

Educational Perspectives in Microbiology: Analysis of the Impact of Virtual Practices *vs.* In-Person Practices on Podiatry Degree Students

Perspectivas Educativas en Microbiología: Análisis del Impacto de las Prácticas Virtuales *vs.* las Prácticas Presenciales en Alumnos del Grado de Podología

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Summary: With the aim of effectively integrating virtual environments in Microbiology practices, the effectiveness of practices in virtual format compared to face-to-face in the Microbiology subject of the Podiatry Degree has been analyzed. After choosing the in-person or virtual practical format, the students voluntarily completed knowledge questionnaires prior to and after the practices, in order to evaluate their performance. Likewise, the commitment and satisfaction of the students was evaluated. The majority of students chose to carry out the practices in person, showing greater commitment and participation in the questionnaires. Both groups experienced an improvement in performance, with no significant differences between formats. Students who participated in the practices expressed a high level of satisfaction in both formats. Virtual practices are an appropriate alternative to face-to-face practices in teaching Microbiology.

Keywords: Microbiology; Chiropody; virtual practices; face-to-face practices; blended learning.

Resumen: Con el objetivo de integrar de manera efectiva los entornos virtuales en las prácticas de Microbiología, se ha analizado la eficacia de las prácticas en formato virtual en comparación con el presencial en la asignatura de Microbiología del Grado de Podología. Tras elegir el formato práctico presencial o virtual, los alumnos realizaron voluntariamente cuestionarios de conocimientos previos y posteriores a las prácticas, con el fin de evaluar su rendimiento. Asimismo, se evaluó el compromiso y satisfacción de los estudiantes. La mayoría de los alumnos eligieron realizar las prácticas en formato presencial, mostrando un mayor compromiso y participación en los cuestionarios. Ambos grupos experimentaron una mejora en el rendimiento, sin diferencias significativas entre formatos. Los estudiantes que participaron en las prácticas expresaron un alto nivel de satisfacción en ambos formatos. Las prácticas virtuales suponen una alternativa adecuada a las prácticas presenciales en la enseñanza de Microbiología.

Palabras clave: Microbiología; Podología; prácticas virtuales; prácticas presenciales; aprendizaje mixto.

1. Introduction

The Covid-19 pandemic led to the temporary suspension of face-to-face education at all levels of Spanish education from March 11 to June 21, 2020 (1). Next, a semi-presential scenario was established, allowing in-person attendance in those activities that could not be carried out in digital format (2). Faced with these extraordinary circumstances, teachers were forced to apply changes in teaching methodology to adapt to the use of new technologies, implementing virtual teaching material that would guarantee the continuity of student learning (3). In this regard, it has been found that the integration of new technologies, such as virtual practices or laboratories, short videos, comics or online questionnaires, constitute tools that promote participation and facilitate the study of Microbiology (4-6). To achieve comprehensive training in the subject of Microbiology, in which students can apply the theoretical knowledge acquired and assemble the different conceptual, procedural, manipulative and attitudinal skills, it is necessary to carry out a practical approach, which has traditionally been executed through practical laboratory (7-8).

On the other hand, it has been shown that the implementation of case studies not only leads to a deeper understanding of the contents, but also stimulates active learning and enhances the ability to make decisions in practical contexts (9). In the context of Microbiology, it has been found that the incorporation of clinical cases, whether in physical or virtual environments, constitutes an effective strategy to promote self-directed learning in students, since this approach effectively facilitates the application of the principles. microbiological in clinical settings, promoting the internalization and practical application of the knowledge acquired in the discipline (10-11).

The traditional Microbiology practices developed for the Degree in Podiatry at the Complutense University of Madrid are based on the analysis of two clinical-practical cases limited to two of the pathologies of infectious etiology that occur in the foot: the diabetic foot ulcer. and onychomycosis. To do this, students must identify the causal agents of the samples provided by performing various stains and biochemical tests. In order to adjust laboratory practices to the non-face-to-face environment, the students were provided with the results obtained in each test in order to identify the microorganism that causes the infection in each clinical case.

The objective of this study was to assess the impact on the motivation, performance and satisfaction of the students of the Microbiology subject of the Degree in Podiatry in carrying out laboratory practices in face-to-face or virtual format during the 2020/2021 academic year.

