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Educational Strategies

The use of mind maps as support in medical education

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ABSTRACT

During their undergraduate years, medical students are exposed to a large amount of information. In this context, students often become passive recipients of information. In recent years there have been a growing number of publications on learning strategies used in medical education, which can help students to learn and integrate information. This situation requires a change in the role of teachers and their methods: they will be less responsible for the content and will be increasingly involved in the guidance of research and knowledge discovery processes. In this scenario, the possibility arises of using a graphical technique called Mind Maps, systematized by Tony Buzan, in the process of knowledge representation. It is a visual technique where information and knowledge are converted to a hierarchical, formatted and illustrated diagram, with structural key terms associated with a subject. This paper aims to describe the main characteristics of mind maps and show how students and teachers can use it in teaching and learning processes, contributing to better quality and performance in medical education.

INTRODUCTION

Higher education in health sciences in general, and in medical studies in particular, has been the target of severe criticism in recent decades [1]. During their undergraduate years, medical students are exposed to a large amount of information. In this scenario, it is likely that students often become passive recipients of abundant information transmitted by teachers, and are rarely, if ever, actively involved in the learning process itself [2]. Thus, in many countries questions have arisen about the ability of medical courses to fulfill the general aims of their programs, which should prioritize students' potential intellectual development, analytical capacity, judgment and critical evaluation, ability to solve problems, critical thinking, and creative and inquisitive approach [1].

In recent years, there have been a growing number of publications on learning strategies used in medical education, which can help students to learn and integrate information [3,4]. However, this situation requires a change in the role of teachers and in their methods: they should increasingly be mediators and facilitators of student learning. Thus, finding appropriate strategies for teaching practices should constitute an essential part of teacher training [1]. In this context, a possibility arises of using a graphical technique called mind mapping, created by Tony Buzan in the 1970s, in the process of knowledge representation [5]. This technique has been used in a variety of activities and by various professionals; in the educational field, it serves to facilitate and enhance the learning process [6].

Mind mapping is a visual technique where information

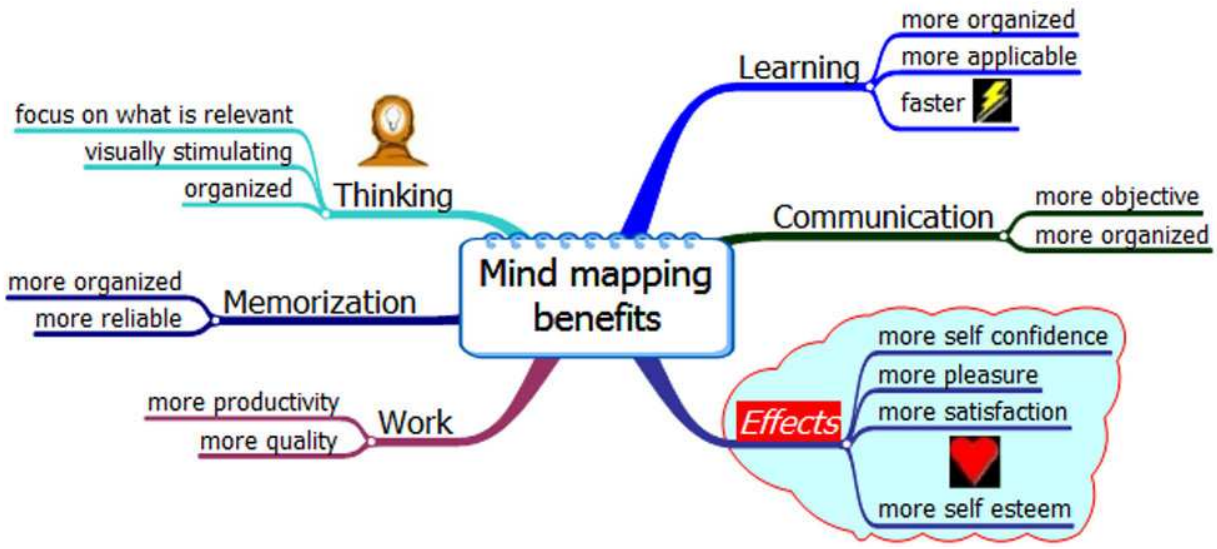


Figure 1. Benefits of Mind Maps elaborated with EasyMapper software, version 1.2 [7].

