Impact of Information and Communication Technologies on histology teaching: an integrative literature review

Impacto das Tecnologias da Informação e Comunicação no ensino de histologia: uma revisão integrativa da literatura

Impacto de las Tecnologías de la Información y la Comunicación en la enseñanza de la histología: una revisión integrativa de la literatura

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Abstract
The aim was to identify the impact of the use of Information and Communication Technologies (ICTs) in the teaching of histology. This is an integrative literature review, qualitative and descriptive. We performed the search on October 2021, using the Virtual Health Library (VHL), Cumulative Index to Nursing and Allied Health Literature (CINAHL), Pubmed, and Science Direct as electronic databases. As a search strategy, the following descriptors in English and Portuguese were used: ("Information technology" AND "Histology"); ("Information technology" AND "Histology" AND "teaching"); ("Information and communication technology" AND "histology"). Original articles that answered the guiding question, in Spanish, English, and Portuguese, published between 2016 and 2021, were included. Four thousand one hundred and fifty-seven (4,157) articles were retrieved, and only seven were selected as eligible for the research. The ICTs present in the sample were Virtual Learning Environments (VLE), with Blackboard and Moodle platforms; Virtual Microscopy; and Digital Games, through the virtual game Kahoot!. The analysis of the data got shows that the impact of ICTs is positive and relevant for academic development, as they enable an interactive environment, capable of being accessed frequently and from different places, besides reinforcing the learning developed in a face-to-face environment. However, instability in the operating system, problems related to connectivity, or even the lack of access of some students to the internet network were perceived as challenges in using ICTs.
Keywords: Education; Histology; Information technology; Learning; Teaching.

Resumo
Objetivou-se identificar o impacto da utilização das Tecnologias da Informação e Comunicação (TICs) no ensino de histologia. Esta é uma revisão integrativa da literatura, de natureza qualitativa e descritiva. A busca foi realizada em outubro de 2021, utilizando a Biblioteca Virtual em Saúde (BVS), Cumulative Index to Nursingand Allied Health Literature (CINAHL), Pubmed e Science Direct, como bancos de dados eletrônicos. Como estratégia de busca foram empregados os seguintes descritores em inglês e português: ("Tecnologia da Informação" AND "Histologia"); ("Tecnologia da Informação" AND "Histologia" AND "ensino"); ("Tecnologia da Informação e comunicação" AND "histologia"). Incluiu-se artigos originais que respondiam à pergunta norteadora, nos idiomas espanhol, inglês e português, publicados no período de 2016 a 2021. Foram recuperados 4.157 artigos, dentre os quais apenas sete foram selecionados como elegíveis para a pesquisa. As TICs presentes na amostra foram: Ambientes Virtuais de Aprendizagem (AVA), com as plataformas Blackboard e Moodle; a Microscopia Virtual; e Jogos Digitais, mediante o jogo virtual Kahoot!. As análises dos dados obtidos demonstram que o impacto das TICs é positivo e relevante para o desenvolvimento acadêmico, pois possibilitam um ambiente interativo capaz de ser acessado em diversas ocasiões e de diferentes lugares, além de reforçar o aprendizado desenvolvido em ambiente presencial. Todavia, instabilidade no

sistema operacional, problemas relativos à conectividade ou mesmo a falta de acesso de alguns alunos à rede de internet foram percebidos como desafios no uso das TICs.

Palavras-chave: Aprendizagem; Educação; Ensino; Histologia; Tecnologia da informação.

