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Validation of a virtual atlas for the teaching and learning of histology: a methodological study

Validação de um atlas virtual para ensino e aprendizagem de histologia: um estudo metodológico

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ABSTRACT

Introduction: The use of innovative technologies can enhance and promote a methodological update in the teaching of Histology in undergraduate courses in the health area, including Medicine, Dentistry, Pharmacy, Nursing and Veterinary Medicine. For the adoption of these resources, it is essential to evaluate the reliability of their content and technical feasibility.

Objective: To validate the content and technique of a virtual microscopy atlas for Histology teaching in undergraduate courses in Medicine, Dentistry, Pharmacy, Physiotherapy and Nursing.

Methods: This was a methodological study conducted from June 2021 to April 2022, involving experts from the areas of Morphofunctional Sciences and Information Technologies. Criteria adapted from Fehring were used for the selection of experts, and a detailed questionnaire was utilized in the proposed validation process. The analysis included descriptive statistics, Content Validity Index, and binomial test to determine agreement among the experts.

Results: Twenty-two experts participated, with eleven from the field of Morphofunctional Sciences and eleven from the field of Information Technology. The study results showed Content Validity Indices of 0.85 and Technique indices of 0.91, indicating strong validation of the digital technology studied. The binomial test confirmed high agreement among the judges, with values above 0.80 in various aspects such as content, attractiveness, and ease of access and handling.

Conclusion: This study effectively validated the content and technique of the virtual atlas, confirming that this digital tool is reliable and viable. The validation process facilitates the adoption of this educational technology, promoting more dynamic and interactive learning.

Keywords: Histology; Atlas; Digital technology; Validation study.

RESUMO

Introdução: *A utilização de tecnologias inovadoras pode promover uma atualização metodológica do ensino de histologia em cursos de graduação da área de saúde, como Medicina, Odontologia, Farmácia, Enfermagem e Veterinária. Para adoção desses recursos, é imprescindível avaliar a confiabilidade do seu conteúdo e a viabilidade técnica.*

Objetivo: *Este estudo teve como objetivo validar o conteúdo e a técnica de um atlas de microscopia virtual para ensino de histologia nos cursos de graduação em Medicina, Odontologia, Farmácia, Fisioterapia e Enfermagem.*

Método: *Trata-se de um estudo metodológico, realizado no período de junho de 2021 a abril de 2022, com especialistas nas áreas de ciências morfofuncionais e tecnologia da informação. Foram utilizados critérios adaptados de Fehring para a seleção dos especialistas e um questionário detalhado no processo de validação proposto. A análise incluiu estatística descritiva, Índice de Validade de Conteúdo e teste binomial para determinar a concordância entre os especialistas.*

Resultado: *Vinte e dois especialistas, dos quais 11 eram da área de ciências morfofuncionais e 11 da área de tecnologia da informação, contribuíram para este estudo. Os resultados demonstraram Índices de Validade de Conteúdo de 0,85 e de Técnica de 0,91, indicando uma forte validação da tecnologia digital estudada. O teste binomial confirmou a alta concordância entre os especialistas, com valores superiores a 0,80 em diversos aspectos, como conteúdo, atratividade e facilidade de acesso e manuseio.*

Conclusão: *Este estudo validou efetivamente o conteúdo e a técnica do atlas virtual, confirmando que essa ferramenta digital é confiável e viável. O processo de validação facilita a adoção dessa tecnologia educacional, promovendo uma aprendizagem mais dinâmica e interativa.*

Palavras-chave: *Histologia; Atlas; Tecnologia Digital; Estudos de Validação.*

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INTRODUCTION

Histology – the microscopic study of cells, tissues and organs – is a fundamental subject in foundation health and biological sciences programmes[1]. Its teaching aims to provide essential morphological and physiological knowledge about the body's organs and systems[2]. This content is fundamental and indispensable for understanding other areas of science, such as Physiology, Pathology, Biochemistry and Pharmacology[1,3]. Together with these disciplines, Histology supports the development of clinical reasoning for the diagnosis and treatment of diseases[1,2,4].

