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Students' Perceptions of a Complementary Pedagogical Tool Based on Significant Learning Theory

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Abstract: ***Concept maps originate from the Theory of Meaningful Learning, according to which knowledge acquisition occurs when learners are able to connect pre-existing cognitive structures with new concepts. This study analyzed the impact of concept maps as a pedagogical tool on the learning outcomes of 161 students enrolled in Human Anatomy courses within the Physical Therapy and Occupational Therapy programs at the Federal University of Minas Gerais, as part of a teaching project conducted in 2022. Students received instructional presentations on the use of CmapTools software and the virtual learning environment. A total of 2,585 concept maps were submitted to a Moodle meta-class for evaluation by project monitors. At the end of the semester, a questionnaire was administered to assess students' perceptions regarding the use of concept maps. Results indicated that 55% of students were unfamiliar with concept maps prior to the intervention, and 52% would recommend concept maps to peers, perceiving them as an innovative and effective study tool that facilitates technology integration. Additionally, 48% of participants reported difficulties in map construction, while 72% agreed that creating concept maps helped identify concepts requiring further review. Based on these findings, it is concluded that the use of concept maps supported the construction of both theoretical and practical knowledge in Human Anatomy.***

Keywords: Meaningful learning; Concept maps; Higher education; Pedagogical strategy; Human anatomy.

1. INTRODUCTION

According to David Ausubel (2000), knowledge is the product of the interaction between relevant pre-existing ideas in the learner's cognitive structure and the mental process of acquiring and retaining new knowledge. This same author had previously presented (Ausubel, et al., 1980) the Theory of Meaningful Learning (TML), where the process of knowledge acquisition is not automatic but occurs when the learner is able to connect pre-existing knowledge to a new concept, creating a logical learning sequence that leads the student to understand the importance of the topic—a relevant factor in the learning process.

According to Agra and collaborators (2019), when teachers adopt Ausubel's contributions, important factors in the teaching and learning process are addressed, such as attention, motivation, and memory, while considering students' prior knowledge and predisposition. In this way, teachers should seek to establish connections between the new concepts covered and elements of the learner's cognitive structure.

The disciplines that form the basic cycle of undergraduate studies serve as a foundation for the development of knowledge required in other curricular components of each program (Souza; Boruchovitch, 2010). Among these disciplines, Human Anatomy is considered one of the pillars of the curriculum for health-related undergraduate programs (Verri, et al., 2011). According to Dangelo and Fattini (2011), the etymology of the word "anatomy" derives from the terms "ana" (into parts) and "tomein" (to cut), reflecting the discipline's focus on the detailed study of body structures, both at the macroscopic and microscopic levels. According to Gray (2010), understanding anatomy requires a context in which terminology can be remembered. However, anatomy goes beyond simple memorization; it is important to know anatomical language and correctly understand the position of structures, integrating a vast amount of information.

In this way, when examining the learning process in the mentioned discipline, it is observed that the difficulties present in the literature, the complex and unusual nomenclatures, as well as the complexity in relating theoretical and practical content, contribute to the demotivation of some students. (Crochemore; Marques, 2017; Silva, et al., 2018).

According to a report released in 2022 by the Federal University of Minas Gerais (UFMG) on the website of the Dean of Undergraduate Studies - PROGRAD, which contains analyses of disciplines from 2014 to 2021, it is found that in Human Anatomy disciplines, significant failure and dropout rates are identified.

In light of the above, the present study aimed to analyze and evaluate the impact of using the Concept Map (CM) as a pedagogical strategy in the "Basic Human Anatomy" discipline, which is part of the curriculum of several health area courses at UFMG, considering academic performance and students' perception of the use of the pedagogical tool.

1.1 Meaningful Learning

According to Ausubel (2000), meaningful learning refers to the acquisition of knowledge from presented material, which must be potentially meaningful to the learner. This process is important for education because it involves mechanisms for the effective acquisition and storage of concepts.

Thus, meaningful learning has two main characteristics: non-arbitrariness and substantiveness. Non-arbitrariness means that "the potentially meaningful material relates non-arbitrarily to existing knowledge in the learner's cognitive structure" (Moreira, 2011, p. 26), that is, new ideas are learned in a relevant way as they connect to other ideas already present in the subject's cognitive structure.

The concept of substantiveness, on the other hand, indicates that "what is incorporated into the cognitive structure is the substance of the new knowledge, not the words used to express it" (Moreira, 2011, p. 26). Therefore, acquiring new meanings independently of the concepts used results in more lasting learning, according to Queiroz and collaborators (2023).