and knowledge are converted into a hierarchical diagram, formatted and illustrated, with structural key terms associated with a theme, helping learners to understand certain content better, integrate it and memorize it faster [7,8] (Figure 1). This paper aims to describe the main characteristics of mind maps and demonstrate how students and teachers in medical education can use it in the teaching-learning process, contributing to better quality and yield. Because mind maps are entirely structural, their applications in teaching and learning are not restricted to a particular context or knowledge domain.

Visual mapping techniques in the context of active acquisition of knowledge

Since the passive acquisition of knowledge (reading, listening, observing) is much less efficient than active acquisition (acting, discussing, building) [9], national and international medical schools have changed their educational programs and teaching strategies, to ensure that students have active responsibility in their learning process and that they are better prepared to complete the course. The effort to develop active learning has been based on a concern, expressed by experienced medical educators, that students are memorizing facts instead of understanding and applying concepts [7].

Modern insights on learning emphasize that learning should be a constructive, self-directed, collaborative and contextual process [10]. The theory of didactic learning methods focuses on the baseline knowledge students possess (individual learning starts in earlier experiences, which is the basis for individual understanding) and seeks to improve upon and convey this information. It also refers to the foundation or starting point in a lesson plan, where the overall goal is knowledge. A teacher or educator functions in this role as an authoritative figure, but also as both a guide and a resource for students. In practice, some lessons have well-reasoned linkage of different forms of learning such as didactic, inquiry and collaborative learning, which effectively achieve multiple learning goals such as cultivating an attitude toward learning, acquiring domain knowledge, developing communication skills and so on [10-12].

Active learning methodologies, such as case-based teaching, web-based teaching, didactic learning and problem-based learning are recognized strategies used to promote critical thinking in students [3,13]. These strategies help students learn and ultimately integrate information [3]. Although these learning strategies may differ in efficacy and applicability, all of them are rooted in a conceptual framework called the constructivist theory of learning, which states that meaningful learning, or learning with understanding, occurs when learners assimilate new information within their existing knowledge. Constructivism also underlies two learning strategies that are promising in the context of medical education - namely, concept mapping and mind mapping [3].

The concept map strategy, which was developed by Joseph Novak, uses hierarchical order to link concepts together with propositions, or the linking of words, between concepts: it is a top-down diagram showing the relationships between concepts, including cross connections between them, and their manifestations [3,14], where the main function or benefit is that the

systematic relationships among sub-concepts relating to one main concept are shown [14]. However, although concept maps have been extensively used in classrooms and related learning and knowledge-sharing contexts, demonstrating their positive effects on student learning for various topics and in various teaching situations, they are not without drawbacks, mainly because: (1) they may not be appropriate for developing procedural skills, i.e. representing or structuring sequential content such as processes or developments over time; (2) the boxes and arrows formatting may also make it difficult to represent a large number of related items in an accessible format; (3) they are not a very rapid visualization technique [14]; and (4) the student creates the concept map without a template, so it may represent the student's own interpretation of ideas [3], which is not always correct. Thus, although numerous benefits can be achieved by applying this visual mapping technique, students or professionals who are faced with having to read or build complex conceptual maps may initially feel overwhelmed or discouraged by the complex web of relationships [14].

In addition to the concept map, there is the mind mapping strategy, which is easier to visualize and relies on student interpretation and understanding. Although this learning strategy has not been widely used in medical education, recent research suggests that mind mapping improves long-term memory in medical students. It is a multi-sensory tool that uses visual-spatial orientation to integrate information and, consequently, help students to organize and retain information [3].

