Int. J. Morphol.,
40(3):789-795, 2022.

Bibliometric Analysis of Global Research Output on Teaching and Learning of Human Anatomy

Análisis Bibliométrico de la Producción Mundial de Investigación sobre la Enseñanza y el Aprendizaje de la Anatomía Humana

Sonia Osorio-Toro[1]; Alejandro Rodríguez-Campo[2] & Howard Ramirez-Malule[3]

OSORIO-TORO, S.; RODRÍGUEZ-CAMPO, A. & RAMIREZ-MALULE, H. Bibliometric analysis of global research output on teaching and learning of human anatomy. *Int. J. Morphol., 40(3)*:789-795, 2022.

SUMMARY: The study and teaching of human anatomy is one of the cornerstones of education of basis science in health professionals. The aim of this study was to present a bibliometric analysis of the global outputs of research on the teaching and learning of human anatomy in the last two decades. The Scopus database was used to search and retrieve studies related to this topic between 2001 and February 10, 2021. A total of 10,481 documents were found through a systematic search strategy. A growing trend in publishing research results was evidenced, starting in 2001 with a considerable increase between 2012 and 2015. Four clusters were identified in studies related to teaching-learning methodologies of human anatomy. These clusters correspond to traditional methods and emerging methodologies such as the use of information and communication technologies, 3D impressions and diagnostic images. In addition, the results of this study indicate that the United States, the United Kingdom and Germany were the countries with the highest production in the number of publications on this topic. Although new methodologies have been included in teaching and learning human anatomy, such as the use of information and communication technologies, the trend in these processes continues to be mediated by the traditional method of cadaveric dissection. However, there is an increase in the immersion of virtual resources as part of these methodologies that should be integrated.

KEY WORDS: Teaching; Learning; Human anatomy; Bibliometric analysis.

INTRODUCTION

The consensus of the European Union regarding the teaching of human anatomy stated the following objectives (Chirculescu *et al*., 2007): (i) provide a basis for building knowledge in other areas of basic sciences such as physiology, histology, pathology, among others, and (ii) relate expected or standard body structure to function and to pathology. These objectives seek to ensure that future medical doctors and other health professionals have access to the same background to build their work. Likewise, it is recommended to include and even combine different learning methods in teaching, such as cadaver dissection, study on plastic models, diagnostic imaging, surface anatomy, problem-based learning and computer-assisted learning, as well as the use of lectures, seminars, and other (Flack & Nicholson, 2018; Zibis *et al*., 2021). It is considered important not to replace one laboratory practice with another, such as eliminating human cadaver dissection with virtual dissection, since they are learning methods that allow the development of different cognitive and manual skills (Chirculescu *et al*., 2007; Singh & Kharb, 2013).

Specifically, in the field of human macroscopic anatomy (HMA), several publications have been analyzed in the form of narrative (Chan *et al*., 2019), systematic (Losco *et al*., 2017) and critical (Estai & Bunt, 2016) reviewers. Those reviews compiled, described, and analyzed the best teaching practices worldwide in this area of knowledge. Nevertheless, bibliometric studies on this topic are still missing.

Bibliometric studies refer to the search, organization and statistical analysis of bibliographic data found in books,

[1] Grupo de Investigación TEBLAMI, Departamento de Morfología, Escuela de Ciencias Básicas, Universidad del Valle, Colombia.
[2] Grupo de investigación Cátedra en Discapacidad y Rehabilitación, Escuela de Rehabilitación Humana, Universidad del Valle, Colombia.
[3] Escuela de Ingeniería Química, Universidad del Valle, Colombia.

Received: 2021-11-11 Accepted: 2022-04-12

articles and other publications. These visualize trends in research in a field of study, providing evidence of its impact and quality. Their analysis allows for researchers to identify the characteristics of the works published in databases, such as authorship, subject areas, country and trends in scientific production in the different areas of knowledge (Chen *et al*., 2017a; Iowa State University, 2022) considered that bibliometric analysis is important to understand research developments in a particular topic by identifying gaps, trends, contradictions and collaborations. Given the above information, the aim of this study was to present a bibliometric analysis of the global research outputs on the teaching, learning and education of human anatomy in the last two decades (2001–2021).

MATERIAL AND METHOD

Data selection. In the current study, the Scopus database was used as a source of bibliometric data to search and retrieve the most relevant studies related to teaching, learning and education of human anatomy. Data were acquired on February 10, 2021, and comprised records obtained from a systematic search of documents matching the search terms in the fields of article title, abstract and keywords.

