Perceptions on the Use of an Online Tool in the Teaching-learning Process in Microscopy

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Abstract: During the COVID-19 pandemic, remote learning was an alternative to maintaining student participation in subjects, active learning, and knowledge development. This approach is necessary for the experimental demands of the practical content of the Cervical Cytology class. This paper presents and discusses using an online platform to learn practical content in the microscopy subject of Cervical Cytology class. The evaluated scenarios demonstrated that the planning of the discipline and personal factors such as student interest and availability could influence the student performance.

1 INTRODUCTION

Digital native is a term defined by (Prensky, 2001) to refer to a generation who were born in a world greatly permeated by technology. That means they expect digital tools to constantly mediate their interactions with the world. Such assumption implies that even contents covered in the classroom need to be closer to their digital daily life to keep students interested and motivated. Therefore, there is a formal expectation that education at all levels (university, high school, and elementary) incorporate educational technologies in their execution resulting in practices of Digital Technologies of Information and Communication (Bahia et al., 2019). This approach aims to facilitate, enhance learning, and include innovative practices in education.

Thus, computational tools are necessary to address that vision in several areas of knowledge since these tools allow the learning process to be modified to suit the student or explore different teaching methods for the same topic.

(Guze, 2015) classify these tools in the following categories: computer-assisted learning, mobile devices, digital games (or serious games), simulations, and wearable equipment. Moreover, despite the similarity between these tools due to the computational resources used, each represents a different interaction model, which explores users' different senses and perceptions, allowing access to activities analogous to the experimental ones in the case of remote learning.

In digital pathology and cytopathology, these approaches range from different scholar levels, from inside university classrooms to conferences and specializations (Maley et al., 2008; Wiecha et al., 2010; Bahia et al., 2019; Guiter et al., 2021). The technology allowed a significant transformation in the process with the digitization of microscopic slides to generate images of whole slides (Whole slide imaging (WSI) or digital slides), which can be manipulated by the operator and used in the learning context (Hanna et al., 2020; Guiter et al., 2021). However, such systems require high-value equipment and are not easy to access. In addition, users (students) also need quality internet access and good computers to use these resources well.

This work proposes a digital tool to support the implementation of remote model microscopy subjects and the discussion and evaluation of such interaction. Hence two remote teaching scenarios of a cytology discipline were implemented using a support tool for assessing students. These scenarios were performed during the COVID-19 pandemic in 2020 and 2021.

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This work is structured as follows: Section 2 presents some related works; Section 3 presents a contextualization of the class used as the basis; Section 4 introduces the digital the tool used; Section 5 presents the evaluated scenarios; Section 6 describes the results observed and Section 7 presents the conclusions of this work.

2 RELATED WORK

(Maley et al., 2008) propose a computational tool used to assist teaching. The authors evaluate how a web system helps in the pathology learning process. It was observed how these students behave in the proposed scenario and how this impacts their learning process. One behavior observed is that users prefer a face-to-face setting and are not fulfilling the application's response deadlines during the school term. However, only a small group of students maintained this behavior. That was associated with individuals' characteristics, who focus on the result as a study strategy.

Another use of computational resources as teaching tools was shown by (Wiecha et al., 2010) where they discuss the use of the Second Life (SL) platform for teaching and training. The SL is a virtual environment focused on providing communication and interaction resources to users. The authors created a test case based on a seminar on the use of insulin for patients with type 2 diabetes. The scenario allowed participants to be more confident about evaluating the need to apply the discussed treatment after participating in the dynamics. In addition, participants also reported that the interaction model was as good or superior to a traditional face-to-face model.

(Krasne et al., 2013) shows a combination of learning tools and algorithms, which presents a system to aid the study of histopathology based on a web system, which implements an adaptive learning model. The user is provided with a study scenario that presents different cases related to the course contents to improve students' long-term content retention. Moreover, the system presents a case study and options to identify which type of problem (injury) the case study addresses. Furthermore, the order in which the case studies are delivered to the user is constructed using an algorithm that learns from the user's performance. It was observed how students' content retention was through their reassessment in later periods, which showed that users who used the system had greater content retention.