Resumen

El objetivo fue identificar el impacto del uso de las Tecnologías de la Información y la Comunicación (TIC's) en la enseñanza de la histología. Se trata de una revisión bibliográfica integradora, cualitativa y descriptiva. La búsqueda se realizó en octubre de 2021, utilizando como bases de datos electrónicas la Biblioteca Virtual en Salud (BVS), Cumulative Index to Nursing and Allied Health Literature (CINAHL), Pubmed y Science Direct. Como estrategia de búsqueda, se utilizaron los siguientes descriptores en inglés y portugués: ("Tecnología de la información" AND "Histología"); ("Tecnología de la información" AND "Histología" AND "enseñanza"); ("Tecnologías de la información y la comunicación" AND "histología"). Se incluyeron artículos originales que respondieron a la pregunta guía, en español, inglés y portugués, publicados entre 2016 y 2021. Se recuperaron un total de 4.157 artículos, de los cuales solo siete fueron seleccionados como elegibles para la investigación. Las TIC presentes en la muestra fueron: Entornos Virtuales de Aprendizaje (EVA), con plataformas Blackboard y Moodle; Microscopía Virtual; y Juegos Digitales, a través del juego virtual Kahoot!. El análisis de los datos obtenidos demuestra que el impacto de las TIC es positivo y relevante para el desarrollo académico, ya que posibilitan un entorno interactivo al que se puede acceder en varias ocasiones y desde diferentes lugares, además de reforzar el aprendizaje desarrollado en forma presencial. - entorno facial. Sin embargo, la inestabilidad en el sistema operativo, los problemas relacionados con la conectividad o incluso la falta de acceso de algunos estudiantes a la red de internet fueron percibidos como desafíos en el uso de las TICs.

Palabras clave: Aprendiendo; Educación; Enseñando; Histología; Tecnología de la informacion.

1. Introduction

The term "Information and Communication Technologies" (ICTs) refers to the use of technological resources that assist communicability, reception, and transfer of knowledge in modernity. ICTs emerged between the 70s and 90s, in the scenario of industrial revolutions, and permeate to the present day innovating in the fields of work, helping and modernizing communication dynamics (Pereira & Silva, 2020). We can also observe this revolution in education and when properly applied, methodologies that use ICTs can help in the teaching and learning process, resulting in the development of many skills by students (Gesser, 2012; Lobo & Maia, 2015).

Subject studies show that these technologies are used in the educational field, and improve student performance, making the process more dynamic, interactive, and playful (Nóbrega et al., 2014). Cheng et al. (2016) suggest, using the flipped classroom method, that the use of ICTs is important in providing opportunities for students to study the materials before class, encouraging them to prepare in advance for the content.

When dealing with the teaching of histology, defined as the science that studies tissues and how they are disposed to compose organs and provide the functionality to them, the use of virtual microscopy, virtual learning environments, gamification, among other technological resources, have made been effective supplements when applied. As it is a morphological science, understanding histology requires skills such as identification, interpretation of two-dimensional structures and their three-dimensional understanding, as well as memorization of what has been studied (Q. P. Silva et al., 2020, Wanderer et al., 2020). Using ICTs improves the way students study, both for the media resources, with good quality images, and for the ease of access to this content repeatedly, a reason that promotes the optimization of time.

Bastos et al. (2020) exemplify the use of ICTs in the teaching of histology by describing the steps for the development of a didactic game, such as a quiz, in order to improve the knowledge of the histology discipline. The authors expose ICTs to facilitate the understanding of content while motivating students to provide material that can be accessed continuously, practically.

Another crucial innovation for the insertion of ICTs in the teaching of histology was the dissemination of virtual microscopy and online digital atlases, as they allow more time for viewing and studying the slides, aiding in understanding and memorizing them. The study of this discipline directly depends on the students' familiarity with histological slides (Rheingantz

et al., 2019). In this sense, a survey carried out by the aforementioned work reiterates the statement when evaluating a digital atlas developed by professors at the Federal University of Pelotas in 2003. Among the students' responses, 92.3% confirmed that the use of this technological resource facilitated the understanding of the discipline, corroborating the widespread use and importance of virtual microscopy today.

There is only one narrative review article in the literature that deals with the use of ICTs in the teaching of histology (Q. P. Silva et al., 2020), this one deals with the main digital tools and discusses their importance as a complement to face-to-face practical activities, not addressing what impact the use of these tools can have on teaching. In this perspective, the aim of this study was to identify the impact of the use of information and Communication Technologies in the teaching of histology.