Search strategy and refining the retrieved documents. To collect studies on human anatomy focused on learning, teaching and education of this discipline, the Boolean operators "AND", "OR" and "AND NOT" were used. The search was carried out using the following search syntax: (TITLE-ABS-KEY (anatomy) AND TITLE-ABS-KEY (learning) OR TITLE-ABS-KEY (teaching) OR TITLE-ABS-KEY (education) AND NOT TITLE-ABS-KEY (veterinary))

The search was refined to the article as document type and was limited to the period between 2001 and February 10, 2021.

Data export and analysis. The information retrieved from the Scopus database in each search was (i) citation information, (ii) bibliographical information and (iii) abstract and keywords. Retrieved data were exported from Scopus to Microsoft Excel®. VOSviewer 1.6.13 software was used for visualization and data analysis (van Eck & Waltman, 2010). Additionally, the minimum number of keyword occurrences was set at 70, and after removing the thesaurus terms, 43 of them met the threshold, which led to 4 clusters.

Bibliometric indicators. In this work, the following bibliometric indicators were evaluated:

· Volume and growth of publications related to learning, teaching and education of human anatomy.
· Subject areas related to learning, teaching and education of human anatomy.
· Co-occurrence keywords network visualization.
· Co-occurrence keywords overlay visualization.
· Most active countries.

RESULTS AND DISCUSSION

A total of 10481 articles were indexed in the Scopus database during the search process. Figure 1 displays the evolution of the number of articles related to teaching, learning and education of human anatomy published per year from 2001 to February 10, 2021. The growth in the number of articles per year shows exponential behavior, indicating a rise in the global research output of this field. Specifically, between 2012 and 2015, an increase in the number of publications is clearly observed (approx. 400 more articles per year). Afterward, the behavior in the number of publications is rather constant. Since the mid-2000s, the use of technologies in the teaching-learning process of human anatomy has been introduced. However, a decade later, a greater use of technology began due to the high costs that educational institutions had to access these resources, limiting their capacity for innovation. In addition, the lack of flexibility of professors to incorporate these technologies into these processes has kept them in traditional methodologies, a situation that has been changing due to the generational change in professors who are better adapted to the use of information and communication technologies (ICTs).

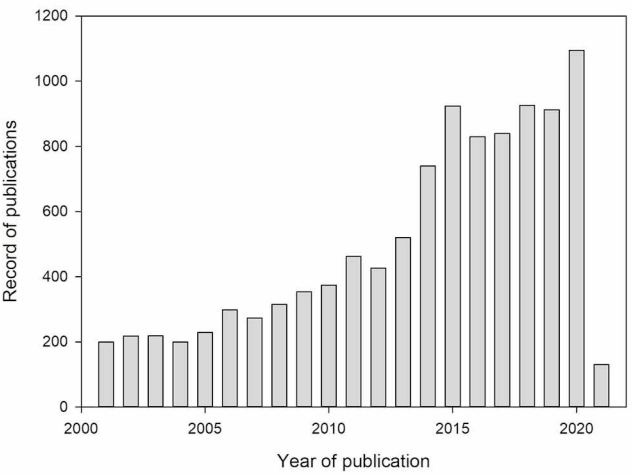

Fig. 1. Evolution of the number of published articles related to teaching, learning and education of human anatomy between 2001 and February 10, 2021, according to the Scopus database.

Increasingly, educational institutions, to adapt to the characteristics of today's society, have been integrating ICT into the training processes. For this reason, during the last decade, there has been an increase in the number of studies that seek to evaluate the impact these technologies have had on teaching-learning in this area of knowledge (Salinas, 2004; Liu *et al*., 2020).

As expected, medicine ranked first and contributed 45.7 % of the indexed articles in knowledge related to teaching, learning and education of human anatomy.

Figure 2 shows the bibliometric network of studies of teaching, learning and education of human anatomy between 2001 and February 10, 2021. The network visualization contains 43 nodes grouped into 4 clusters (Fig. 2a).

