of learning.
4.2 Synchronous learning phase: the use of the game in an online class experience

The synchronous learning phase had a high overall satisfaction, being evaluated between good and excellent (Figure 7, question B). The students’ approval was also expressed in the open field comment section, like the following:

I enjoyed the synchronized class with the intern teachers, they were always smiling, had great explanations, and great interaction with the students. I don’t know if it is because I see things from a positive point of view, but I cannot express a negative aspect of the class. I always left the class with a big smile and more knowledge. (Personal font: Anonymous comment of a student given in the form “Avalie os Profs” [34])

![Figure 7. Graphic shows the students’ opinion regarding the aspects of synchronous classes taught using Google Meet. The answers point to the percentage regarding the criteria (excellent, good, regular, bad, terrible) according to each given question]

Personal connection with the students through a “smile” produced motivation and inspiration to them, as mentioned in the answer form. Establishing personal bonds between them is relevant to Biochemistry, to break historical negativity as a voluminous, tedious, and unattractive subject [9]. A teacher’s motivation, as simple as it may sound, was a key element to help the student find purpose, connection, and joy in their learning process. In an online space, where learning is done mostly autonomously, and in a stressful environment of the pandemic, this human connection and motivation are required for many students. This aspect was also observed in another student’s comment:

Well, the synchronous class is already a positive point, even more with teachers good willing to give a class end up giving me a greater desire to study. (Personal font: Anonymous comment of a student given in the form “Avalie os Profs” [34]).

On the other hand, to avoid some difficulties reported in the literature when teaching Biochemistry [10], we chose to use a game. In the context of online education, the games caused higher student engagement. Using the game strategy in the synchronous learning phase was crucial in this online experience and caused the online gathering moment to become more active and shared.
The game “Pick your Plate” was evaluated in the form “Avalie os Profs” as good or excellent by most students (Figure 8, C). A student commented:

You were pfts (perfect), you can absorb all the content and I loved the way you used games to explain <3. (Personal font: Anonymous comment of a student given in the form “Avalie os Profs” [34]).

The universe of games is already a winner with the young students, because their main hobby was games, as informed personally and by the form. On the other hand, personal communication with other teachers that were lecturing in the COVID-19 pandemic reported a lack of interest in the classes online, little or no participation together with tiredness from massive online time typing and attending to classes. Thus, to choose beforehand and develop learning strategies based on each student, the class profile is crucial to create connections and overcome barriers found in the literature [9-11, 24].

The students’ love for games should be a hint for the teachers nowadays. For Figueiredo [5], teaching must include beauty and dynamics found in gaming into the online educational experiences. Espíndola, Reses [4] demonstrate the advantage of learning through games diminishes the fear of losing.

Our experience with the game in the synchronous learning phase together with other learning moments was evaluated as highly satisfactory (Figure 8). At the same time, a new interesting outcome came, the openness and playful atmosphere made students want to discuss. An engaging debate arose with the discussions, such as caloric expenditure, daily nutritional table, cost of obtaining food, food visuals, obesity, and consumption of carbohydrates in different cultures, among others.

On the other hand, some students said they missed face-to-face classes, as it occurred before the COVID-19 pandemic. These feelings were expressed through the following comments: “It’s really fun, the teachers are really nice, but they don’t have the same energy as a face-to-face class”; “The negative point is that they didn’t have a direct explanation of them”; “Positive side is that the activity and subject is much clearer and easier to understand, and the negative thing is that it was not in person”.

Altogether, it shows that learning is still a personal process. For some of them, online learning was an easy experience, but to others the substitution of a person in the place of a computer screen is unalike. School culture is also a place of security. At the same time, as COVID-19 vaccination occurs, a new hybrid format of teaching, having both online and classroom learning, will help these feelings of dissatisfaction to diminish.

Finally, the last moment for the synchronous classes was to prepare the students for the activities that should be developed in the asynchronous learning moment. Starting by showing the website, reading the information, demonstrating the software interface “Eat
and Exercise” and tools, also reading the evaluation activity and providing space for questions. Overall, the students found this part of the class as well explained (Figure 8, D).