2. Methodology

This is an integrative literature review, with a qualitative and descriptive approach, based on the six steps described by Mendes et al. (2008): (a) identification of the theme and selection of the hypothesis or research question; (b) establishment of criteria for inclusion and exclusion of studies/sampling or literature search; (c) definition of the information to be extracted from the selected studies/categorization of the studies; (d) evaluation of studies included in the integrative review; (e) interpretation of results; (f) and synthesis of knowledge. For the development of this review, the following guiding question was first elaborated: What is the impact of the use of Information and Communication Technologies in the teaching of histology?

The following electronic databases were used: Virtual Health Library (VHL), Cumulative Index to Nursing and Allied Health Literature (CINAHL), PubMed, and Science Direct. The search was carried out on October 2021 and the adopted descriptors, and their combinations in English and Portuguese, were taken from the Health Sciences Descriptor Bank (DeCS), separated by the Boolean operator "AND", being observed in table 1.

Table 1. Electronic database and search strategies.

DATABASE	SEARCH STRATEGY
VHL / CINAHL / PUBMED / SCIENCE DIRECT	"Information technology" AND "Histology" "Information technology" AND "Histology" AND "teaching" "Information and communication technology" AND "histology"

Source: Elaborated by the authors (2022).

This integrative review included original articles from research with primary data that associated the use of Information and Communication Technologies (ICTs) with the teaching of histology, in Portuguese, English, and Spanish, published from 2016 to 2021, and those that answered the research question. Duplicate articles, review articles, monographs, dissertations, book chapters, and studies carried out outside the higher education environment were excluded. Subsequently, all documents found were independently evaluated by two reviewers, who read the titles and abstracts.

Articles with satisfactory information in the abstract were chosen to a full reading. After selection by title and abstract, and exclusion of articles that did not fit the pre-established criteria, the reviewers independently evaluated the articles in full and made their respective selections, in case of divergence, consensus remedied the selection or exclusion.

A standardized form was used for data extraction (Ursi & Galvão, 2006), in which the following data were recorded: author, year, aim, main results, educational technologies used, and conclusions. In addition, the studies were categorized based on the technologies used in Virtual Microscopy, Virtual Learning Environment and digital games. From the information got from the data collection instrument, the analysis was carried out in a descriptive and qualitative way, in order to encompass the results on ICTs in the teaching of histology.

3. Results

The results of this integrative review are a consequence of the identification of 4,157 published works, of which 1,060 reports were excluded by reading the titles and abstracts, leaving 3,097 articles for eligibility. Among these, 3,090 were eliminated for not meeting the inclusion criteria, leaving only seven articles to compose the sample, which answered the guiding question. In Figure 1 and Table 2, there is, respectively, the representation of the selection process of the studies through a flowchart adapted from the Prisma 2009 FlowDiagram (Moher et al., 2009) and the research sample.