Cluster of Traditional Teaching-Learning (Yellow Cluster. This cluster includes research that has addressed the teaching-learning of human anatomy, based on the traditional method of dissection, a word whose etymology gives this area of knowledge its name (Winston, 2012). This has been the main teaching-learning method used for more than 400 years, and its advantages include active learning, the practice of manual skills, teamwork, coping with stress and empathy (Zibis *et al*., 2021). Different authors consider this method the gold standard for teaching and learning human anatomy (Evans & Watt, 2005; Sugand *et al*., 2010; Moro *et al*., 2017). In focus groups in which medical students are asked about their learning methods, they have stated that they consider cadaveric dissection indispensable for understanding the three-dimensionality of the human body, the location of structures and tissue differentiation (Mitrousias *et al*., 2020). Chan *et al*. (2019) report that dissection is considered the pedagogical strategy that provides the greatest learning benefits; however, its technical feasibility is complex and costly.

Cluster of Emerging Teaching-Learning (Green Cluster). This cluster covers research on teaching-learning through various methodologies that have emerged over the years, such as computer-assisted learning, integrated curriculum and even different ways to studying human anatomy (macroscopic anatomy, which also includes bioscopic anatomy) have been organized.

Regarding computer-assisted learning, there is research that covers teaching proposals that include ICT, such as the use of different 3D software, virtual dissection and augmented reality platforms, and video production. Some articles have also referred to it as computer-based learning. Fleague *et al*. (2018), conducted a quantitative experimental study in which they compared the academic performance of medical students using the traditional lecture and laboratory practice method with one group and the inverted classroom modality with another group, sharing online different resources such as videos explaining anatomy using dissected cadavers and explanatory videos with 3D images from the Ciberanatomy application. The researchers found that students' academic performance using the inverted classroom method was superior to that of students using the traditional method. Virtual resources permit self-pacing, and 3D images were considered the most important learning method, followed by teacher instructions and videos with cadaveric specimens.

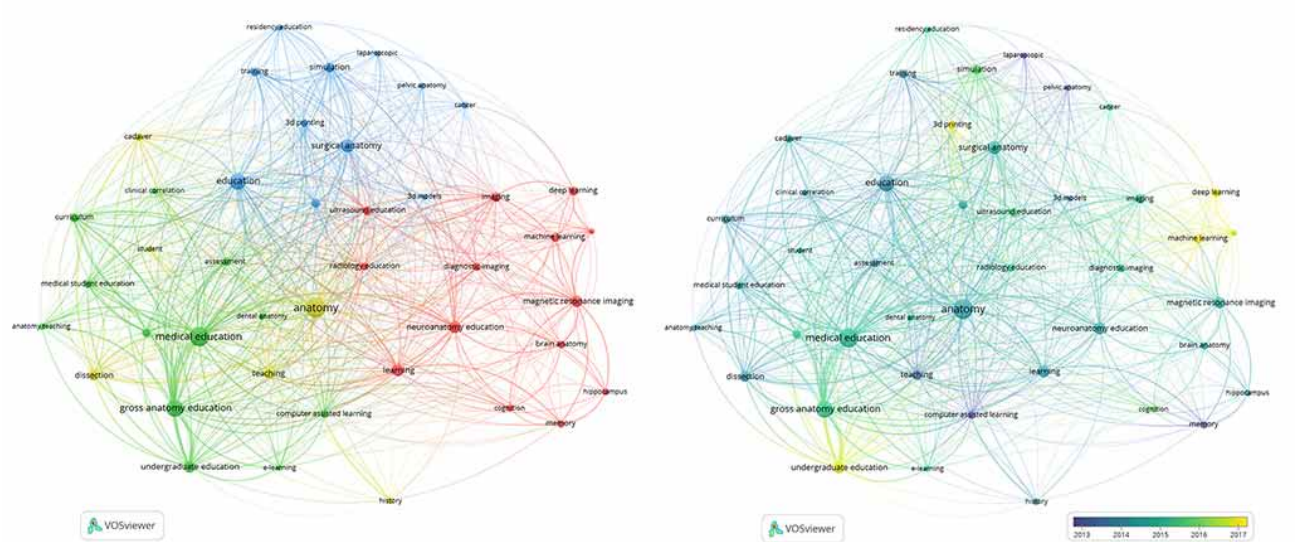

Fig. 2. Summary of studies related to teaching, learning and education of human anatomy between 2001 and February 10, 2021. (A) Bibliometric network. (B) Research topic map with time overlay. Note: The minimum number of occurrences of a keyword is 70.

Likewise, different universities have worked on developing simulators, software, atlases, among other resources for the teaching of human anatomy (National Library of Medicine, 2019). For example, at the University of Colorado, there is the Visible Human of the Center for Human Simulation with the aim of training future health professionals in this area, especially in the location of the three dimensions and their abstraction in computer images required for the understanding of radiological images (Spitzer & Ackerman, 2008). This is necessary because clinical, diagnostic and therapeutic procedures are becoming increasingly complex and use technological tools for their precision.