Since its establishment as a research area and educational discipline independent of Anatomy, Histology has traditionally been taught using glass slides with tissue samples, visualised under optical microscopes[5,6]. Traditional optical microscopy (OM) is still the primary methodology used to teach and study histology in medicine, dentistry, pharmacy, physiotherapy and nursing courses, especially in less developed countries. Through OM, students can observe the cellular composition and extracellular matrix of tissues and organs, discern subtle variations in tissue characteristics and integrate these observations with the functions of organs and systems[2,7,8].

The introduction of computers, the internet, slide scanning equipment (capable of completely digitising samples on glass slides) and visualisation applications has revolutionised the teaching of histology. These advances have led to the emergence of digital technologies that expand and diversify teaching methods and learning styles[9]. With these digital resources, Histology teaching and learning methodologies have evolved from a traditional method – a lecture followed by practical lab-based activities using printed materials and OM – to a more flexible and collaborative approach. This new perspective facilitates access to content at any time and place[3,10], meeting the expectations of the current generation of students, who value content creation, interactivity and sharing information electronically[1,10].

Among the technological innovations applicable to the teaching of Histology, the virtual atlas stands out. Developed on the basis of computer graphics concepts such as image capture and processing and virtual reality, this IT tool provides three-dimensional objects for studying one or more elements[11]. The use of the virtual atlas allows for a significant reduction in laboratory time and makes it easier to present the same image to a larger group of students. It also contributes to group discussions, which are usually hampered by the isolation typical of using OM[12].

However, despite the importance of digital technologies for teaching and learning histology, academic production in this area is scarce. An integrative literature review performed on five databases found no national articles on the development and validation of digital technologies, including the virtual atlas[13]. This finding highlights a knowledge gap and justifies this study. Furthermore, for an educational technology to be effective, it needs to be validated as a scientific tool[14]. The aim of this study was to validate the content and technique of a virtual atlas for teaching Histology in undergraduate courses in Medicine, Dentistry, Pharmacy, Physiotherapy and Nursing.

METHOD

This quantitative methodological study was conducted between June 2021 and April 2022. It consisted of validating the content and technique of the PUCRS *Atlas de Histologia em Cores* [Color Atlas of Histology], prepared by the authors, involving a systematised assessment approach by experts. The assessor were experts in Morphofunctional Sciences and Information Technology, ensuring a rigorous and multidisciplinary analysis of the teaching material in question.

This technology represents a web-based learning tool developed with the specific purpose of facilitating the study of basic tissues and gametogenesis. The selection of content was strategically based on the topics most frequently covered in the classroom, with the aim of optimising the relevance and applicability of the educational resource in all the undergraduate health courses.

The *Atlas de Histologia em Cores da* PUCRS [PUCRS Color Atlas of Histology] is an educational resource available in digital format (https://editora.pucrs.br/edipucrs/acessolivre/livros/atlas-de-histologia/) and is open access, allowing for unrestricted use by any user. The material can be accessed directly via a browser, without the need for specific software, guaranteeing compatibility with different devices and operating systems. Its structure is interactive and intuitive, facilitating content navigation. The home page presents a list of tissues that allows direct access to the topics covered, organised into sections such as Epithelial Tissue, Connective Tissue, Muscular Tissue, Nervous Tissue and Gametogenesis.

The atlas provides images with histological structures of animal origin highlighted, brief descriptive texts and interactive icons, facilitating the autonomous construction of knowledge according to the Constructivist Theory proposed by Jean Piaget. In this theoretical context, the student assumes the role of constructor of their own knowledge, exercising autonomy in the educational process and interacting with their peers and the virtual environment, contributing to intellectual development[15]. Figure 1 shows an example of a micrograph available in the atlas.

The number of experts needed to validate the atlas was determined using the formula $n = Z\alpha^2.P.(1-P)/d^2$, where