A mind map is a schematic representation of words, ideas, concepts or other items associated with a theme of study, being composed of topics organized into a hierarchy; i.e. there is a central topic from which others radiate [15]. Its construction is very simple and is based on the descending hierarchy of concepts, irradiating ideas and flow of topics, using keywords and reading hourly [6,16]. In a mind map the main theme of the study is inserted in the center, from which keywords connected by colored lines and images branch nonlinearly in a divergent pattern. These keywords correspond to subtopics that, in turn, may present smaller branches that present more detail about the subject included, in a progressive branching pattern [5,7,15]. Thus, a mind map is mainly a tool for organizing ideas via keywords, colors and images in a structure that radiates from a center [16]. It can be elaborated manually or through software. One obvious advantage of the software-based approach is that it lends itself easily to e-learning contexts where the visual methods can be viewed or edited remotely by all learners via application sharing; besides, topics and subtopics can also include hyperlinks, notes and other properties [14,15,17].

Mind maps can be used in any situation that presents a structure of hierarchical relationships and their use develops the ability to organize and apply knowledge. They also show accurately the missing elements in their structure; thus, the user is prompted to seek and fill in the information still needed to complete the understanding of the system [16]. By making it easier to reach an understanding of the fundamental principles of a large amount of information and to organize and integrate many concepts, mind maps can be used as support for self-learning methods and also to promote active learning [7]. The content is mapped into a single structure and thus, into an integrated form. Therefore, just as the tools generally help in the execution of mechanical activities, mind maps help the intelligence, expanding the capacity to think systemically, allowing segmented attention and maintaining a relationship with the whole [16].

The purposes and reasons for the use of mind maps in teaching and learning are: (1) extracting what is relevant in a discursive text; (2) organizing ideas; (3) learning through synthesis, filtration and reorganization of ideas, which is a powerful stabilizer of learning; (4) facilitating revisions; (5) planning, better visualizing both the content mastered and that not yet mastered, to help in planning studies; (6) collaborating: study in groups or in pairs allows mutual enrichment, and mind maps elaborated by or submitted to a group may be of higher quality, by the contribution of more people in the form of ideas and criticisms [17].

In medical education, the advantage of using mind maps is that this technique enables students to use a new learning option, integrating information and, thus, helping them organize and retain that information [3,4].

Overview of Mind Maps in Medical Education

The advantage of using mind maps in medical education is that this technique can benefit more students with different learning styles [4], since these maps have the potential to provide a strategy for retaining information, integrating critical thinking and skills to solve problems [18]. Thus, the use of mind maps as a learning strategy can help students to master the tsunami of information presented in medical school [3]. However, although some studies indicate that mind maps are perceived by medical students [7], examiners [3] and researchers [4] as a useful learning tool, it has not been proven that mind mapping increases the domain of information in short-term memorization or critical thinking in relation to standard annotations [4]. Moreover, although it has been demonstrated that medical students using mind maps can gather information successfully in the short-term, not experiencing any disadvantage compared to those who study via annotations [4], the motivation of

students who used mind maps was lower than those using self-selected techniques of study [7]. One possible explanation is that a tool can be very useful, but only for those who know how to use it, which implies training requirements.

Although mind maps are often presented as a technique, their nature is rather to provide a way of representing knowledge; the technique itself will consist of the way the map is used. Therefore, users of mind maps need training in their use to make the most of the resource's potential. The structuring of ideas into simple and leveled topics effectively has the potential to increase the yield from studying and using knowledge, but this by itself is not enough; it also needs to have semantic quality, e.g. the quality of the organization of ideas in a mind map. Mind maps, being hierarchical, are suitable for representing knowledge with hierarchical structure or adaptable to this structure. Inadequately represented, knowledge will suffer distortions or adjustments that may result in loss of information. Thus, the motivation for choosing a technique of self-selected study that works tends to be greater than for choosing a new technique that can take a long time to master.