There are a variety of proposals of laboratory practices for the teaching of HMA that seek to facilitate the understanding of the most difficult subjects to learn, e.g., those regions with small structures that are difficult to visualize and that cannot be modeled in two-dimensional images. An alternative is the use of virtual resources to facilitate teaching, such as the creation of educational videos based on computerized axial tomography (CAT) images of healthy patients, which allow for the construction of three-dimensional structures in software permitting the visualization of the tiny and complex structures of the different body regions. To develop these virtual resources, the University of South Australia surveyed different professors in the area to define the subjects with the greatest teaching and learning difficulties and interviewed the directors of the academic programs to determine the needs and utilities of the proposed contents. This strategy has been used for three years, in which focus groups and anonymous surveys have been conducted, and found that these videos have helped students learn the different names and functions of the organs and have improved their ability to apply the concepts in a clinical context (Massy-Westropp *et al.*, 2019).

To help students understand human anatomy, it is necessary that they mentally represent the physical structures, as well as the ability to mentally rotate images in the three spatial planes and imagine movements and functions. In this sense, the technology has allowed for the development of different interactive tools that achieve spatial representation of anatomical structures to facilitate teaching and learning. It has been demonstrated that 3D animations are efficient in achieving learning, especially of the musculoskeletal system involving movements and joint functions. However, the passive visualization of all these digital resources does not favor learning (Hoyek *et al.*, 2020).

Some universities have moved away from laboratory practices involving dissection and the study of human specimens completely. This has required novel approaches to anatomical science education and led to the emergence of innovative teaching techniques using virtual resources (Yousuf *et al*., 2020). Although different methodologies are proposed to favor the construction of knowledge in this area, traditional teaching predominates worldwide (Zibis *et al*., 2021). Traditional teaching includes lectures in which the professor explains the topic to be covered, followed by a laboratory practice of dissection or observation of cadaveric pieces so that students can recognize and differentiate the anatomical structures. Finally, an evaluation at the end of the module studied can cover between 2 and 3 body regions.

Another group of methodologies is the integrated curriculum, in which HMA is taught not only in the first semesters but also throughout the entire curriculum, articulating the area with other subjects such as physiology, pathology, and embryology, among others. Traditionally, academic programs in medicine and other health disciplines concentrate the basic and clinical sciences at the program's beginning and end, respectively. This curricular organization has generated strong criticism due to the lack of relevant anatomical knowledge in recent graduates. The curriculum at Brighton Sussex Medical School was reformed with an integrated approach based on teaching-learning by body systems (digestive, cardiorespiratory, among others). In this case, anatomy is considered a central element in the training of future medical doctors. Therefore, the teaching of this area is included from the first to the last semesters, including cadaver dissection activities in relation to the development of clinical practice (Evans & Watt, 2005).

Finally, HMA includes research that contemplates living anatomy, also known as bioscopic anatomy or surface anatomy, which proposes, among others, the use of learning methodologies based on body painting, identifying anatomical regions and differentiating superficial structures that are visible and palpable on the body itself. Cookson *et al*. (2017) conducted a qualitative study based on grounded theory. These authors collected data through interviews with academics and clinicians who used body painting as a learning method, concluding that it is a valuable complement to anatomy education. In addition, it allows for approaching clinical skills that contribute to the preparation of students with practice. Additionally, anatomy has also been taught through the physical examination of classmates or simulated patients.

Cluster of Teaching-Learning Through Various Representation Models (Blue Cluster). This cluster groups teaching-learning methodologies involving 3D printing, the use of anatomical models and surgical training. Regarding the first one, studies have used 3D prints of different

anatomical regions differentiating each of its parts employing colors in such a way that they facilitate the differentiation and the understanding of the relationship with the structures that conform it. Chen *et al*. (2017b) evaluated the efficiency of learning skull anatomy in third-year medical students using three anatomical models. The first group practiced with real dry skulls, the second with 3D printed skulls and the third with two-dimensional images of the atlases. The researchers concluded that 3D printed skulls facilitated learning by allowing greater recognition of the structures observed.