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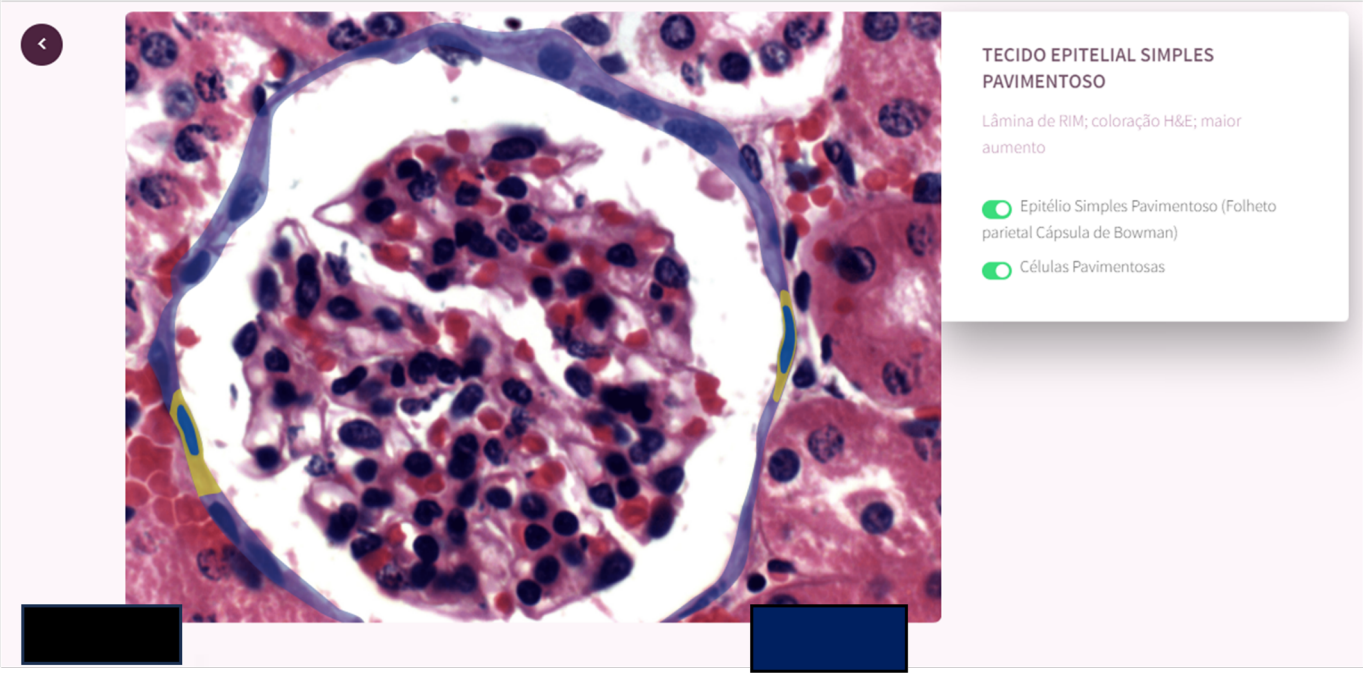
Figure 1. Photomicrograph highlighting simple squamous epithelium. Fortaleza, Ceará, Brazil, 2022.



Source: https://editora.pucrs.br/edipucrs/acessolivre/livros/atlas-de-histologia/tecido-epitelial-simples.html#pavimentoso

Zα corresponds to the confidence level chosen (95%), P is the minimum proportion of individuals who agree with the relevance of the components of the serialised album (85%) and d is the acceptable margin of error (15%)[16]. Based on this calculation ($n=1.96^2.0.85.0.15/0.15^2$), a figure of 21.76 specialists was obtained. This number was rounded up to 22, with 11 experts assigned to content validation and 11 experts to technical validation.

The experts were selected using the Lattes Platform of the National Council for Scientific and Technological Development (CNPq), with search terms such as "Thesis", "Dissertation", "Histology", "Information Technology" and "Virtual Atlas". For the selection and inclusion of experts, a model adapted from Fehring[17], which recommends the following criteria: master's or Ph.D., published work, at least one year's experience or specialisation in the field. The scoring criteria required each expert to achieve a minimum of 3 points, distributed as follows:

4 points for associate professors (with Ph.D.) in the areas of Morphofunctional Sciences/Information Technology, 3 points for assistant professors (with a master's degree) in these areas, 2 points for publications in indexed journals related to the subject of the study and for specialisation in the subject area, and 1 point for an undergraduate degree in the specific areas (Digital Health and Media or Information Technology).