(Darici et al., 2021) report the implementation of a histology course in a remote model for the context of the COVID-19 pandemic. Students from two different academic periods (second and third) were evaluated in the scenario developed. These students were introduced to the course content and performed interactive activities during remote classes. At the end of the course, the students' performance was evaluated as 71% (second period) and 74% (third period). However, the students' evaluation of the model was positive, on a 100-point scale with 1 being "very good" and 100 being "very bad" students reported a median of 21 (second semester) and 22.5 (third semester).

The works described in this section show that the remote teaching-learning process is possible and feasible. However, they present a great variety in how they work and are applied, consequently impacting their performance.

3 CERVICAL CYTOLOGY

The Cervical Cytology class aims to present to undergraduates the dimension of cervical cancer and how screening for this neoplasm is essential to ensure women's health. This class aims to enable students to develop logical, critical, and analytical reasoning in the face of cervical cancer screening. All screening steps are characterized, from the collection of the material to the release of the diagnosis report, including staining techniques, assembly, reading of the cytological smear, interpretation, quality monitoring, and report. In addition, there is content focused on the physiology of the female reproductive system, histology, cytology of the cervix, hormones, menstrual cycle, inflammatory processes, microbiota, and cytomorphological criteria of malignancy.

Most of the concepts and contents presented in the class are linked to identifying and recognizing elements in the Pap smears when viewed under an optical microscope or in images originated from them. Traditionally, the professor explains the content by exposing many images illustrating cervical-vaginal smears, infectious agents, microbiota, inflammatory processes, cytological changes, and other important biological structures to understand the theory studied fully. So, the visualization of images within this discipline's teaching is crucial for better student learning.

The course evaluation is split into two parts: theoretical and practical. The practical classes of the discipline are carried out under an optical microscope for visualization of cytology slides after each theoretical class, covering the topics and biological structures taught for a better understanding of the students. Thus, each student has an optical microscope and slides available to visualize the subjects teach in the theoretical classes and are present in the slide. Also, the practical classes are accompanied by the teacher and allow the students to look at different examples equivalent to multiple slide images over each lecture's content.

The periods evaluated were remote, so applying the traditional practical test under an optical microscope was impracticable. Therefore, the tool presented in Section 4 was essential to assess students regarding the visual requirements required in the practical test, which are fully linked to the theoretical content taught. In addition to the tool presenting a content review, it was responsible for learning tests.

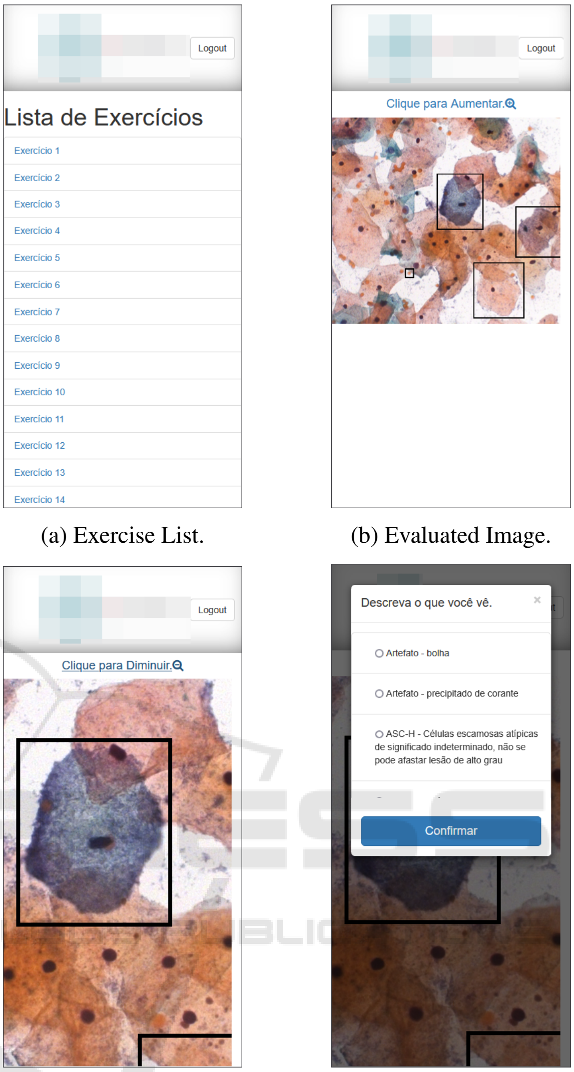
4 THE SYSTEM

This section describes the system used during the class as a support tool. The computational system was constructed based on the interaction process for identifying and recognizing the elements present in the Pap smear. The students perform these activities in optical microscopes during classes and practice tests. Thus, the online platform was built to replicate the interaction and experience from those situations. Moreover, due to accessibility, the system was designed to be used in mobile device browsers. Also, the system interface is in the students' native language. Figure 1 shows screens of the implemented system.