Regarding the use of anatomical models, university models for the study of organs or body segments are used in their practice room; the materials, colors, sizes and textures used in these models vary (Smith *et al*., 2018). Different studies compare the academic performance of students when recognizing anatomical structures using plastic anatomical models and cadavers. Those studies report similar results, recommending replacing the study in cadavers with plastic models with the advantage that these models do not need a large infrastructure or costly maintenance compared to amphitheaters (Halou *et al*., 2013; Mitrousias *et al*., 2020). However, there are differences between the anatomical models, some of which are very similar to real organs and body structures, such as those used in the study by Mitrousiaus *et al*. (2020), which may explain the results obtained (Chan & Cheng, 2011).

Other anatomical models are similar to the images of human anatomy atlases, in which colors are used pedagogically to recognize the structures. This methodology facilitates the location and differentiation of tissues for learning (Chen *et al*., 2017b). However, medical students should recognize the structures and the different parts by their location and anatomical relationship since in the real human body, several tissues can be visualized similarly and a mistake of structures can be related to an incorrect diagnosis (Triepels *et al*., 2020). Therefore, an inadequate treatment plan. Thus, the use of anatomical models can favor the approach of this topic, but it is necessary to look for methodologies that include the approach to real anatomical structures.

There are also teaching-learning proposals that use the elaboration of models to achieve visual literacy and spatial location evaluated through the elaboration of cross-sectional drawings of body regions, which are the most difficult to understand (García Fernández & Mateos Jiménez, 2018). The University of California facilitates learning by metaphors, analogies and facial expressions to provide new ways of thinking, focus activities on common human functions and improve understanding of anatomical and physiological relationships. The authors found that this method provides a nice way to understand the interactions between organs and systems (Williamson & Lee, 2018).

In terms of surgical training, different methodologies seek to strengthen the student's spatial skills, specifically training in visualization, orientation, dynamic spatial capacity and mental rotation, considered cognitive skills necessary for the understanding, representation and location of body structures. These skills have been studied through digital applications, physical models and augmented reality (Langlois *et al*., 2020).

The red cluster corresponds to research involving the use of diagnostic imaging for the teaching-learning of HMA, as well as the study of the cognitive processes required for such learning. Some of this research falls within the field of neuroscience (Moscova *et al*., 2015). Endoscopic images, X-rays, MRIs, and CT scans, among others, are generally included as a complement to clinical cases so that students can apply anatomical knowledge and understand the importance of knowing the body structures that will be the basis for diagnosis and treatment. Different authors highlight the need to teach by integrating clinical sciences with basic sciences to achieve meaningful learning (Ministerio de Salud & Ministerio de Educación, 2017; Fleagle *et al*., 2018).

Figure 2b shows the different methodologies of teaching, learning and education of human anatomy employed over time, e.g., dissection, curriculum, training, and computer-assisted learning studies concentrated the studies between 2013 and 2015, while studies of machine learning, deep learning, 3D printing and undergraduate education did in 2017.

Machine learning is currently one of the revolutionary fields that is being successfully implemented in many areas. It has an important role in the education sector to explore various possibilities through which the system can perform a cognitive analysis based on a given set (Naidu *et al*., 2020). In addition, this revolutionary field is rapidly gaining popularity in the health care sector, as these tools could play a key role in defining the way medicine will be practiced, allowing for professionals to be part of the emerging data science revolution (Kolachalama & Garg, 2018).

In the case of deep learning, students in their learning process investigate the content until they obtain their criteria, reinterpreting, understanding and applying knowledge to share with classmates and solve problems (Lara, 2020).