Use of Mind Maps by Medical Students

A learning strategy is a thinking tool that students can use to actively acquire information, and some examples include mnemonics, charts and maps [3]. In the context of mind maps, the essence of the learning action is to develop a mind map of the given content. The goal of mind mapping techniques is to make it easier for students to represent or manipulate a complex set of relationships in a diagram, which in turn facilitates analysis, memorization and understanding these relationships [18]. The ability to understand these relationships has been proposed as reflecting the kind of thinking needed for clinical practice [19]. Throughout the process of formatting the content in mind maps, students will be actively studying because they will be generating a product and not just trying to memorize content; this will organize thinking and stimulate learning. To fix the knowledge one can make a critical review of the mind map, making sure that the hierarchy and flow of topics are appropriate; the same mind map will serve as material for further revision of the subject, so that students can quickly reactivate their learning. In addition, the mind map can also be used for study planning. Based on the mind map, students can assess their learning, topic by topic, and plan their dedicated effort based on the needs identified in the assessment. Finally, to present and explain the mind map to someone is a very effective strategy to test and integrate content, since sharing of experiences allows students to critically think and undertake structured reflection on how the events may influence their personal circumstances. This facilitative approach to teaching teases out previous learning and helps students 'make sense' of experiences in relation to real world events [20].

In the conventional medical curriculum, which divides the subjects into a basic cycle and a clinical cycle, human anatomy is a core discipline, constantly and commonly allocated in the first two years, as it is understood as essential to the profession [21]. However, many students have difficulties in learning anatomical structures, particularly with regard to memorization [9]. In this context, mind maps can help organize ideas and facilitate memorization, due to their visual and conceptual structure. Next, we look at a practical example: discursive text and a mind map on the external anatomy of the kidneys (Figure 2).

EXTERNAL ANATOMY OF THE KIDNEY: DISCURSIVE TEXT (Adapted from Moraes and Colicigno, 2007) [22].

Each kidney has an apex, a base, a convex lateral border (outer side), and a concave medial margin (inner side). In the latter there is a deep fissure called the renal hilum, a region that allows kidney structures to enter and exit (*veins, arteries, nerves and the ureters). Superficially, the kidney is covered by a fibrous tunic. If we make a longitudinal section in a kidney, passing through its edges, we see a fibrous outer layer, which is called the renal cortex. Toward the medial side, we find the renal medulla, a dark reddish structure in a triangular shape, with its base facing the cortex and its apex facing inward, called the renal pyramid, interspersed by column-shaped structures termed renal columns. At the apex of these pyramids the renal papilla is found,* a *structure that releases its excreta into a system of renal calyces (major and minor) which unite to form the renal pelvis, which leads into a thin tube called the ureter. This system, together with the blood vessels and nerves which have access to the kidney, are found in an expansion of the renal hilum called the renal sinus.*

Use of Mind Maps by Medical Teachers

Despite the proposed changes in curriculum and teaching, changes in medical education have encountered difficulties, as teachers continue to teach in the way they know and resist taking on new teaching-learning methodologies [1]. This is because clinical teachers rarely receive formal instruction in the basic concepts and principles of education: their knowledge is generally related to behavior, strategies and teaching techniques, but few understand the basic principles, theories and concepts of teaching and learning [23]. Moreover, teaching is considered a secondary activity by the medical profession: the criterion for recruitment of teachers in medical courses

is primarily focused on the quality of their performance in their technical area of expertise. In other words, teachers are hired on the basis of their work in research and scientific publications rather than their teaching ability [1]: it is generally assumed that expertise as a practitioner will translate into effectiveness as a teacher [23]. Also, it is difficult for teachers to design lessons rationally because few studies have explored the potential to connect different forms of learning effectively [11]. Since mind maps can facilitate the application of knowledge gained from clinical practice and research to help patients in various aspects of diagnosis and treatment [19], as well as helping to manage qualitative data in processes involving patients [24], this tool can stimulate clinical teachers to think "outside the box". In turn, its application in teaching practice will become easier, and students thereby assimilate key information essential for professional practice, either working on case studies, engaging in problem-based learning or pursuing other learning strategies.