Figure 1. Integrative Review Flowchart.
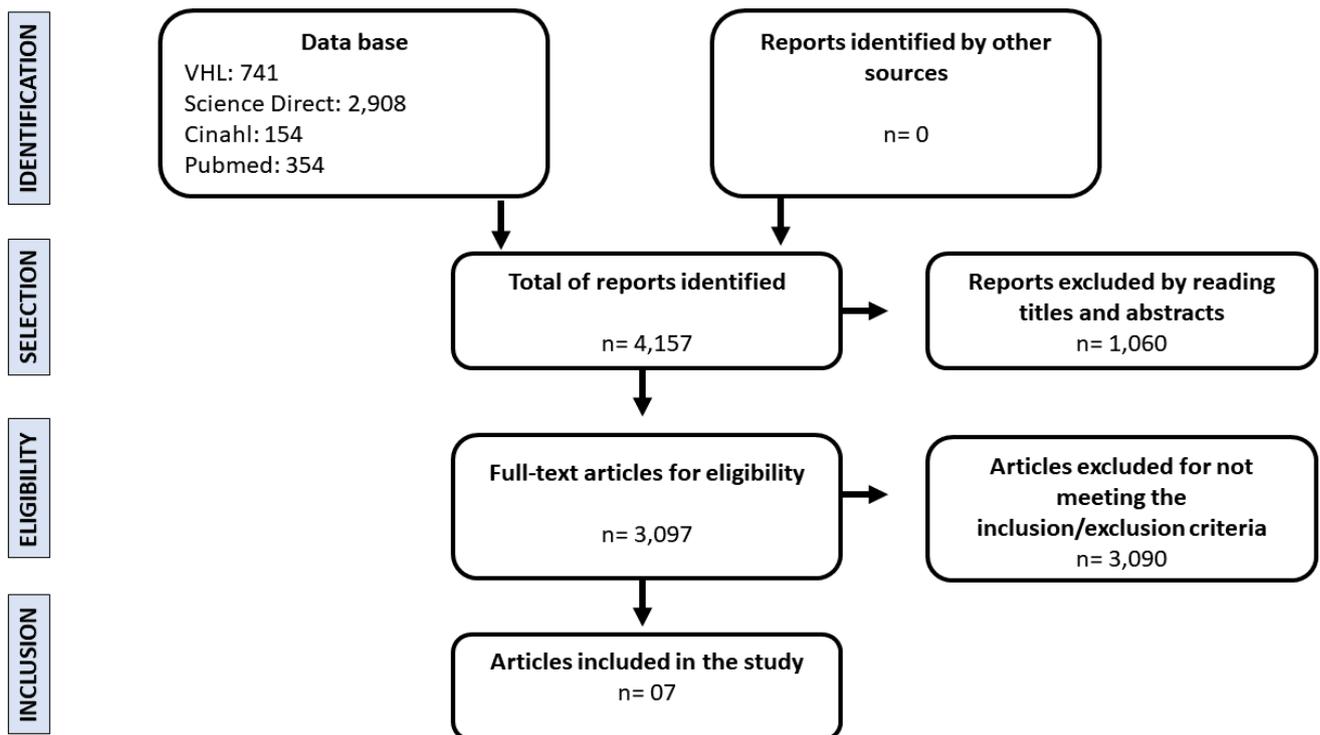
Source: Elaborated by the authors, adapted from Prisma 2009 FlowDiagram

Table 2. Articles selected for the literature review.

Author/Year	Objective	Main results	Educational Technologies	Conclusions
Alotaibi & Al Qahtani, 2016	Assess students' perceptions of the use of virtual microscopy.	85.1% of students prefer a virtual microscope (VM) to a light microscope (LM).	Virtual Microscopy	Exams and assessment research show that using MV can improve learning performance and efficiency.
Cheng et al. 2016	Assess the effectiveness of the flipped classroom to improve student learning outcomes.	There were two study groups, the control (traditional teaching) and the group that used the inverted classroom. The group where the inverted classroom was applied performed better than the control group.	Virtual Learning Environment (Blackboard)	Using the flipped classroom can improve the teaching of histology and the student's performance, since, according to them, the flipped classroom encourages them to study more.
Godoy-Guzman et al. 2019	Generate a Moodle class on anatomy and histology of the human placenta as a complement to the traditional theoretical class.	80% of students claim a greater understanding of theoretical classes; 63.97% show that it is a good didactic complement; 50% claim better learning outcomes.	Virtual Learning Environment (Moodle)	Using Moodle had several benefits in the learning and positive evaluation of the students as a complementary class.
Darici et al. 2021	Implementation of a histology course in an online format based on videoconferencing software.	There were no significant differences in the exam results of second and third-semester students. The evaluation of the digital histology course was positive.	Virtual Microscopy	Implementing an online histology course is workable and effective for teaching histology during the covid-19 pandemic, as well as being well accepted by students.
Rojas-Mancilla et al. 2019	Assess the impact of smartphone use for a histology class using retrieval practices, supported by the Kahoot!!	97% reported that the game is important for learning and 100% recommend its replication in classes and say the method is "fun, interesting and attractive".	Digital games (Kahoot!)	The quick feedback provided by Kahoot! together with the stimulus to dynamism in the classroom, can enhance the teaching of contents.
García-Iglesias et al. 2018	To evaluate the effectiveness of mixed-method academic tutoring in two basic subjects in Veterinary Science studies at the University of León (Spain).	There was an increase in scores in the cytology and histology tutored groups (first exam, $p = 0.009$; final exam, $p = 0.023$) and an increase in participation in the final exam in the tutored groups (87.3% versus 77.2%).	Virtual Learning Environment (Online tutoring/Moodle)	The online tutorial, together with traditional methods, is a favorable method for developing a student-centered learning method for veterinary science content.
Santos et al. 2021	To verify the student's perception and academic performance on implementing virtual microscopy (VM) in a Brazilian Medical School.	Virtual microscopy (median = 29) had a higher score (better handling, adequacy, learning effectiveness) when compared to optical microscopy.	Virtual Microscopy	Virtual microscopy proved to be effective and consistent with the social realities of Brazil, and also during the COVID-19 pandemic.