Each expert selected was formally invited by email, including a presentation by the team responsible for the project and detailed instructions for the study. After agreeing to take part, the specialist received a further email with a Google Docs link containing the Informed Consent Form (ICF) and a questionnaire adapted from the study by Pereira et al[18]. The first part of the questionnaire aimed to characterise the experts in social terms (gender and age) and academic/professional terms (undergraduate degree, time since graduation, specialisation, master's degree, Ph.D., current occupation, field of work and experience with the subject), while the second part contained statements referring to the atlas, which was made available via an attached link. It is important to mention that the instructions required for assessing the atlas were also provided to the participants.

Experts in the field of Morphofunctional Sciences evaluated the atlas on criteria such as the objective of the proposal, ease of learning, form of support, content and attractiveness. The assessment was based on a Likert scale, with the following scores: 1 – Strongly disagree, 2 – Disagree, 3 – Neutral, 4 – Agree and 5 – Strongly agree. Likewise, Information Technology experts examined the atlas, applying the same scale, but focussing on ease of access, language, resources used, interface, user friendliness and support. All the experts were given an initial deadline of 30 days to return the evaluation tool, which could be extended for a further 30 days in the event of failure to complete the assessment in time. Experts who failed to respond within 60 days or who sent the questionnaire with incomplete information were excluded from the study.

The data collected was organised using Microsoft Excel for Windows, version 13. The categorical variables were

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descriptively analysed, resulting in absolute and relative frequencies. Numerical variables were analysed using measures of central tendency and dispersion. To validate the data, the Content Validity Index (CVI) was applied, which was calculated in two different ways: the Item-Level Content Validity Index (I-CVI)[19], which assesses the proportion of agreement among the experts in relation to each item, and the Scale-Level Content Validity Index (S-CVI), which is the average of the I-CVIs calculated for all the items.

According to the literature on validation studies involving more than six experts[20], any item with a value of more than 0.78 is considered approved. To assess the proportion of agreement between the experts, the binomial test was used with the software R, version 4.1.2. A proportion of agreement equal to or greater than 0.80 was considered statistically significant, adopting a significance level of 5%[19].

This study received approval from the Research Ethics Committee of the Federal University of Ceará (UFC), registered under CAAE number 40716820.3.1001.5054 and favourable opinion number 4.566.045. All the procedures carried out complied with the ethical principles established by Resolution 466/2012 of the National Health Council.

RESULTS

As regards the profile of the Morphofunctional Sciences experts involved in the study, the majority were women and aged 40 years or less, with an average of 38.5 (±6.74) years. Less than half of the participants had graduated in Biology, with an average time since completion of their undergraduate degree of 14.4 (±7.47) years. In terms of qualifications, some had post-graduate specialisations and most had completed a master's degree or Ph.D. All the experts worked as teachers. In the area of professional activity, some of them taught histology and embryology. With regard to length of experience with the theme of the atlas, more than half had more than 10 years' experience, with an average of 12.8 (±7.94) years (Table 1).

Among the IT experts, a considerable proportion were male. Most of the experts were over 40 years old, with an average age of 42 (±7.31) years. As regards academic background, approximately half had a degree in Computer Science, with an average time since graduation of 20 (±6.03) years. In terms of qualifications, just over half had no specialisation, while a significant proportion had a master's or Ph.D. Professionally, almost all of them worked as teachers in their respective fields. As for experience with digital platforms similar to the one in this study, around 80% had more than 10 years' experience, with an average of 15.7 (±5.71) years (Table 2).

Table 1. Characterisation of experts in the area of Morphofunctional Sciences.

Variables	n	%
Gender		
Female	8	72.72
Male	3	27.27
Age		
≤ 40 years	7	63.63
> 40 years	4	36.36
Undergraduate Course		
Medicine	1	9.09
Dentistry	2	18.18
Biological sciences	5	45.45
Veterinary medicine	1	9.09
Biomedicine	1	9.09
Nutrition	1	9.09
Time since Graduation		
≤ 10 years	3	27.27
> 10 years	8	72.72
Specialisation?		
Yes	4	36.36
No	7	63.63
Master's Degree?		
Yes	10	90.90
No	1	9.09
Ph.D?		
Yes	9	81.81
No	2	18.18
Current occupation		
Teacher	11	100
Area of work		
Surgical pathology	1	9.09
Histology	1	9.09
Histology and embryology	4	36.36
Histopathology	2	18.18
Cell biology and histology	1	9.09
Developmental embryology and toxicology	1	9.09
Biotechnology	1	9.09
Experience with the subject		
≤ 10 years	5	45.45
> 10 years	6	54.54

Source: Prepared by the authors.