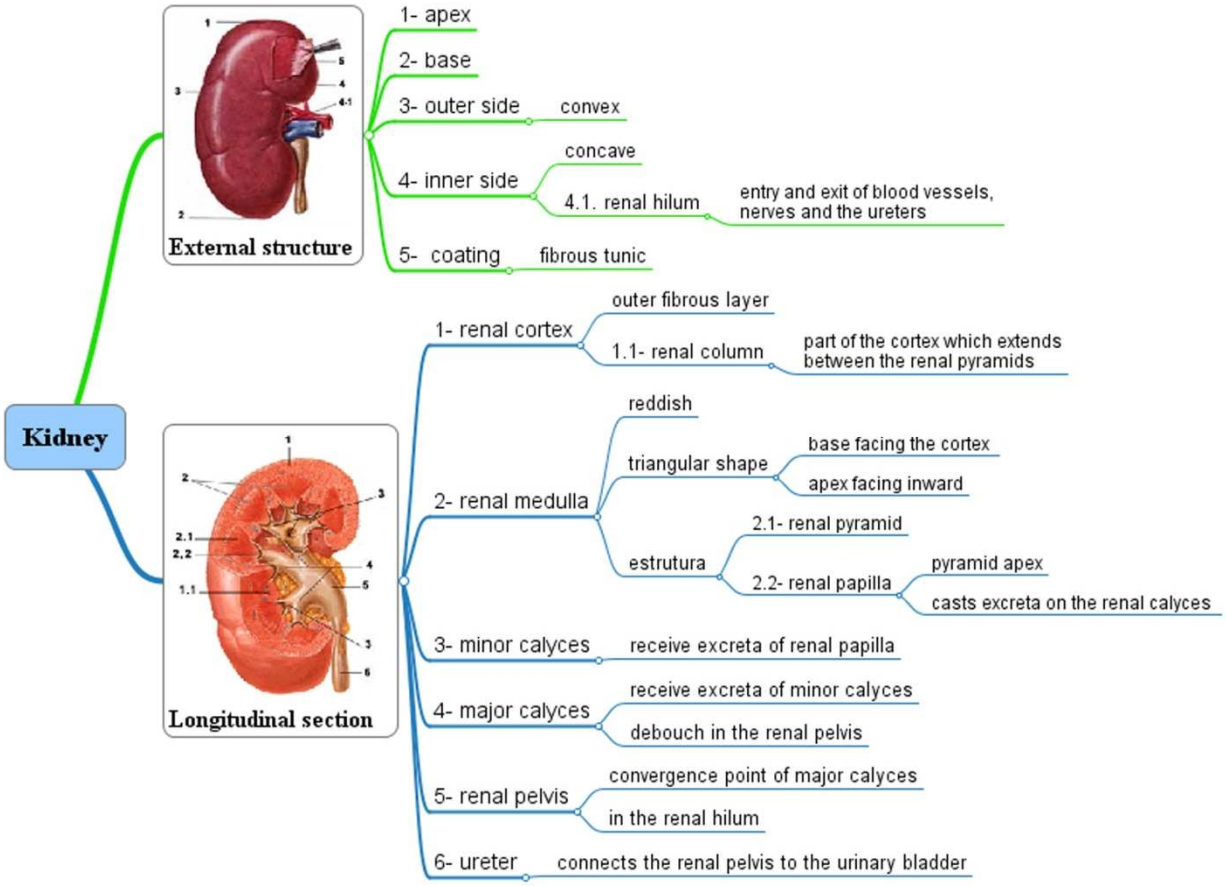
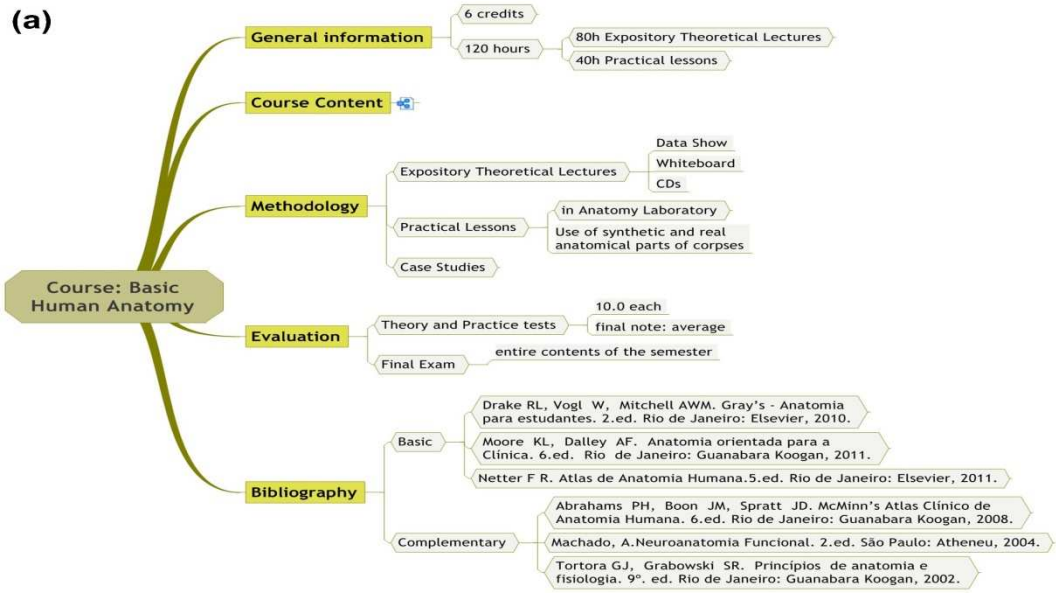