Among the knowledge representation tools based on the principles of TAS, there are CMs (Novak; Cañas, 2007). CMs were created in the 1970s by Joseph Novak, based on Ausubel's TAS, and thus provide the organization of knowledge through the hierarchical arrangement of concepts (non-arbitrariness principle) in an integrative manner (Novak, 1998; Novak; Gowin, 1999). According to Tavares (2007), the CM is a schematic structure tool to represent a set of concepts, structuring the student's knowledge.

For Novak and Gowin (1984), maps are used as a visual representation of knowledge through diagrams that organize and relate concepts. Still according to Santos and Costa (2021), CMs consist of a set of ideas that are linked to concepts and perceptions through symbols, drawings, and words, establishing hierarchically organized relationships.

Concept Maps (CMs) have several important characteristics, such as the hierarchical organization and linking of concepts. The hierarchical organization generally follows an arrangement, as described by Novak and Cañas (2010), where more general concepts should remain at the top, while more specific concepts should be placed below. The inclusion of cross links, or cross connections, which are links between different concepts, is also important. In line with the ideas of Novak and Cañas (2010), this is an essential feature in the development of CMs, as it makes it possible to see how one concept relates to another within the map. In this way, this pedagogical tool aids in promoting student learning, as it fosters a sense of unity, articulation, subordination, and hierarchical organization of disciplinary content, enabling an integrated perception of the concepts covered (Figure 1).

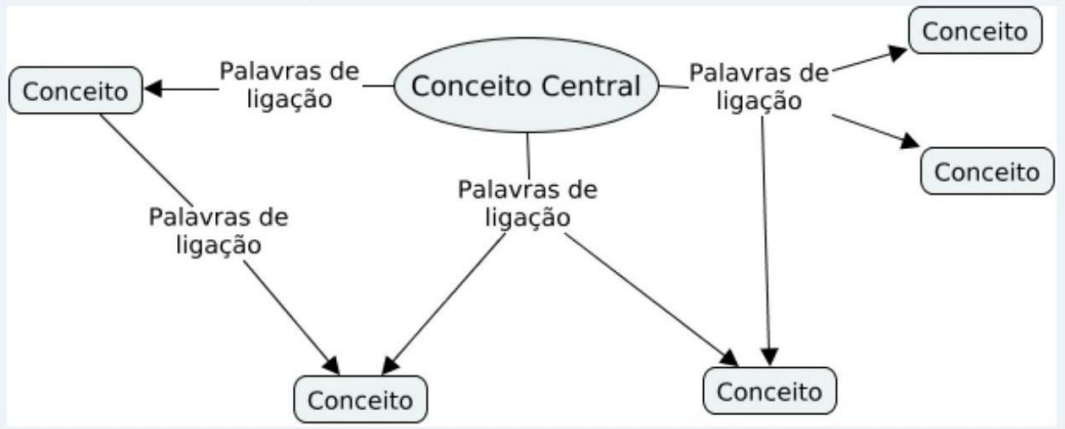

Figure 1: Structural Model of a Concept Map

1.2 Concept Maps in Higher Education

CMs were created based on three principles of Ausubel's Meaningful Learning Theory (MLT). First, the development of new meanings is related to relevant concepts and propositions previously established in the student's cognitive structure; second, hierarchical organization within the cognitive structure; third, explicit, precise, and integrated relationships between concepts and propositions, which are more verbal, according to Novak and Cañas (2007). Teaching methods based on the application of CMs have already demonstrated success in higher education, being implemented in various courses across different fields, including several health-related courses (Silva; Lima; Santos, 2017; Queiroz, et al., 2023), exact sciences (Moreira; Soares; Paulo, 2008), and biological sciences (Queiroz, et al., 2018).

The experience of Queiroz and collaborators (2023) presented the results of applying the CM tool in a health-related course at UFMG. The study points out that the applied pedagogical tool:

"(...) was of extreme importance for the training of students, monitors, and professors, contributing to the promotion of debate regarding pedagogical innovations and the use of CMs in higher education, providing an effective opportunity to reflect on learning processes and plan interventions to improve and ensure the success of teaching practices".

Freire-Maia and collaborators (2011) also demonstrated the positive use of CMs, including by students, when adopted in subjects of the Dentistry Course at UFMG. Furthermore, the authors also pointed out that "the application of CMs should be encouraged from the beginning of the course".