2. Methods

Given the exceptional nature of the social and health situation during the 2020/2021 academic year, in which safeguarding the health of risk groups prevailed, the practices were carried out voluntarily. Students had the option to choose between the in-person or virtual format, and these practices did not constitute a weighted component in the final evaluation of the subject. In this way, the 71 students who were taking the subject of Microbiology in the 1st year of the Degree in Podiatry at the Complutense University of Madrid during the 2020/2021 academic year (2020 curriculum) were asked to carry out the following activities (figure 1):

1. *Previous knowledge questionnaire (Pre Questionnaire)*. At the beginning of the course, a questionnaire was developed with 10 basic questions to assess the prior knowledge of all students in the field of Microbiology.

2. *Choice of internship format.* Subsequently, the students enrolled in the Microbiology practices of the Podiatry Degree, choosing one of the practicum format options: in-person or virtual.

2.1. *Group of face-to-face practices.*

The practice script provided essential knowledge to address the diagnosis and treatment of diabetic foot ulcer and onychomycosis. In the case of diabetic foot infection, a bacteriological diagnosis was carried out, providing detailed information on sample collection and sowing, isolation and identification of microorganisms (including types of culture media, sowing methods, growing conditions). incubation, staining and batteries of biochemical tests), as well as the study of antibiotic sensitivity using the antibiogram. On the other hand, in the diagnosis of onychomycosis, caused by various fungi, identification was carried out through macroscopic observation and the application of various microscopic techniques and stains. The script was available on the Virtual Campus of the subject two weeks before the start of the practices, allowing students to access and prepare adequately for the laboratory practices.

The in-person practices consisted of a brief theoretical introduction of the laboratory practice script by the professor, through which the students were instructed in the two priority areas of the diagnosis of podiatric infections. Next, the students proceeded to perform the different tests that allowed them to identify the microorganisms and know their sensitivity, in order to establish an appropriate treatment. The practices lasted 6 hours spread evenly over 3 consecutive days.

2.2. *Virtual internship group.*

An adjustment to the original script designed for in-person practices was carried out with the aim of adapting it to a virtual format. This process involved the necessary modifications to ensure that the content, instructions and practical elements were effective and applicable in an online environment. For this purpose, images and practical examples were incorporated that illustrated microbiological diagnostic tests and sensitivity tests. In addition, a detailed theoretical procedure was provided, accompanied by a concise explanation of the results of each diagnostic test. As for the in-person practices, the practice script was uploaded to the Virtual Campus so that it could be consulted by the students 2 weeks in advance of carrying out said practices.

The practices were uploaded to the Virtual Campus and also consisted of carrying out the diagnosis and treatment of each clinical case. It began with a short introductory text that addressed the problem and images of the results obtained for each of the different diagnostic and sensitivity tests proposed were provided, so that the students could solve each of these clinical cases.

2.3. *Questionnaire to solve the clinical-practical case.*

The students had to complete a 10-question questionnaire uploaded to the Virtual Campus. A part of the questions was directed at the resolution of the two proposed clinical cases. Another part, to answer general questions about the diagnosis of the two priority areas of diagnosis of podiatric infections that the student must assimilate. The students had 2 weeks to resolve the clinical cases.

2.4. *Satisfaction questionnaire.*

The students had to rate the activity with a Likert-type scale 1 (I didn't like it at all) - 5 (I liked it a lot).

2.5. Final knowledge questionnaire (Post Questionnaire).

Voluntarily, the students, once they finished the practical period, whether in person or virtual format, had to respond again to the knowledge questionnaire posed at the beginning of the academic year.