Figure 2. Mind map elaborated with EasyMapper software, version 1.2, about the text External Anatomy of the Kidneys, adapted from Moraes and Colicigno (2007) [18]. The elements that were missing in the structure of the text were inserted into the mind map.

Normally teachers must follow predetermined content, but this content is not always in a very appropriate format. It can appear within pages and pages of discursive text that, even when partially segmented, may describe the concepts of teaching methodologies in a fragmented and disorganized way, making learning and concept application difficult and reducing related productivity and efficiency. Educational materials usually contain elements of grammar, like punctuation and prepositions, which are very helpful for accurate reading comprehension but are not vital to the understanding and assimilation of meaning content. In this sense, mind maps can make a significant difference, because they organize content into topics with a single idea, increasing levels of detail and decreasing levels of generalization, thus serving as a secure base for the content sequencing required for planning teaching [8], as showed in Figure 3.



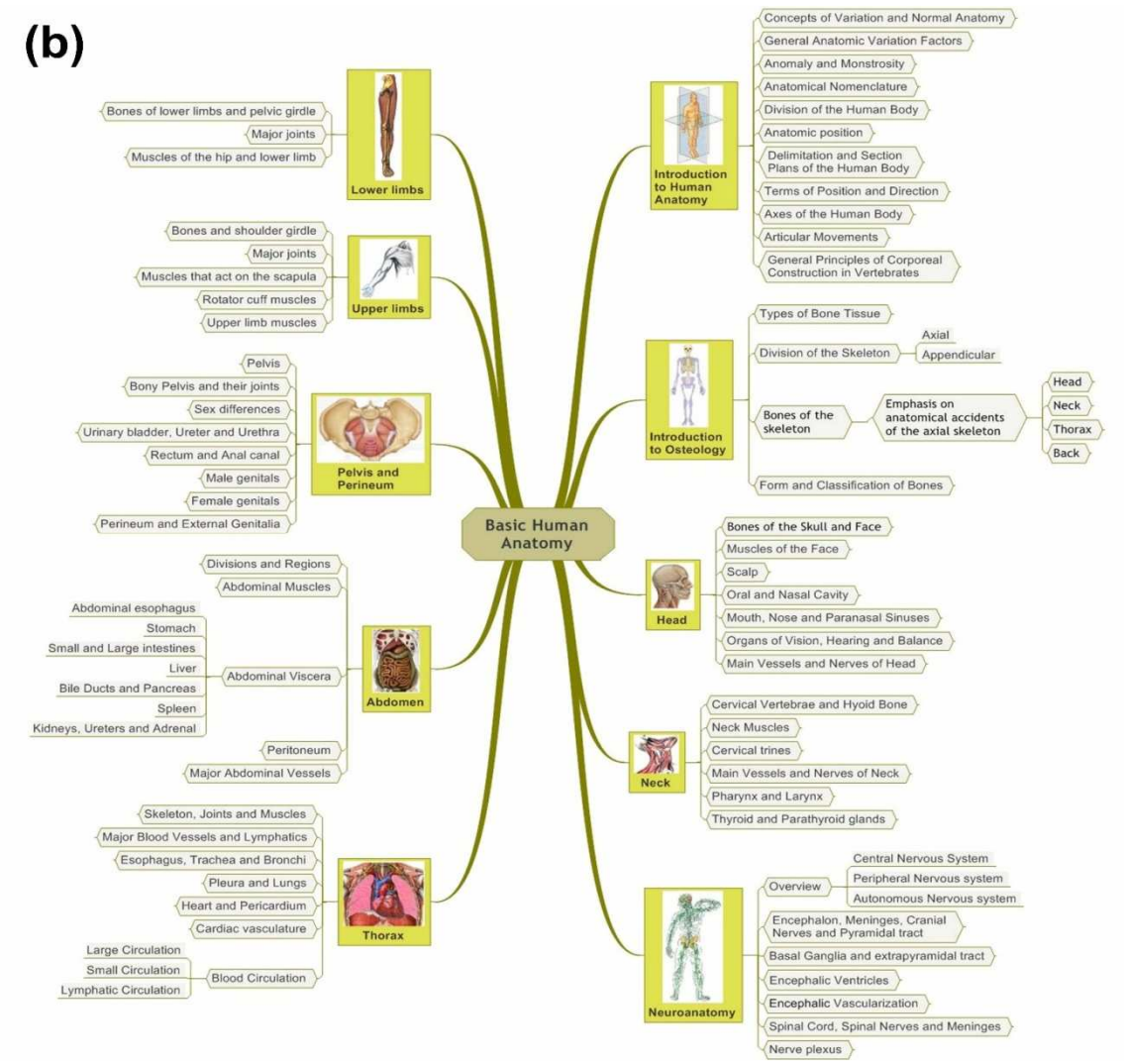


Figure 3. Mind map elaborated with MindManager Lite 7 software, of a course plan and content of Human Anatomy - 1st semester of medical school. **(a)** Course plan, where the mind map of the content of Basic Human Anatomy is indicated with a hyperlink; **(b)** Course content of Human Anatomy.

The same mind map can be used by the teacher in lesson preparation, in the lesson itself, and be delivered to the students, in conjunction with the classes [8,16]. When being defined, and with mind map software editing facilities, the main topics and their detailed topics can be productively edited. If an entire course