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In the evaluation of the questionnaire on the *Atlas de Histologia em Cores da* PUCRS, performed by specialists in Morphofunctional Sciences, 90.9% considered the proposal of the atlas to be adequate and 100% agreed that the tool can help the study of Histology in an effective and non-exhaustive manner. As regards content, 90.9% of the evaluators recognised that the atlas is in line with the content traditionally covered in the subject, while 100% said that it is attractive to students (Table 3).

Regarding the Content Validation Index (CVI), two questions in the questionnaire did not reach the agreement level considered ideal for this study, specifically in the areas of "ease of learning the concepts and their applications" and "ability to provide comprehensive help". The average recorded CVI was 0.85. The binomial test showed a statistically significant agreement of more than 0.80 for the following items: proposal of the atlas (p = 0.914), support for studying histology in a non-exhaustive way (p = 1.00), suitability of the content (p = 0.914) and attractiveness of the material (p = 1.00) (Table 3).

In the evaluation carried out by the IT experts, a high percentage responded that the atlas was easy to access and all considered it understandable. In relation to the resources used in the atlas, all the experts said they were adequately implemented and the majority rated the interface as attractive. In terms of user-friendliness, all the experts highlighted the ease of use and a significant number recognised that the atlas facilitates the study of Histology in a non-exhaustive way (Table 4).

Regarding the IVC, all the questions evaluated, except for the one that asks whether the "resources used in the virtual atlas are implemented in an extensive manner ", showed agreement values of above 0.78, with an average CVI of 0.91. The binomial test showed agreement statistically higher than 0.80 in several aspects: ease of access (p = 0.914), understanding of the content (p = 1.00), suitable execution of the resources (p = 1.00), attractiveness of the interface (p = 0.914), user friendliness (p = 1.00) and help in studying histology in a non-exhaustive way (p = 0.914) (Table 4).

DISCUSSION

The results of this study revealed a Morphofunctional Sciences expert profile of predominantly women with an average age of 38.5 (±6.74) years. These findings are in line with the study by Santos et al[21], which also identified a significant female predominance in the sample, especially in the 30-34 age group. Among the possible explanations for this trend, Souza and Hein[22] highlight the significant increase in young women entering the labour market. Furthermore, Santos et al[21] suggest that the greater female participation in health courses may contribute to this predominance.

Table 2. Characterisation of experts in the area of IT.

Variables	N	%
Gender		
Female	3	27.27
Male	8	72.72
Age		
≤ 40 years	4	36.36
> 40 years	7	63.63
Undergraduate Course		
Computer science	6	54.54
Computer technology with a major in information systems	2	18.18
Social Communication - Advertising	2	18.18
Mechanical Engineering	1	9.09
Time since Graduation		
≤ 10 years	-	-
> 10 years	11	100
Specialisation?		
Yes	5	45.45
No	6	54.54
Master's Degree?		
Yes	11	100
No	-	-
PhD?		
Yes	8	72.72
No	3	27.27
Current occupation		
Teacher	11	100
Area of work		
Computing	6	54.54
Graphic Design	1	9.09
User experience and interface design	1	9.09
Distance learning in Health	1	9.09
Multimedia	1	9.09
Information Technology	1	9.09
Experience with the subject		
≤ 10 years	2	18.18
> 10 years	9	81.81

Source: Prepared by the authors.

Table 3. Morphofunctional Science experts' evaluation of the virtual atlas for teaching and learning Histology.

Items	DF	D	N	C	CF	I-CVI[a]	P value*
The virtual atlas is appropriate for its intended purpose	0	0	1	3	7	0.90	0.914
The virtual atlas makes it easier to learn the concepts used and their applications	0	1	2	4	4	0.72	0.382
The virtual atlas provides comprehensive help	0	3	1	3	4	0.63	0.161
The virtual atlas helps you study histology in a way that is not exhausting	0	0	0	3	8	1.00	1.000
The content of the virtual atlas corresponds to the content of the histology literature	0	1	0	4	6	0.90	0.914
The virtual atlas is attractive to histology students	0	0	0	3	8	1.00	1.000
S-CVI						**0.85**	

DF – Strongly Disagree; D – Disagree; N – Neutral; C – Agree; CF – Strongly Agree;
I-CVI - *Item-Level Content Validity Index*; S-CVI - *Scale-Level Content Validity Index*.
[a] - Calculated on the basis of the number of experts who agreed or strongly agreed
*Binomial test.
Source: Prepared by the authors.