Source: Elaborated by the authors (2022)

In the seven selected articles one can observe the use of digital technologies, such as virtual microscopy, online tutoring, classroom platforms, and interactive games. The undergraduate courses of the students who took part in the research were: Medicine, Dentistry, Veterinary Medicine, Obstetrics, Kinesiology, and Medical Technology. In addition, regarding the countries in which the studies were carried out, Chile, with two publications, and Saudi Arabia, China, Brazil, Spain, and Germany, with one publication each. Of the articles that make up the sample, 85.71% are in English and 14.28% in Spanish. PubMed and VHL were the databases with the highest number of articles included, with three articles for each, followed by Science Direct, with only one result inserted.

The results identify students' well-tolerated ICTs, constituting an important tool for enhancing the teaching and learning process. The analysis of the samples allows us to verify the positive impact on teaching when using digital media,

being evaluated with good reception and perception by the students. These technologies are extensions of reality to the virtual world through the use of virtual microscopy and classroom platforms, with good acceptance of the use of these environments being observed. In addition, active learning methods were perceived through gamification, in which Kahoot! and BlackBoard enhanced the memorization of contents. It is necessary to emphasize the great potential that information and Communication Technologies exert by complementing traditional teaching, filling gaps, and reinforcing concepts worked in face-to-face classes, serving as an environment to answer any doubts.

As reported by Santos et al. (2021), over 95% of the students in the study pointed out that virtual microscopy is important or very important for learning, although approximately 61% of the students revealed the ability to know how to handle the optical microscope as necessary.

In addition, among the seven articles selected, two of them (Darici et al., 2021; Santos et al., 2021) referred to the use of ICTs in the academic environment during the health emergency resulting from the COVID-19 pandemic, to continue the university activities during the restrictions adopted in the fight against SARS-Cov-2. According to Darici et al. (2021), the histology course mediated by such technologies showed similarities with the teaching of this discipline in face-to-face format. Thus, the use of virtual microscopy and recorded classes can, for example, meet the needs of students at a totally atypical moment, as experienced during the pandemic caused by COVID-19.

4. Discussion

The analysis of the data got shows that the impact of Information and Communication Technologies (ICTs) is positive and relevant for the academic development of students since they enable an interactive environment, capable of being accessed on different occasions and from different places, besides reinforcing the learning developed in a face-to-face environment (Caliari et al., 2017; Silva et al., 2021). In addition, we can observe in this study the use of several ICTs in the teaching of histology: Virtual Microscopy (VM), digital games, and Virtual Learning Environments (AVA). Thus, under Caliari et al. (2017), the use of information technologies enabled a participatory and innovative environment, capable of expanding the strategies of competitiveness among students and complementing face-to-face teaching, thus becoming an excellent tool for the teaching of histology.