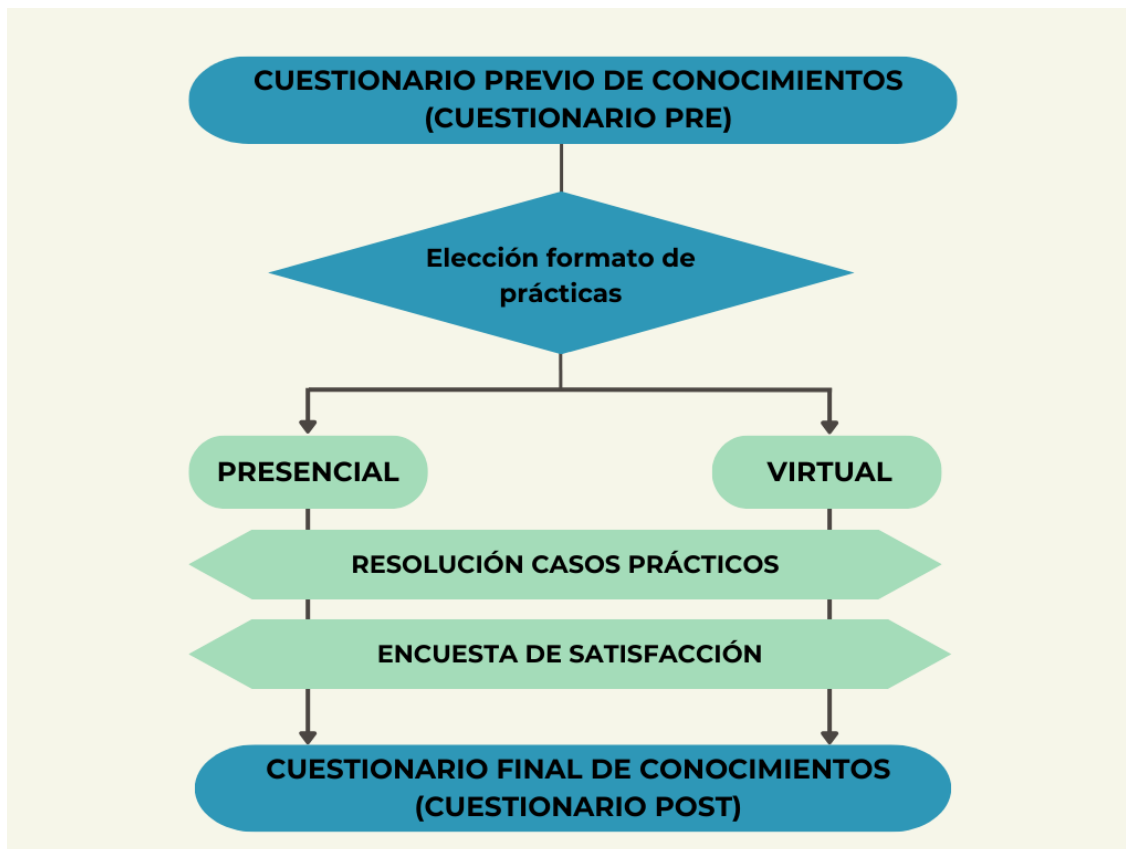


Figure 1. Diagram of the activities carried out by the students.

After obtaining informed consent from the students, in relation to the Teaching Innovation Project of the Complutense University of Madrid of the 2020/2021 call No. 177: Preparation of virtual teaching material for the practices of the subject of Microbiology of the Degree in Podiatry, the evaluation of the impact and quality of the practices was carried out by studying the three educational parameters: commitment, performance and satisfaction. Commitment was assessed taking into account the completion of the different pre and post questionnaires and the clinical case. Performance was evaluated by comparing the results of the previous knowledge questionnaires with the results of the questionnaires after completing the practices and the grade obtained in the clinical cases. To measure satisfaction, a survey was conducted in which students expressed their opinion. The informed consent and questionnaires were completed using Google Forms in an identified manner. The data were analyzed using the GraphPad Prism 8 program. The statistical test used was the unpaired T test with Welch correction except for the comparison of participation between groups, in which the χ^2 test was used.

3. Results

Commitment

Of the 71 students enrolled in the Microbiology subject of the Podiatry Degree, 52 (73.2%) chose the face-to-face format and 19 (26.8%) chose the virtual format, although not

all of them completed the pre-knowledge surveys. and post nor the clinical cases (figure 2). In the face-to-face group, 39 students (75.0%) completed all the proposed questionnaires, while in the virtual group there were 8 (42.1%). Significant differences in participation were detected between groups both in the choice of format ($p < 0.0001$) and in the completion of the questionnaires ($p < 0.0095$).