Table 4. Information Technology experts' evaluation of the virtual atlas for teaching and learning Histology.

Items	DF	D	N	C	CF	I-CVI[b]	P value*
The virtual atlas is easy to access	0	0	1	4	6	0.90	0.914
The language used in the virtual atlas is easy to understand	0	0	0	4	7	1.00	1.000
The resources used in the virtual atlas are implemented correctly	0	0	0	6	5	1.00	1.000
The resources used in the virtual atlas are implemented in an extensive manner[a]	0	0	3	4	4	0.72	0.382
The atlas interface is attractive	0	0	1	3	7	0.90	0.914
The virtual atlas is easy to use	0	0	0	5	6	1.00	1.000
The virtual atlas helps you study histology in a way that is not exhausting	0	0	1	4	6	0.90	0.914
S-CVI						**0.91**	

DF – Strongly Disagree; D – Disagree; N – Neutral; C – Agree; CF – Strongly Agree;
I-CVI - *Item-Level Content Validity Index*; S-CVI - *Scale-Level Content Validity Index*.
[a] - Fully or completely
[b] - Calculated on the basis of the number of experts who agreed or strongly agreed
*Binomial test.
Source: Prepared by the authors.

The significant presence of biologists among the experts may be related to the fact that Histology, a branch of Biology, is dedicated to the anatomical and functional study of cells, tissues and organs[3]. The average time since graduation of the experts (14 years), with a prevalence of experts who hold master's degrees and Ph.D., is considered fundamental in educational technology validation studies. These findings contributed to the quality of the analyses performed. With an average of 12 years' experience in the field, the educators offer an in-depth pedagogical perspective, vital for the effective development of digital educational resources[23].

On the other hand, the greater participation of males among Information Technology experts corresponds to expectations, given that the literature indicates a male predominance in this area[24]. Furthermore, digital tools involving concepts of computer graphics and image processing[11] are usually developed by professionals in the field of Computer Science, in which men are still in the majority. The average time since graduation of the participants was 20 years, which suggests that they are adequately qualified to evaluate the atlas. It is noteworthy that there was a majority of experts with masters or Ph. D titles who are also professors with more than 15 years' experience in the field of Information Technology.

Average agreement on the content and technique of the atlas was considered adequate, with an index above 0.80. These results suggest the potential use of the atlas as a

complementary digital resource for Histology practical classes in health courses such as Nursing, Dentistry and Medicine. Previous experiments to validate virtual tools for teaching morphology among medical students, as reported by Liu et al[25], have shown an increase in student satisfaction and higher academic performance compared to the control group. In another study by Khasanah, Pratiwi and Zahroh[26], 90.7% of content experts, 91.4% of digital media experts, 90.4% of reviewers, 87.43% of biology teachers and 84.7% of high school students rated the atlas as good quality, corroborating the results of this study.

The majority of experts agreed that the atlas was suitable, corroborating studies that highlight this type of tool as a viable didactic resource for teaching and learning histology[25,22,28]. It's important to note that both teachers and students have shown increasing acceptance of these tools[25,26]. The virtual atlas developed in this study facilitates a quick understanding of basic tissues and gametogenesis. Its features include digitisation and visualisation of histological structures, interactive resources (microscopic images with dynamic markings, intuitive section navigation and multi-device compatibility), textual descriptions in Portuguese and open access, allowing flexible study at any time and place. This accessibility can encourage students to devote more time to studying histology, contributing to an increase in satisfaction with learning and academic performance[29].

In terms of helping with the study of Histology, all the Morphofunctional Sciences experts and most of the Information Technology experts recognised that the atlas facilitates learning in this subject. This benefit can be attributed to the quality of the images presented, which are visualised in high resolution, reducing the time needed to identify histological structures[30]. Notably, in this atlas, marker points have been used on histological structures to improve the diagnostic accuracy of cells and structures. From a constructivist perspective, this organisation, adapted to the learner's level of cognitive development, favours individualised learning[31].