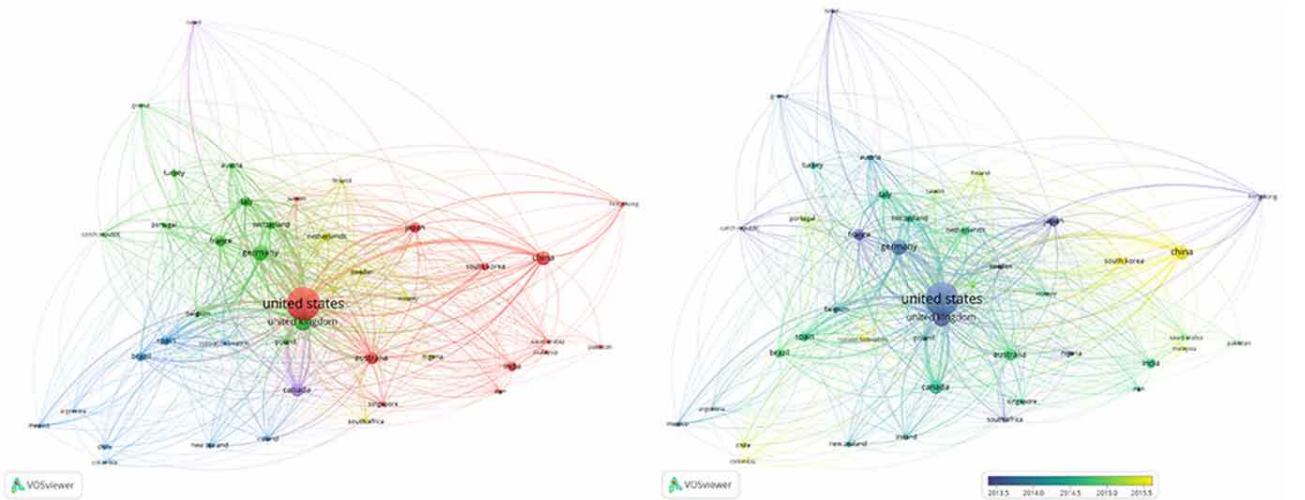

Fig. 3. Bibliometric map of the global collaboration network among countries researching teaching, learning or education of human anatomy between 2001 and February 10, 2021. The minimum number of documents of a country is 40.

Figure 3 contains 5 clusters and 43 countries of studies related to teaching, learning and education of human anatomy. The leading countries in this field were the United States, the United Kingdom and Germany (Fig. 3a). However, China, South Korea, Malaysia and Colombia concentrated their studies on this topic in 2015 (Fig. 3b).

CONCLUSIONS

Studies related to learning, teaching and education of human anatomy have increased over time (2001–2021), with a breaking point after 2012. The studies were focused mainly on the following clusters: (i) teaching-learning based on methodologies such as cadaver dissection, computer-assisted learning, integrated curriculum and macroscopic anatomy; (ii) teaching and learning methodologies involving 3D printing, the use of anatomical models and surgical training; and (iii) research involving the use of diagnostic imaging for teaching and learning HMA, as well as for the study of the cognitive processes required for learning. Additionally, the countries that published the most studies on human anatomy education and had the strongest collaboration network were the United States, the United States, the United Kingdom and Germany.

ACKNOWLEDGEMENTS. Sonia Osorio-Toro thanks to Universidad del Valle for the comssion for doctoral formation N°096, 4 of July 2019, and the Doctorado Interinstitucioinal en Educación de la Universidad del Valle.

OSORIO-TORO, S.; RODRÍGUEZ-CAMPO, A. & RAMIREZ-MALULE, H. Análisis bibliométrico de la producción mundial de investigación sobre la enseñanza y el aprendizaje de la anatomía humana. *Int. J. Morphol., 40(3)*:xxx-xxx, 2022.

RESUMEN: La enseñanza y el aprendizaje de la anatomía humana es uno de los pilares de la educación científica básica para los profesionales de la salud. El objetivo de este estudio fue presentar un análisis bibliométrico de los resultados globales de la investigación sobre la enseñanza y el aprendizaje de la anatomía humana en las últimas dos décadas. Se utilizó la base de datos Scopus para buscar y recuperar estudios relacionados con este tema entre 2001 y el 10 de febrero de 2021. Se encontraron un total de 10.481 documentos mediante una estrategia de búsqueda sistemática. Hubo una tendencia creciente en la publicación de resultados de investigación, comenzando en 2001 con un aumento considerable entre 2012 y 2015. Se identificaron cuatro grupos en estudios relacionados con metodologías de enseñanza-aprendizaje de anatomía humana. Estos clusters corresponden a métodos tradicionales, metodologías emergentes como el uso de tecnologías de información y comunicación, impresión 3D e imágenes de diagnósticas. Además, los resultados de este estudio indican que Estados Unidos, Reino Unido y Alemania fueron los países con mayor producción en el número de publicaciones sobre este tema. Si bien se han incluido nuevas metodologías en la enseñanza y el aprendizaje de la anatomía humana, como el uso de tecnologías de la información y la comunicación, la tendencia en estos procesos continúa siendo a través del método tradicional y la disección cadavérica. Sin embargo, hay un incremento en la inclusión de recursos virtuales que se integran al aula.

PALABRAS CLAVE: Enseñanza; Aprendizaje; Anatomía humana; Análisis bibliométrico.

REFERENCES

Chan, A. Y. C. C.; Cate, O. T.; Custers, E. J. F. M.; Leeuwen, M. S. & Bleys, R. L. A. W. Approaches of anatomy teaching for seriously resource-deprived countries: a literature review. Educ. Health (Abingdon), 32(2):62-74, 2019.