Figure 1a presents the list of exercises (or **activities**) that students must answer on the topics studied in the theoretical class. When the user clicks on one exercise of the list, the system shows a screen similar to Figure 1b. The image to be evaluated is presented with the regions of interest (denominated **questions**) to be identified and named. Multiple regions of interest in the same image make up the activity. The student is also able to zoom in on the image to see more details of the analyzed region, as shown in Figure 1c. Finally, the student clicks on the region, and multiple options are presented to select which alternative best describes the highlighted (or marked) region, as shown in Figure 1d. The student has prompt feedback about his answer and can view the correct answer for a region if he has selected the wrong option. The exercise is completed and corrected by answering all the questions in the image.

Besides, considering the return of face-to-face activities, this tool can also be used in the routine of practical classes to establish knowledge, not only in cytology but in any subject involving microscopy.

It is necessary to point out that the presentation and description of this tool are not essential for this article, but their use in the process of interaction in online pathology classes. To facilitate understanding, in the next section, we will describe the experimentation scenario used to evaluate the interaction between students and their performance in the tool.



(a) Exercise List. (b) Evaluated Image. (c) Region of Interest. (d) Answers Alternatives.

Figure 1: System Screens.

5 TEST SCENARIOS

In this section, the observed scenarios are described. They correspond to two approaches of remote learning activities carried out during the COVID-19 pandemic between 2020 and 2021. In both scenarios, the system described in Section 4 was used, in which 87 activities and a total of 249 questions were considered.

5.1 Scenario 1: Shorter Academic Period

The first scenario corresponds to a model of a reduced academic period, designed as an alternative for remotely carrying out the subject during the pandemic. The class was developed in a shorter time than the traditional one, in this case, nine weeks instead of eighteen weeks. Thus, in addition to the remote execution model, it was also a faster and more compact model than the traditional one. The classes were four times a week instead of twice. However, the participation of students in this period was optional, so the student enrolled in the course had some interest or motivation in carrying out this process.

As for the course dynamics, system access, and evaluation, the students had only one deadline at the end of the school term. This deadline includes all the activities of the system.

5.2 Scenario 2: Regular Academic Period

The second scenario corresponds to a regular model of academic terms carried out remotely. In this case, the period comprises fourteen weeks, and the participation of students in the period was mandatory.

In this scenario, the dynamics, system access, and evaluation were divided into two deliveries: around the first half of the course, which means around 50 days, and the other half at the end of the school term.

6 RESULTS AND DISCUSSIONS

This section presents the results observed in the scenarios described above. Only the data from students who have completed the course are considered, that is, those who have completed the discipline.

6.1 Scenario 1: Shorter Academic Period

In Scenario 1, 12,164 responses were obtained from 50 students (97.70% of all possible answers, 98.11% of all possible activities), which resulted in an average of 243.28 responses per student. Students had an average hit rate of 85.47% concerning answered questions and 83.51% concerning all available questions.

Figure 2 shows the distribution of student responses during the period considering the class. Interestingly, most responses are concentrated in the last two weeks of the period. However, some answers are in the middle of the observed period, which corresponds to the end of complementary activities to the discipline.

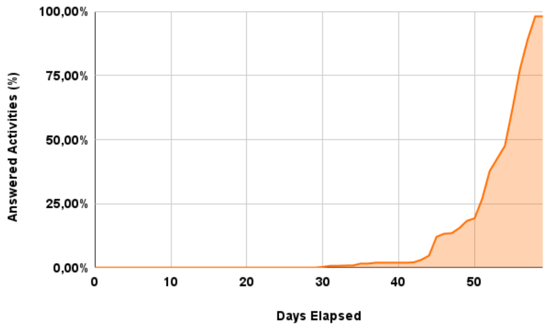


Figure 2: Accumulated Activities Answered in Scenario 1.