4.3 Asynchronous learning phase: the use of simulator in an online individual experience

The asynchronous learning phase was taught as a pedagogical activity that would allow the students to deepen the connections between Biochemistry and daily life [9,10], through a macro view of the pathways and their implications on Health and Exercise [9].

This phase had the requirement for autonomous learning. Despite the explanation in the last moment of the synchronous learning phase, we also created extra videos to provide guidance and to keep closeness to the students during the asynchronous learning moment [32, 34]. We understand that this further step can help guide autonomous learning without being lonely. Together the guidance (like the “Atividade Assíncrona” page) and open/easy communication (like WhatsApp) in multiple forms (videos, audios, images, texts, etc.) produce a pedagogical asynchronous learning experience mostly evaluated as good or excellent (Figure 8).

For the students, the use of the simulator was also considered a relevant experience in the learning process. Almost 90% of the students were evaluated to be excellent (Figure 8, question D). This result is a consequence of the friendly atmosphere and the loss of fear to try/explore, as reported by Espíndola, Reses [4]. The use of simulators, as for the game, allowed students to lose the fear of Biochemistry, of exposing
themselves on camera, and also gain a much-needed enthusiasm and participation in the learning teacher-student process.

Moreover, the simulators allowed exploring the variables in a dynamic “why” and “what if”. These questions are very important in scientific thinking [4] and they can be observed in reflections like:

My character got thinner over time, stimulating me to put on weight, causing him to end up starving to death in the end. So, I imagine that I need to eat a little more or take it easy in physical exercises. (I imagine that it is the first option because my exercises are not done daily, besides the fact that I have been known, since I was little, for having an appetite down in my family.) (Personal font: Anonymous comment of a student given in the form “Avalie os Profs” [35]).

Another student linked physical health and mental health while using the “Eat and Exercise” software:

Another important reflection taken from this class is that it is not enough to have health in the body, it is also important to have mental health. (Personal font: Anonymous comment of a student given in the form “Avalie os Profs” [34]).

This is very important since diets and body image concerns are among the main causes of depression and anxiety among teenagers [36]. At the same time, it shows the connection made by the student between the debate in the first moment of the synchronous learning phase and the activity in the asynchronous phase. It also points to the student’s correlation between Biochemistry and daily life, an educational goal aimed at this internship.

Both the educational game “Pick your Plate” and simulators “Eat and Exercise” prevented learning from being a mere training to pass on the national exams [6]. However, they formed important attributes for a person to act in society, such as thinking together as a group; a constructive resolution of problems; reflecting deeper on the concepts and their relation to daily life; understanding how concepts are interconnected in a broader point of view.

5 Conclusions and Implications

This was unique learning and teaching experience that occurred exclusively online due to the COVID-19 pandemic. Our experience shows that dynamic teacher-student found in a classroom should be present as well in the online process. Although the physical connection was unavailable, dialogue, joy, and happiness should be always found as a common ground.

The use of online strategies like games, simulators, and a variety of ways to represent contents together with multiple channels of communication and expression
produced new paths for Biochemistry teaching, where concepts were connected to daily life experience. Enhancing students’ critical thinking was also accomplished by allowing the integration of various physiological phenomena together with the daily life aspects, such as food, exercise, and other daily issues like the choice of fat for cooking, the vegetarians’ ingestion of proteins, doubts about diet, diet disorders and body image.

The application of the game “Pick your Plate” [29] also brought a unique aspect to Biochemistry learning, that is its relationship to culture and society, and how our behaviors are entangled with time beyond culture and society.

The students’ overall enthusiasm and satisfaction can help to see this learning experience as the beginning approach for integrating ICT potentialities into Biochemistry teaching in the future.

Further improvement to assure the students’ access to technology (computer, internet, etc.) is still a demand for future educational programs.

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