Chan, L. K. & Cheng, M. M. W. An analysis of the educational value of low-fidelity anatomy models as external representations. Anat. Sci. Educ., 4(5):256-63, 2011.

Chen, B.; Tsutsui, S.; Ding, Y. & Ma, F. Understanding the topic evolution in a scientific domain: An exploratory study for the field of information retrieval. J. Informetr., 11(4):1175-89, 2017a.

Chen, S.; Pan, Z.; Wu, Y.; Gu, Z.; Li, M.; Liang, Z.; Zhu, H.; Yao, Y.; Shui, W.; Shen, Z.; *et al*. The role of three-dimensional printed models of skull in anatomy education: a randomized controlled trail. Sci Rep. 7(1):575, 2017b.

Chirculescu, A. R. M.; Chirculescu, M. & Morris, J. F. Anatomical teaching for medical students from the perspective of European Union enlargement. Eur. J. Anat., 11(S1):63-5, 2007.

Cookson, N. E.; Aka, J. J. & Finn, G. M. An exploration of anatomists' views toward the use of body painting in anatomical and medical education: An international study. Anat. Sci. Educ., 11(2):146-54, 2017.

Estai, M. & Bunt, S. Best teaching practices in anatomy education: A critical review. Ann. Anat., 208:151-7, 2016.

Evans, D. J. R. & Watt, D. J. Provision of anatomical teaching in a new British medical school: getting the right mix. Anat. Rec. B New Anat., 284(1):22-7, 2005.

Flack, N. A. M. S. & Nicholson, H. D. What do medical students learn from dissection? Anat. Sci. Educ., 11(4):325-35, 2018.

Fleagle, T. R.; Borcherding, N. C.; Harris, J. & Hoffmann, D. S. Application of flipped classroom pedagogy to the human gross anatomy laboratory: Student preferences and learning outcomes. Anat. Sci. Educ., 11(4):385-96, 2018.

García Fernández, B. & Mateos Jiménez, A. Comparación entre la realización de maquetas y la visualización para mejorar la alfabetización visual en anatomía humana en futuros docentes. Rev. Eureka Enseñ. Divulg. Cienc., 15(3):3605, 2018.

Halou, H.; Chalkias, A.; Mystrioti, D.; Iacovidou, N.; Vasileiou, P. V. S. & Xanthos, T. Evaluation of the willingness for cadaveric donation in Greece: A population-based study. Anat. Sci. Educ., 6(1):48-55, 2013.

Hoyek, N.; Di Rienzo, F.; Guillot, A. & Collet, C. The role of mental and motor processes in conceiving, developing and validating 3D interactive human anatomy learning tools. FASEB J., 34(S1):1-1, 2020.

Iowa State University. Bibliometrics - Research Methodologies Guide - Library Guides at Iowa State University. Ames, Iowa State University, 2022. Available from: https://instr.iastate.libguides.com/c.php?g=49332&p=318077

Kolachalama, V. B. & Garg, P. S. Machine learning and medical education. NPJ Digit. Med., 1:54, 2018.

Langlois, J.; Bellemare, C.; Toulouse, J. & Wells, G. A. Spatial abilities training in anatomy education: A systematic review. Anat. Sci. Educ., 13(1):71-9, 2020.

Lara, M. V. Aprendizaje profundo. Involucra al mundo para cambiar el mundo. Educ. Cienc. Biol., 5(1), 2020. Available from: http://ojs.cfe.edu.uy/index.php/RevEdCsBiol/article/view/663

Liu, Q.; Geertshuis, S. & Grainger, R. Understanding academics' adoption of learning technologies: A systematic review. Comput. Educ., 151:103857, 2020.

Losco, C. D.; Grant, W. D.; Armson, A.; Meyer, A. J. & Walker, B. F. Effective methods of teaching and learning in anatomy as a basic science: A BEME systematic review: BEME guide no. 44. Med. Teach., 39(3):234-43, 2017.