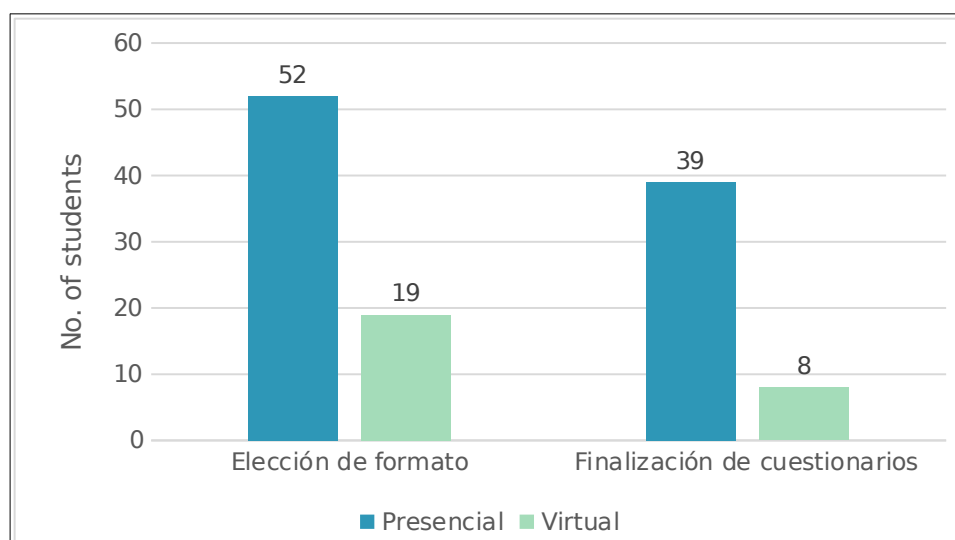


Figure 2. Number of students who chose each format and completed the total number of questionnaires for each of the groups: in-person and virtual.

Performance

With respect to the pre and post questionnaires, as seen in Figure 3, the practices, in any of the formats used, improved the students' performance, observing a significant increase of 2.0 points (face-to-face) and 1.9 (virtual) in the grade obtained in the questionnaires ($p < 0.0001$ in both formats). No significant differences were observed between both formats (in-person and virtual) in the grade obtained before or after carrying out the practices ($p = 0.2964$ and $p = 0.2377$, respectively).

The students in the face-to-face practice group obtained an average score of 6.4 out of 10 points on the clinical-practical case questionnaire, while those in the virtual practice group obtained an average score of 8.0 out of 10 points. Significant differences were found between both groups ($p = 0.0199$).

Satisfaction

The degree of satisfaction with the practices was high, as an average value of 4.1 out of 5 was obtained for the students who completed the practices in face-to-face format and an average value of 4.0 for those in the virtual format. No significant differences were seen between formats ($p = 0.7514$).

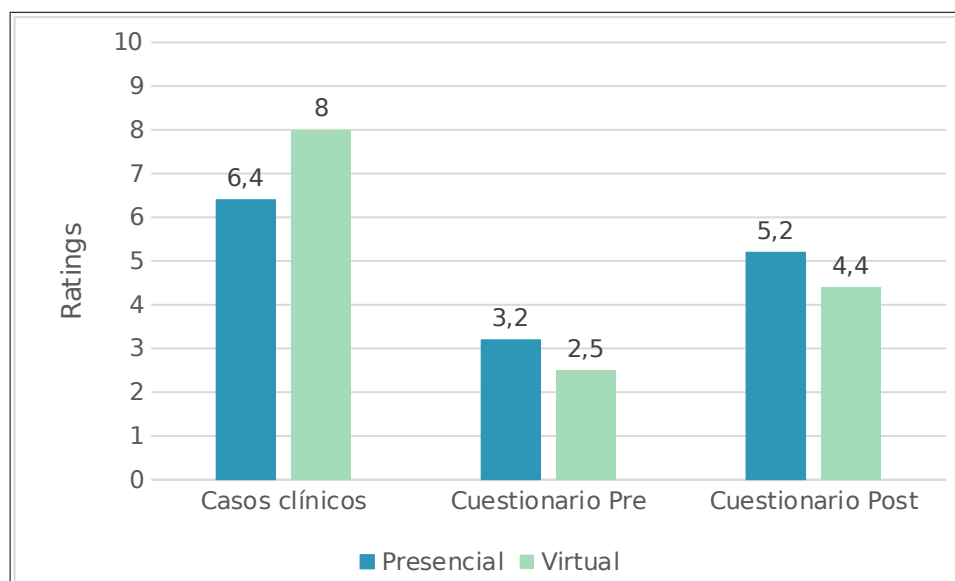


Figure 3. Average grade obtained for the clinical cases and the pre (prior to the practices) and post (after the practices) questionnaires for the students of the in-person and virtual format.

4. Discussion

Over the last two decades, it has been observed that university Microbiology laboratories are reducing their instruction hours or even being eliminated due to limited resources, time or space, and general curricular changes (12-13). In response to these limitations, conducting practicals in a virtual format in the Microbiology laboratory has gained popularity as an alternative to in-person practices, especially in contexts where accessibility or resource limitations can be a challenge. (7, 8, 14). Additionally, the Covid-19 pandemic has acted as a catalyst, accelerating the transition to virtual practices, and accentuating the usefulness of these practices by providing an effective and flexible alternative that addresses the limitations associated with in-person practices (15). In previous studies developed by this group, it has been shown that the flexibility of learning trajectories through virtual activities improves the interest and learning of students in the study of Microbiology (16-17). With the aim of incorporating a virtual approach in the development of laboratory practices, the present study evaluates and compares the impact of Microbiology practices in the Podiatry Degree in face-to-face and virtual format, through the analysis of three educational parameters: commitment, performance and satisfaction.