In addition, the assessment made by both groups of experts indicated that the atlas is considered attractive to students of Histology in health courses (Medicine, Dentistry, Physiotherapy and Nursing). This perception can be attributed to the colourful design , "interactivity icons" and brief explanatory texts, along with a user-friendly interface[32]. Other factors contributing to its acceptance include ease of access and high usability on mobile devices and desktops, without the need to install additional software[33]. These characteristics are fundamental to capturing students' attention, encouraging them to study the content in a more engaged way, which can have a positive impact on their academic performance[34].

Most of the Morphofunctional Sciences experts agreed that the content of the atlas adequately reflects the topics covered in Histology teaching. This result suggests that the atlas is a significant digital teaching resource for the teaching and learning process in Histology. It is essential that studies involving the production of digital technologies for teaching in different health courses assess the reliability of the information, since the internet allows content to be disseminated by individuals with no expertise in the subject matter[35]. Health education content requires rigorous validation.

It is worth highlighting the questions that did not reach the I-CVI value established in this study, especially regarding the ease of learning the concepts and their applications, as well as the complete provision of assistance. It is plausible that concern about the use of virtual atlases in histology teaching was a predominant issue in the assessment of the Morphofunctional Sciences experts. This concern is supported by the literature, which suggests that web-based learning tools should complement the use of optical microscopy. Donkin et al[36] concluded that this integrated approach improves learning and academic performance. Given this evidence, the virtual atlas could be effective in building knowledge when used as a complementary resource to optical microscopy, without replacing it.

The results relating to the accessibility, ease of understanding and handling of the atlas indicate that most the IT experts rated these characteristics positively. This consensus is attributed to the rigorous process used to build this technology, which aimed to create a tool accessible on any device connected to the internet, using clear and objective language. Regarding the resources used in the atlas, there was general agreement that they were well implemented. This finding reflects the design of the atlas, which includes a visually pleasing interface, text fonts of an appropriate size and style, concise texts, a screen background with soft colours and images pertinent to the content studied, aspects that facilitate acceptance by students[32].

On the other hand, the question about whether "the resources used in the virtual atlas are implemented in an extensive manner" did not reach the expected I-CVI. This result can be explained by a flaw in the adaptation of the evaluation instrument, in which the question led to imprecision in its interpretation, possibly affecting the clarity of the expected response.

One limitation of this study was the lack of a validation process with the target audience, represented by undergraduate students in Medicine, Dentistry, Pharmacy, Physiotherapy and Nursing. This restricted the evaluation of its suitability and potential impact on users' academic performance. It is

therefore recommended that future research include validation of the atlas by students in order to deepen insights into its effectiveness as an educational tool.

CONCLUSION

The virtual atlas developed for teaching and learning Histology was subjected to evaluation and validation of its content and technique by experts in Morphofunctional Sciences and Information Technology. According to the experts' assessment, the atlas fulfils its purpose satisfactorily, being considered comprehensible, accessible, attractive and effective in facilitating the study of Histology in an engaging and less tiring way. The validation of the content and technique suggests the viability of its use as a virtual teaching resource. It is hoped that investigating the real impact of this resource on the academic performance of undergraduate students in Medicine, Dentistry, Pharmacy, Physiotherapy and Nursing will confirm its educational effectiveness.

CONTRIBUTION OF THE AUTHORS

Davide Carlos Joaquim: Conception and design of the manuscript, data collection, analysis and interpretation, drafting and revising of the manuscript. Ismael Pordeus Bezerra Furtado: Data analysis and interpretation, drafting and revising of the manuscript. Márcia Rodrigues Payeras: Design of the atlas and revision of the final version of the manuscript. Ana Paula Franco Lambert: Design of the atlas and revision of the final version of the manuscript. Ana Caroline Rocha de Melo Leite: Conception and design of the manuscript, data analysis and interpretation, drafting and revising of the manuscript. Virgínia Cláudia Carneiro Girão-Carmona: Conception and design of the manuscript, data analysis and interpretation, drafting and revising of the manuscript.

CONFLICT OF INTEREST

We declare no conflict of interest.

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DECLARATION OF DATA AVAILABILITY

Research data is available in the body of the document.

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