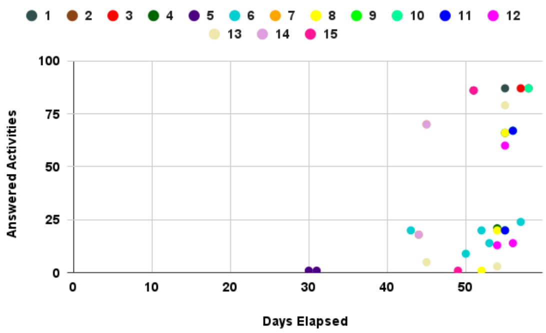
Figure 3 shows the distribution of student responses during the period. Students with less than 70% hit rate were considered outliers and excluded from the analysis (resulting in 45 students out of 50), the remaining students' results were divided into 3 groups of size 15 based on their performance. Thus, the **group 1** corresponds to students with a hit rate between 100% to 89.5%; **group 2** corresponds to the correctness range from 89.5% to 83.5% and **group 3** corresponds to the correctness range from 83.5% to 75%. Each color in the Figures 3a, 3b and 3c represents a student and in case of overlap only one colored point is shown.

By observing the Figures 3a, 3b and 3c, we can identify two behaviors among students: (**I**) resolution of activities throughout the course and (**II**) resolution of activities at the end of the course. These behaviors occur in all groups in different proportions. However, the behavior **II** seems to be connected to better student performance. Given that in group 1, which contains the users with the best success rates, at least two-thirds of the students did the activities at the end of the course, and in one or two interactions, they answered 87 activities (247 questions) in two days.

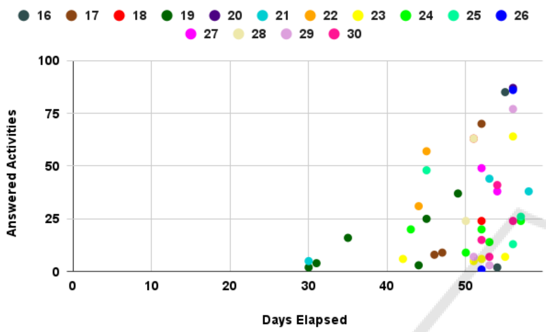
6.2 Scenario 2: Regular Academic Period

In the second scenario, 2,113 responses were obtained from 9 students (94.29% of all possible answers, 90.42% of all possible activities), resulting in a rate of 234.78 responses per student. On average, these students had a hit rate of 80.69% concerning what they answered and 70.08% concerning all activities.

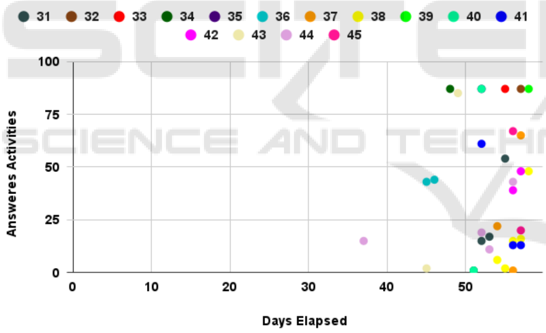
Figure 4 shows the distribution of student responses during the academic period. It is interesting



(a) Group 1.



(b) Group 2.



(c) Group 3.

Figure 3: Students Complete Activity Distribution in Scenario 1.

to note that, as in this scenario, two delivery dates were made for the activities (50 and 84 days elapsed since the beginning). The distribution of responses is concentrated around these two dates.

Figure 5 shows the distribution of student responses during the period. The responses are clustered around the 50th (day of the first delivery) and 84th (second delivery), with a smaller concentration in the last one. However, the number of responses decreased in the second delivery. This behavior can be related to the student's feeling of having already passed the discipline and redirecting his efforts to other courses.