Silva and collaborators (2018) showed that the incorporation of CMs into the teaching context of Human Anatomy represents an effective pedagogical strategy. This approach goes beyond traditional learning methods such as textbooks, lectures, and atlases, promoting students' critical development. Additionally, the results indicate that such a tool influences the improvement of students' final grades, as well as greater satisfaction during the learning process. All of this is due to the fact that CMs have characteristics that favor the construction of meaningful learning.

According to Dangelo and Fattini (2011), knowledge about anatomical structures is not static; on the contrary, it is a process that expands as new strategies and technologies are used, which requires continuous evolution in the learning process. Silva and collaborators (2018) add that while some changes, such as the advancement of technologies, have facilitated the study of Anatomy, others have made the process more challenging.

Silva and collaborators (2018) state that despite the various developments aimed at improving academic training, students' overall performance is still below expectations, resulting in high failure and dropout rates. Due to its complex nature, with a large number of structures requiring memorization, anatomy teaching can be demotivating, especially for those encountering the content for the first time (Salbego, et al., 2015).

The use of MC as a complementary teaching tool in the Human Anatomy courses at the Institute of Biological Sciences (ICB) of UFMG has been employed since 2013. However, the present study will present the team's experience in the context of the Human Anatomy courses for the Physical Therapy and Occupational Therapy programs in 2022. The syllabus of these courses includes the study of Systemic Anatomy and Applied Anatomy, with the total class hours divided into practical and theoretical classes, totaling 120 hours for Physical Therapy and 60 hours for Occupational Therapy. According to the report published in November 2022 by the Statistics Sector of the UFMG Dean of Undergraduate Studies, the Human Anatomy course had failure rates of 5% and 3.4%, and dropout rates of 9.4% and 6.8% in 2020 and 2021, respectively.

In this context, the analysis of these data contributed to the pedagogical monitoring of curricular academic activities, as well as assisting in the reformulation of strategic plans and the application of complementary teaching tools. Thus, the basis of this study is to promote, through TAS, better content retention, as well as the reduction of failure and dropout rates in the Human Anatomy course.

2. METHODS

2.1 Target Population

The application of the MC development and construction tool was carried out with 161 students, in both semesters

of 2022, in the Human Anatomy course of the basic cycle, offered by the ICB of UFMG in the Physical Therapy and Occupational Therapy programs.

2.2 Methodological Steps

2.2.1 Project presentation

Initially, to enable students to understand the dynamics of structuring the MC, presentations were held, some in person in the classroom and others via an explanatory video lesson. In this regard, the following pedagogical strategy was used to develop the pre-established themes:

a) identification of ideas, concepts, and keywords about the theme;
b) enumeration of the main concepts conveyed in the presentation text;
c) evaluation and classification of the enumerated concepts in descending order of importance;
d) insertion of keywords and formation of short sentences with appropriate propositions, using arrows to link the enumerated concepts;
e) identification of connections between the different concepts that make up the map;
f) dynamic reading of the map.

Concurrently, there was also an explanation of how to post on UFMG's educational platform, Moodle, where the format should be an image to facilitate the correction of each theme in the designated location.

2.2.2 Metaturma on the Moodle platform

After all clarifications, the students constructed maps and posted them in image format in the designated and individualized location within the metaturma of the Human Anatomy course for their class. It is emphasized that the posted maps should present the same configurations discussed in the previous project presentation, with hierarchy, identification, enumerations, propositions, connections, and dynamics established—all inherent aspects for better visualization of the final product.

Regarding the evaluation of the MCs, the essential characteristics already mentioned earlier, those based on the frameworks for map construction, were analyzed and highlighted. Failure to meet the taught and designated prerequisites was pointed out and detailed for the student on Moodle, with the possibility of correction and resubmission on the platform.

2.2.3 Application of the questionnaire

After the posting and completion of the MC evaluation on Moodle, a semi-structured questionnaire was sent at the end of each academic semester to all students who took the Human Anatomy course in the Physiotherapy and Occupational Therapy programs in 2022. The questionnaire was applied to verify the qualitative impact, which was not intended for comparison but aimed to establish support for the learning facilitated by the use of MCs as a pedagogical strategy.

Some of the questions in the questionnaire sent to the students are shown in Table 1.