However, difficulties in accessing digital platforms were reported in the studies evaluated, such as instability in the operating system, problems related to connectivity, or even the lack of access of some students to the internet network, being perceived as challenges in using ICTs. From this perspective, the educational environment must have as one of its characteristics, whether with digital resources, flexibility, identifying and valuing the differences between students in order to achieve an inclusive space, considering social class, ethnicity, and students' cultural practices (Melo et al., 2005).

The advancement of educational processes is directly linked to the evolution of the means of communication, which follows technological innovations, enabling innovative strategies in teaching and learning; however, they have as an obstacle the difficulty in using such technologies, whether related to the technical particularities of digital media or how they should be used, considering the pedagogical aspects that permeate them (Quartiero, 1999). In this way, a greater use of virtual platforms in disciplines that until then had a purely traditional approach, such as histology, with students in person in the classroom, restricted the use of laboratories at pre-established times.

Using ICTs as a complement to face-to-face teaching has been predominantly observed in subjects in basic areas of health courses, such as histology (Júnior & Silva, 2014). The observation of histological slides through computers and mobile devices facilitated the access of many undergraduate students. In this sense, students can find high-quality images in the digital environment and the didactic support necessary to merge the contents taught (Paulsen et al., 2010).

The traditional way of working with the histology discipline in most universities requires a classroom and/or a

laboratory equipped with optical microscopes, which requires skill and familiarity in handling the device to develop practical activities effectively; other important points that permeate this traditional model are blade replacements, besides the maintenance and replacement of equipment, making it financially costly for institutions (Calado, 2019; Chimmalgi, 2018).

Virtual microscopy emerges as an efficient method in order to allow students to observe the slides in high-definition images of any extracurricular environment, as many times as they want, and with all the pedagogical devices that can be linked to the dynamics of VM. It is inferred, therefore, that the findings in this study regarding the greater preference of students for VM instead of conventional optical microscopy, including the report of better grades and academic performance of students inserted in ICTs, is consistent with the findings of other similar works that evaluated virtual microscopy (Alotaibi & Alqahtani, 2016; Chang et al., 2021; Chimmalgi, 2018).

Another ICT widely used and observed in this study is the use of Virtual Learning Environments (VLE), which through software offer a dynamic and attractive space, conducive to digital teaching. For Mozzaquatro and Medina (2008), VLEs can help in systems that work as distance education or serve as a complement to face-to-face teaching, integrating content in an organized and participatory way, in which students are inserted in an environment in which can interact efficiently and stimulatingly.

As pointed out by Paiva (2010), the internet made possible the emergence of several technologies aimed at education, among them, the VLE, providing a favorable space for the participation of those involved, aimed at an environment in which learning takes place collaboratively among students, sharing experiences and integrating knowledge differently. Still, the author points to the different ways in which these environments can present themselves, with the presence of tools that allow the realization of asynchronous and synchronous communication, opinion resources, such as polls, besides mechanisms for evaluation, administration, and collective constructions, for example. However, although virtual learning environments can stimulate active learning and develop the skills to achieve the teaching objectives that have been outlined, students who make use of this ICT need to have motivation, interest, and individual effort so that they achieve positive results (Bezerra et al., 2020).

In the present study, platforms that refer to virtual learning environments, including BlackBoard and Moodle, can be observed. Both platforms were means by which students could interact and carry out the proposed activities with the teaching of histology.

Moodle is a software that works on operating systems compatible with its specificities, allowing the provision of courses and the management of research and events. It is a program capable of creating a receptive virtual environment for learning, with support for hosting profiles, avatars, creating groups and questionnaires, besides managing the content to be worked on. It can also serve as a student notebook, as grades can be assigned and tests can be administered (Paiva, 2010). Similar to Moodle, BlackBoard has several functionalities, including being able to host courses and serve as a teaching manager, besides having the possibility of the teacher taking live classes, allowing greater interaction between students and teachers (Meléndez & Rojas, 2021).