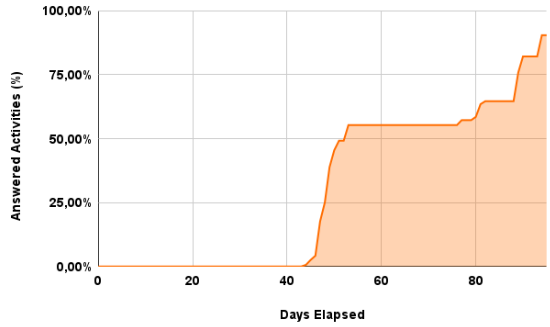


Figure 4: Accumulated Activities Answered in Scenario 2.

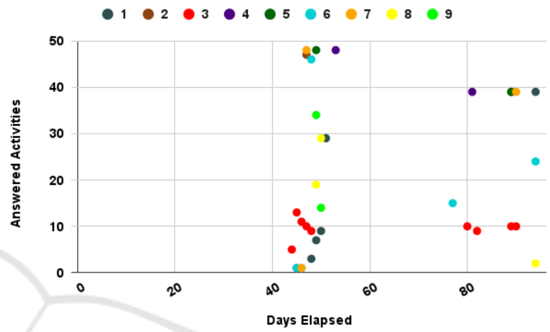


Figure 5: Students Complete Activity Distribution in Scenario 2.

6.3 Discussion about Both Scenarios

In general, the methodology utilized in Scenario 1 allowed it to have the highest success rate. This behavior can be associated with the fact that the students answered all the activities at the evaluation period end. The course structure favors that behavior as the subject is passed to the students by cumulative exposition. This increases the students' ability to assess the elements on the images over the period. In this way, students could assimilate more information about the structures and the exposure during classes.

Figure 6 presents a summary of user success rates in both scenarios. Considering the first delivery of Scenario 2 as a splitting point, the data was separated into two halves (the first and the second delivery of Scenario 2). In the first half, it is observed that both scenarios were obtained answers to almost all questions. However, the hit rates are both relative to what was answered, and the total is proportional to each other.

In the second half, there is again a lower delivery rate of activities by students in Scenario 2. However, the success rates relative to what was answered by the students is high, on the order of 80%. The low delivery of activities reinforces the hypothesis that students preferred not to respond to the activities, either because they have already passed the subject or have

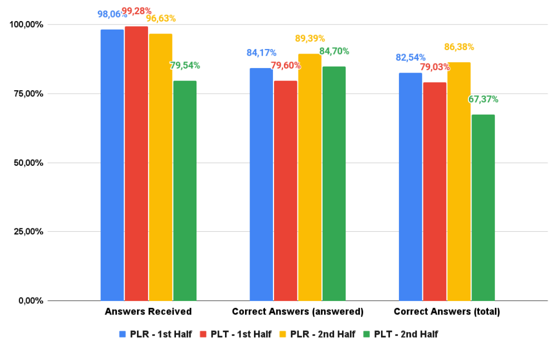


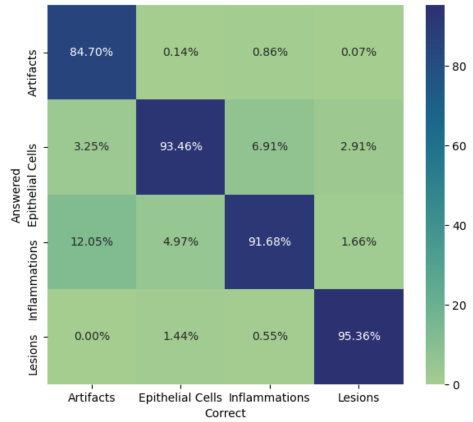
Figure 6: Answers Distributions in Both Halves of the Test Scenarios.

other priorities (other courses). The observed hit rates indicate they knew the subject; however, they preferred not to answer the activities.