Table 1: Questions sent to students via Moodle

QUESTIONS FOUND IN THE QUESTIONNAIRE
Before starting the course, were you already familiar with the MC methodology?
How do you rate the guidance received in the introductory class for understanding the MC?
Do you consider that the monitor's work contributed to the application of MC in your course?
How do you evaluate the virtual learning environment (Moodle) used for the application of MC?
Did you encounter difficulties in developing the MC?
Do you intend to continue using CMs as a study tool in other subjects later in your course?

3. RESULTS AND DISCUSSION

In the application of CMs each semester, a total of 30 tabs were opened in Moodle related to 30 themes linked to the basic human anatomy subjects, for example: "Skeletal System", "Muscles of the Hand", "Innervation and Vascularization of the Lower Limbs", among others, resulting in a total of 2,585 CMs posted (Figure 2).

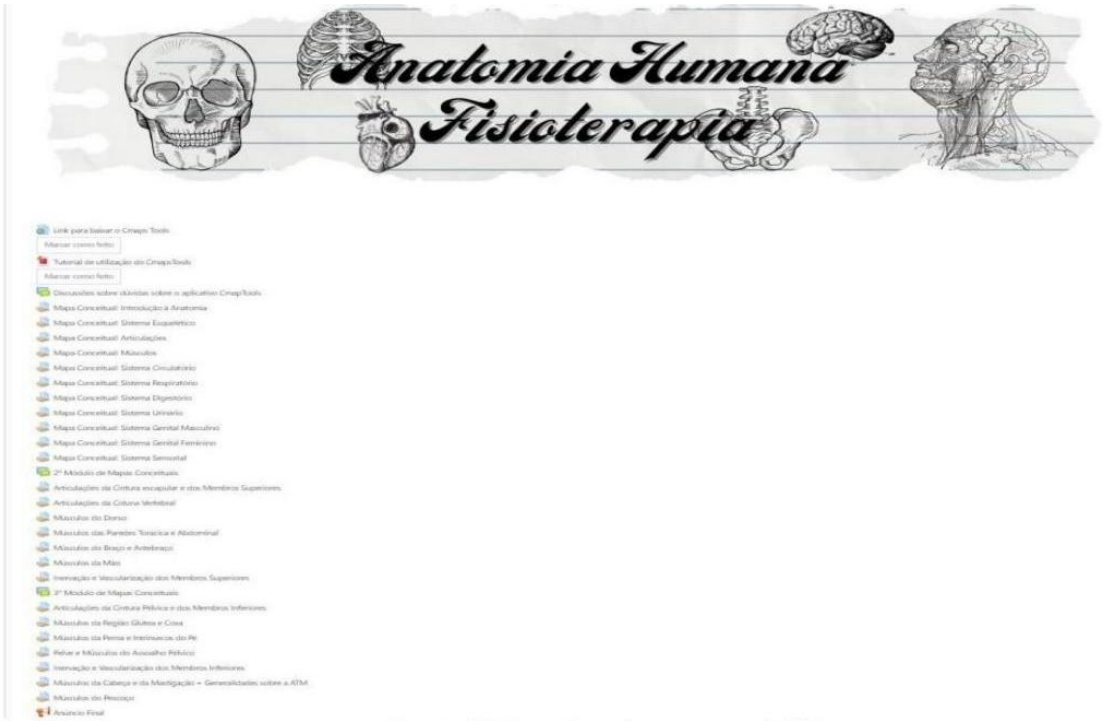

Figure 2: Metaturma representation in Moodle

In the first CMs developed by the undergraduates, the monitors observed the following difficulties: inadequate distribution of concepts, placing more than one concept in the same box, incorrect use of linking words, as well as the overall organization of the map. After creating a few maps, the students were able to understand and apply the tool appropriately.

As an example, below is a map by an undergraduate student in her first contact with the project and the CMapTools tool (Figure 3) and a CM by an undergraduate student in the final phase of the project with experience in developing the graphic representation of concepts (Figure 4).