Commitment

Although virtual internships may offer certain advantages for students such as accessibility, comfort, or allowing a personalized pace of study, several recent research indicates that in-person internships continue to be the preferred method for students for practical learning. Microbiology (7-8, 14). In our case, of the 71 students enrolled in this subject, the majority chose in-person attendance (73.2%). Likewise, the students who carried out the practices in face-to-face format were more participatory in completing the questionnaires than the students who carried out the practices in virtual format, with significant differences being seen between both groups for the completion of the questionnaires. This difference suggests that the students who participated in the in-person practices had a greater willingness and commitment to complete the different activities. It has been pointed out that the lack of direct interaction with the instructor and classmates in virtual environments can affect the motivation and commitment of students (8, 18) and that

Microbiology practices in face-to-face format offer greater internal motivation due to immediate feedback (14).

Performance

Both the in-person and virtual formats lead to a significant improvement of 1.9-2 points in the questionnaire scores after completing the practices. This suggests that both formats can be effective in improving student performance, which is consistent with previous research that compared the effects of virtual and in-person education and found similar results in academic performance (19-21).

However, in the literature there is disparity regarding the results obtained in benefit of either of the two formats. In this way, some studies reveal that the performance of students in the distance modality can be significantly lower than that of participants in the conventional modality (22) and vice versa (23-24). Both the design of the material and the evaluation instruments used and the skills assessed could influence the variability of the results.

However, although there is an improvement in the grade, the grades obtained in the post questionnaires are 4.4 and 5.2 out of 10. It has been observed that the application of grades that affect the weighted grade encourages participation and improvement student performance (25-26), so the voluntariness of the activity can lead to less effort on the part of the students. In one study, despite the voluntary nature of the Microbiology laboratory sessions, it was observed that the results in the laboratory-related exams obtained higher scores than those who did not perform the practices. (27).

On the other hand, the students in the virtual practice group obtained a higher grade than those in the face-to-face group (8.0 vs. 6.4 out of 10 points, respectively), with significant differences noted. It is interesting to note that the virtual format could have certain advantages in the acquisition of knowledge in specific contexts. Accordingly, it has been shown that using a computer simulation to perform bacterial identification led to a deeper understanding of the material (28), or that interactive case-based sessions improve student performance in this aspect (29). Similarly, it has been suggested that virtual education may facilitate a greater degree of self-direction on the part of students, which in turn may lead to better understanding and retention of information (19).

Despite the obvious advantages that practices in virtual format can offer, it is important to consider that with this type of practices it is not possible to acquire the different manipulative skills that are acquired in the laboratory, such as carrying out staining techniques, seeding in media. cultivation or use of microscope. However, the virtual format completely meets its objective when the purpose is to understand the process, as well as the interpretation and analysis of the results (30).

Satisfaction

The results obtained show that the students who participated in the practices, whether in person or virtual format, presented a high level of satisfaction with the activity carried out, with scores of 4.1 and 4.0 out of 5, respectively. These findings are consistent with previous research that has highlighted student satisfaction with virtual practices in Microbiology through the use of various formats to carry them out. (23, 30). This can be attributed to several factors: The flexibility and convenience provided by the virtual format may allow students to participate in internships more conveniently, adapting to their own circumstances and schedules. Additionally, the ability to access additional resources and materials online and the opportunity to review and repeat hands-on activities can contribute

to a satisfying learning experience (21). When the evaluation of an interactive session based on cases has been carried out, it has been observed that students consider these tools useful and serve to review (29).

At the same time, student satisfaction can be influenced by several individual and situational factors, such as prior expectations, level of motivation, and the teaching style used (31).

Limitations of the study

The present study presents several limitations in terms of the number of students and the area to which it is limited, since the sample used is restricted to Podiatry students during the 2020/2021 academic year. Since it was a voluntary activity, the response rate was low. It would be interesting to expand the number of students and implement this project also in other Degrees taught by this Department: Medicine and Human Nutrition and Dietetics. In future research, it would be relevant to increase the number of items in the questionnaires and explore in greater detail the specific reasons that contribute to students' high satisfaction with these practices.

5. Conclusions

- Despite the advantages of virtual internships, interest, level of participation, and commitment were significantly higher in the in-person format.
- Performance was similar in both formats, but students who completed virtual practices obtained a significantly higher score in the clinical-practical cases.
- Students showed a high level of satisfaction with both practice formats.
- Virtual practices are an appropriate alternative to face-to-face practices in teaching Microbiology.

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