Massy-Westropp, N.; Giles, E.; Dantu, R.; Wechalekar, H. & Burlakoti, A. Developing and evaluating virtual anatomy resources for teaching allied health disciplines. Res. Learn. Technol., 27, 2019. Available from: https://journal.alt.ac.uk/index.php/rlt/article/view/2125

Ministerio de Salud & Ministerio de Educación. Documento de Recomendaciones para la Transformación de la Educación Médica en Colombia. Comisión para la Transformación de la Educación Médica en Colombia. Bogotá, Ministerio de Salud & Ministerio de Educación, 2017. Available from: https://www.minsalud.gov.co/sites/rid/Lists/BibliotecaDigital/RIDE/VS/transformacion-educacion-medica-colombia.pdf

Mitrousias, V.; Karachalios, T. S.; Varitimidis, S. E.; Natsis, K.; Arvanitis, D. L. & Zibis, A. H. Anatomy learning from prosected cadaveric specimens versus plastic models: a comparative study of upper limb anatomy. Anat. Sci. Educ., 13(4):436-44, 2020.

Moro, C.; S˘tromberga, Z.; Raikos, A. & Stirling, A. The effectiveness of virtual and augmented reality in health sciences and medical anatomy. Anat. Sci. Educ., 10(6):549-59, 2017.

Moscova, M.; Bryce, D. A.; Sindhusake, D. & Young, N. Integration of medical imaging including ultrasound into a new clinical anatomy curriculum. Anat. Sci. Educ., 8(3):205-20, 2015.

Naidu, V. R.; Singh, B.; Al Farei, K. & Al Suqri, N. Machine Learning for Flipped Teaching in Higher Education—A Reflection. In: Masri, A. N. & Al-Assaf, Y. (Eds.). Sustainable Development and Social Responsibility—Volume 2. Proceedings of the 2nd American University in the Emirates International Research Conference, AUEIRC'18—Dubai, UAE 2018. Cham, Springer International Publishing, 2020. pp.129-32.

National Library of Medicine. Projects Based on the Visible Human Data Set. Products. Bethesda, National Library of Medicine, 2019. Available from: https://www.nlm.nih.gov/research/visible/products.html

Salinas, J. Innovación docente y uso de las TIC en la enseñanza universitaria. RUSC Univ. Knowl. Soc., 1(1):1-16, 2004.

Singh, V. & Kharb, P. A paradigm shift from teaching to learning gross anatomy: meta-analysis of implications for instructional methods. J. Anat. Soc. India, 62(1):84-9, 2013.

Smith, C. F.; Tollemache, N.; Covill, D. & Johnston, M. Take away body parts! An investigation into the use of 3D-printed anatomical models in undergraduate anatomy education. Anat. Sci. Educ., 11(1):44-53, 2018.

Spitzer, V. M. & Ackerman, M. J. The Visible Human® at the University of Colorado 15 years later. Virtual Real., 12(4):191-200, 2008.

Sugand, K.; Abrahams, P. & Khurana, A. The anatomy of anatomy: a review for its modernization. Anat. Sci. Educ., 3(2):83-93, 2010.

Triepels, C. P. R.; Smeets, C. F. A.; Notten, K. J. B.; Kruitwagen, R. F. P. M.; Futterer, J. J.; Vergeldt, T. F. M. & Van Kuijk, S. M. J. Does three-dimensional anatomy improve student understanding? Clin. Anat., 33(1):25-33, 2020.

van Eck, N. J. & Waltman, L. Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics, 84(2):523-38, 2010.

Williamson, J. & Lee, C. What's behind that smile: using analogies, facial expressions, and special senses to demonstrate the interactions between body systems in anatomy and physiology lab classes. Am. Biol. Teach., 80(9):661-7, 2018.

Winston, H. A medical student-cadaver relationship. Virtual Mentor., 14(5):419-21, 2012.

Yousuf, M. S.; Harvey, H. L.; Ramzy, A.; Al Sharei, A. S.; Al-Zboun, W. Q. & Badran, D. H. The attitude of medical students towards the teaching of Anatomy. Eur. J. Anat., 24(6):449-58, 2020.

Zibis, A.; Mitrousias, V.; Varitimidis, S.; Raoulis, V.; Fyllos, A. & Arvanitis, D. Musculoskeletal anatomy: evaluation and comparison of common teaching and learning modalities. Sci. Rep., 11(1):1517, 2021.

Corresponding author:
Sonia Osorio-Toro
Grupo de Investigación TEBLAMI
Departamento de Morfología
Escuela de Ciencias Básicas
Universidad del Valle - COLOMBIA

E-mail: sonia.osorio@correounivalle.edu.co

Sonia Osorio-Toro	0000-0002-9755-2738
Alejandro Rodríguez-Campo	0000-0001-9590-8342
Howard Ramirez-Malule	0000-0003-1013-5809