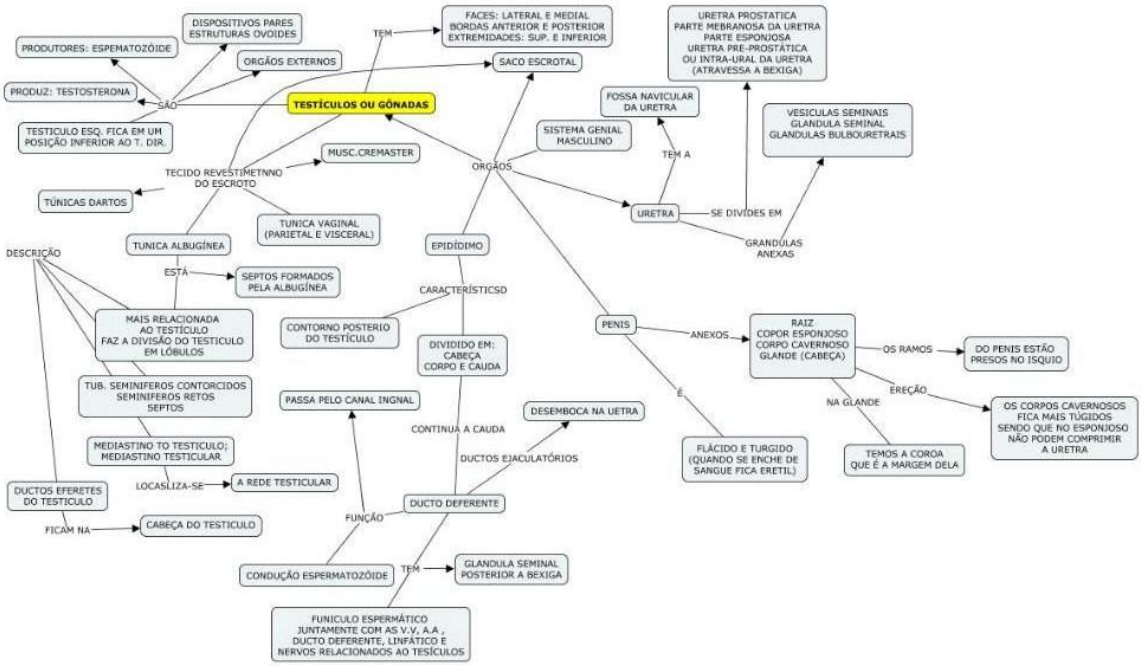

Figure 3: Representation of a CM developed at the initial stage of the project

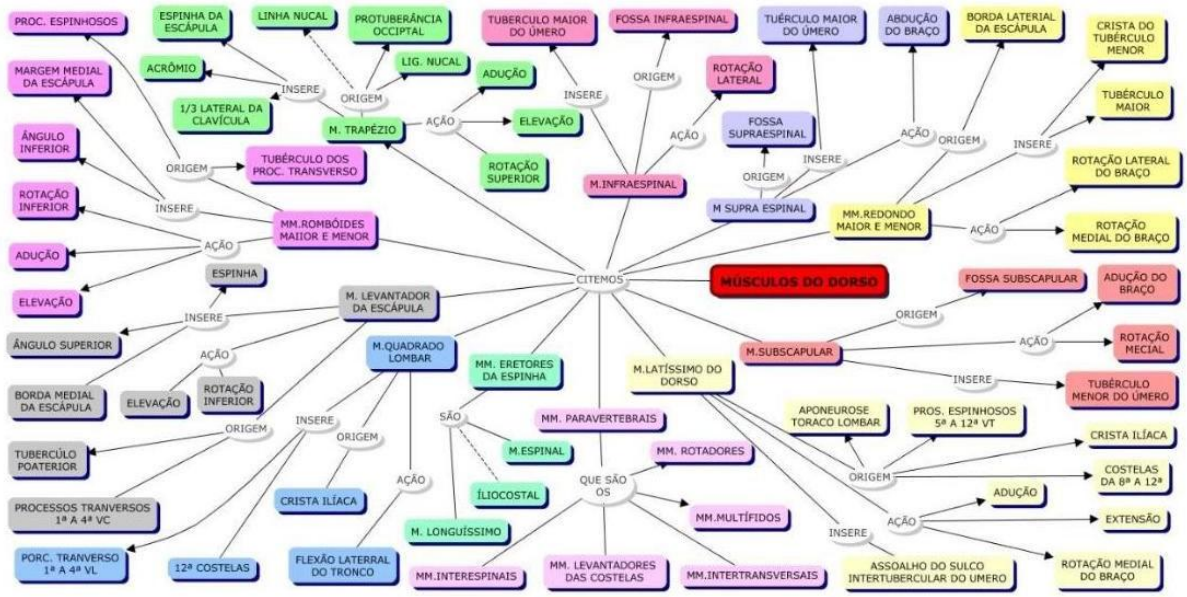

Figure 4: Representation of a CM developed in the final phase of the project.