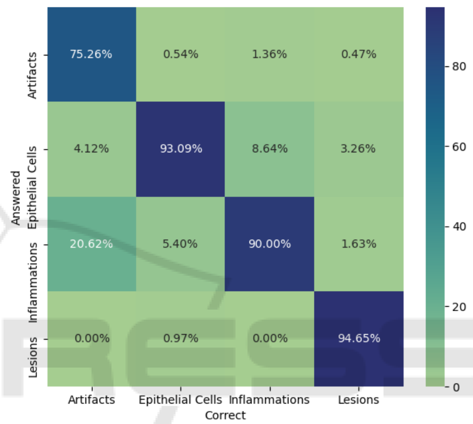
Figure 7 presents the confusion matrix of the students' answers for the main concepts addressed in the discipline. A confusion matrix is a form of visualization in which the columns represent the instances' actual category while each row represents the instances' answered category. Since the activities contain multiple alternatives, they were categorized into four thematic groups based on their concepts, these groups being: **Artifacts** (1), **Epithelial Cells** (2), **Inflammations** (3), and **Lesions** (4). The **Artifacts** group gathers the alternatives for materials foreign to the cytology sample, such as dye precipitate and bubbles. The **Epithelial Cells** group gathers alternatives representing the cells collected from the cervical epithelium. The **Inflammations** group gathers alternatives associated with the cellular changes that indicate an inflammatory process associated with some infectious agents. And **Lesions** group gathers the alternatives representing the classifications for different changes in cervical epithelial cells. Also, if a student answered a wrong alternative but the alternative was in the same group as the correct answer, it will be considered a "hit" for this graph since the user had a small conceptual error.

In Figure 7a the confusion matrix for Scenario 1 is presented, and it is interesting to observe that users confuse responses from category 1 with category 3. However, the reverse process almost does not happen. The results may indicate a learning effect during the course span since the group 3 alternatives are content from the middle of the course while the category 1 alternatives are from the beginning. There is also some confusion between category 2 and 3 alternatives, inflammations, and lesions.

Figure 7b presents the confusion matrix of the responses obtained for Scenario 2. Like Scenario 1, there are also errors between categories 1 and 3, but



(a) Scenario 1.



(b) Scenario 2.

Figure 7: Confusion matrices for responses categories.

with a volume greater than occurred in the first scenario. This may be a consequence of carrying out the activities in two stages since, in this scenario, the students had less exposure to the contents when they were answering the first half of the activities (compared to Scenario 1), which may have caused this higher error rate. Similar to the first scenario, there is also some confusion between category 2 and 3 alternatives.

As categorized above, the response options were generalized into four groups. However, the user may have answered some alternative in the same category as the correct answer, which marks the answer as incorrect. The table 1 presents the hit and miss rates within each category. Interestingly, there is a constant error rate above 7% across all categories and scenarios. Furthermore, in Scenario 2, there is a higher error rate compared to Scenario 1.

Table 1: Categories' hit and miss rate.

Scenario 1			Scenario 2		
Category	*Hits*	*Miss*	*Category*	*Hits*	*Miss*
Artifacts	92.78%	7.22%	Artifacts	89.04%	10.96%
Epithelial Cells	91.37%	8.63%	Epithelial Cells	86.54%	13.46%
Inflammations	91.92%	8.08%	Inflammations	90.91%	9.09%
Lesions	92.67%	7.33%	Lesions	86.94%	13.02%

7 CONCLUSIONS

The COVID-19 pandemic has created the need to incorporate remote education experiences into the cervical cytology discipline quickly. This proposal developed a framework that allowed students to interact with images and subjects similar to those in a practical class. Also, we evaluated how different classroom scenarios impacted student performance.

The data collected demonstrate that in Scenario 1 a better average performance of students was obtained. This performance can be associated with both the discipline's methodology who performed in less time with more condensed content, and students' commitment since participation in the term containing Scenario 1 was optional. Also, it is important to emphasize that the two scenarios present a difference in the participants' composition, motivations, and the number of students in each scenario. So some differences in the performance are related to that.

The virtual environment allows the student to choose what and when to do it. For example, he can organize himself, focusing on more difficult content (individualization of learning). Although the student is not in a real laboratory, the diagnostic context is covered and the situations created are very close to routine. Another clear point in remote teaching is that even if the laboratory does not have slides with a specific lesion, it is possible to create a repository with different images from different locations and the most varied lesions. Thus, it allows the student to see, detect and learn in the widest possible way.

Finally, it is noteworthy that the external factors also impact in the teaching-learning process (and consequentially, their performance). Some of the external factors include the time, the performance on other subjects or disciplines studied parallel and personal context.

Further experimental investigations are needed to better estimate the impact of this learning model. One improvement is using the system in more academic periods to obtain more reliable data. Moreover, the system can be improved to make it easier to access and better interact with the different actors (students and teachers) without impacting the model's performance.

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