The BlackBoard was used as an adjuvant in the teaching of histology in a group that adopted the inverted classroom method, in which it was found that the students included in this study felt encouraged to study more, which is consistent with the proposal by which the students virtual learning environments promote, with the more active participation of the student, not just being a mere spectator (Cheng et al., 2016). Moodle was observed in two studies, one of them referring to a class on anatomy and histology of the human placenta in a complementary way to traditional and theoretical classes, getting positive evaluations from students, with learning results presented as positives; and the other study with the platform inserted in the support of online tutoring in cytology and histology subjects, in which it is postulated as an effective method in learning with the student at the center of the teaching process (García-Iglesias et al., 2018; Godoy-Guzmán et al., 2019).

The teaching of histology applied to such platforms that expand the possibilities of communication between students is fundamental, as it allows teachers greater freedom to work with the content exposed in the laboratories in a complementary way and students reinforce and work on the information got in the classroom and from the visualization of the histological slides made by optical microscopy. Therefore, the use of the BlackBoard and Moodle platforms reported in these studies is in line with the aforementioned proposals regarding virtual learning environments, in which interaction and communication between students are enhanced, once they go from mere spectators and information receivers to protagonists, allowing better assimilation of content, especially when platforms complement traditional teaching.

Active methodologies, in the educational scenario, have acted to mitigate the problems encountered in the teaching and learning process, as they can lead the student to exercise a reflective practice, which can be presented to students highlighting, among them, games, by proposing recreational activities to students to get better results, and can serve as didactic and pedagogical support for teachers in teaching content (Alves & Maciel, 2014; Moraes & Vanzella, 2018).

Maranhão (2019), by implementing the use of games in the classroom through Kahoot!, in the discipline of bioethics, applied questionnaires in the format of multiple-choice "quizzes" at the end of the content given in the classroom, in order to evaluate the performance and learning of students in a fun and fast way, getting a positive response from the students, with active participation while providing a competitive environment. Similar to what was observed in this study, in which the same platform was applied to histology classes, it was noticed that this method allowed quick feedback on the topics exposed by the educators. Corresponding to this analysis, Monteiro et al. (2020), in a similar study, also used Kahoot! to evaluate the performance of students in the discipline of human histology, also noting that students could reflect on the questions they got right and wrong, since there was immediate feedback.

5. Conclusion

It was observed in this study that the use of ICTs had a positive impact on the teaching of histology, with great approval from the students. Therefore, the inherent benefits of ICTs, when well applied and developed, can be highlighted, such as allowing students to use digital media to strengthen learning and not be limited to the physical spaces of laboratories and traditional optical microscopy, which require equipment. of good quality and skill in handling the microscopes.

Another important point is student interaction, made possible by virtual environments, which encourage students to take part in the teaching and learning process, reaching a leading role in education and abandoning the passive state in front of the contents worked.

We concluded the ICTs can improve the teaching of histology, allowing teachers and students to adapt the educational process to the different realities that may exist in educational institutions, respecting the heterogeneity of students. In this way, information and communication technologies can be allied in the teaching of various subjects, as they allow access to education from anywhere, making use of methodologies capable of encouraging students to fix and review the contents worked within the classroom, besides encouraging interaction and competition in a playful and promising way for those involved in this teaching-learning process, which can serve as a unique platform or, as most observed in published works, as a complement to the traditional model of education systems, simply by only have access to the internet network and electronic equipment compatible with the technologies adopted.

The limitation of this study is the fact that most of the articles included are observational studies that evaluated the use of ICTs through the application of questionnaires, not being reassessed at another time or evaluated using interventionist studies, which implies limitations methodological. In addition, the sample used in the studies was small to extrapolate the results to other educational contexts.

The synthesis of knowledge, got through this integrative literature review, shows the need to carry out new studies in

several educational contexts, in order to reflect different realities, to evaluate the use of ICTs that motivate and positively impact students during the teaching and learning process in the Histology discipline.

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