At the end of the 1° and 2° semesters of 2022, among the 161 students enrolled in the Human Anatomy subjects, the focus of the present study, 33 agreed to participate in the research, signing the Informed Consent Form (ICF) and answering the questionnaire conducted via Google Forms. The results obtained from the analysis of the responses will be described below.

It was noted that 55% of the students were not familiar with the CM methodology before starting the subject. In this context, 24% of the students reported total satisfaction and 43% partial satisfaction regarding the guidance received in the introductory class for understanding TAS and CMs. Aguiar and Correia (2013) address the importance of adequate guidance and appropriate feedback on the use, development, and construction of maps. In this sense, 55% of the students considered that the monitors' work contributed positively to the application of CMs, in addition to showing 33% total satisfaction and 33% partial satisfaction regarding the monitors' evaluative feedback.

Regarding the use of Moodle for publishing and correcting CMs, 36% of the students were completely satisfied, while 9% were completely dissatisfied. 15% of the students reported difficulties with the organization of the platform, the available materials, as well as access to post activities. In contrast, 72% reported total or partial satisfaction on the same points. It should be noted, then, that the appropriate use of the Virtual Learning Environment (VLE) for innovative education should stimulate curiosity, collaboration, problem-solving, the search for information, and its contextualization (Moraes; Grigoli, 2013).

In the development of the maps, 52% of the students completed them without any difficulty, while 48% encountered some obstacles in their creation. Moreira and Masini (1982) describe that CMs can be complex, which ultimately results in difficulties in retaining content, in addition to the student's ability to build their own hierarchies, which may be inhibited. Thus, among the challenges encountered by the students, 38% related to adapting the structure to the evaluated parameters, 56% to the time required to create the CMs, and 6% to the use of the CmapTools platform.

Of the total participating students, 27% expressed an intention to continue using the pedagogical tool, CMs, as a study method. In their justifications, they reported: "I noticed that CMs use a way of organizing ideas that aligns very much with how I think and understand things" and "the maps help in quick content reviews". In this regard, 52% of these students stated that they would recommend the use of CMs to other colleagues, perceiving them as a pedagogical innovation and an effective study method that allows the use of new technologies. From this perspective, it can be stated that the students who wish to continue using CMs agree with what is pointed out by Moreira and Buchweitz (1993), who state that through CMs it is possible to structure, hierarchize, relate, and integrate concepts of a specific topic.

Regarding the students' perception of creating CMs, 57% agreed that creating the maps led them to reflect on other possible complementary learning tools. According to Hoffmann (2001), creating a CM teaches and drives learning through the active search for new information, reflection on the learning procedures themselves, as well as self-reflection as a learner. In this sense, 48% of the students stated that creating CMs also actively contributed to diagnosing essential elements for reviewing content in human anatomy courses.

Aguiar and Correia (2013) argued that while creating CMs, students can identify strengths and weaknesses in their own understanding of specific content, establishing a guide for reviewing those that are still unclear. In this sense, 72% of the students who responded to the questionnaire agreed that CMs helped them diagnose elements that needed review regarding the studied topic.

Finally, in the self-assessment, from the students' perspective regarding their commitment to creating CMs, 72% of the students agreed that they were satisfied with their development and proficiency in this applied activity. Creating a map involves exercising critical thinking, analytical and synthesis skills, and creativity; all of which can positively influence the student's engagement in the CM development process (Cotta, et al., 2015).

4. FINAL CONSIDERATIONS

The results presented in this study demonstrated that the use of CMs as a complementary pedagogical tool facilitated knowledge construction and promoted undergraduate students' engagement in studying Human Anatomy courses. The reported experiences indicated that this pedagogical strategy can be effective for other courses, strengthening the connection between new concepts and prior theoretical and practical knowledge.

The observations and perspectives found in the questionnaire analysis showed that the hybrid approach, involving the development of maps using software such as CmapTools and posting them in a virtual learning environment like Moodle, can be useful in different contexts, offering a viable and effective alternative for promoting teaching and learning, as well as expanding the reach of face-to-face theoretical and practical classes. It can also be emphasized that the difficulties reported by the students were relevant for improving and detailing the information regarding the development and construction of the CMs during the guidance process.

Furthermore, the results of this work indicated that the experience provided learning regarding the process of searching for and producing scientific knowledge, in addition to enabling the project team to develop time and people management skills and to gain proficiency in the content covered.

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