and not just a discipline is being designed, all topics can be identified and then distributed in disciplines, which defines a new primary level in the mind map. After it is stable, the course content can be used in several ways: to register references for each topic, possibly with hyperlinks; as a guide to lesson planning; it can be shown in a web page; it can be delivered to the students. It can also be used by the teacher to control which topics have already been covered and which have not, simply by formatting topics with a different color [8,17]. When planning work, the teacher can use a mind map to work out the structure of lessons, classes and activities. For example, a template of a mind map to define tasks that have learning objectives as a basis is shown in Figure 4.

Final considerations

According to constructivist learning theory, most notably propounded by Jean Piaget, we learn not only by simply memorizing new facts and concepts, but also by assimilating information into a preexisting knowledge structure [25,26]. This theory is supported by the empirical evidence that the development of an elaborate and well-structured framework of knowledge determines, at least in part, how knowledge is used for decision-making and problem-solving [26]. Thus, learning is basically an experience of constructing meaning. The experience can be individual or collective; however, learning is unique and individual. A series of activities is performed: tasks, reading, discussions and reflections, which result in learning [8,15]. In this regard, the elaboration of mind maps as auxiliary diagrams for constructing meaning can greatly facilitate learning. However, it should be remembered that mind mapping, as a technique, requires training. To process a mind map, one has to know its components and rules and how to read a mind map, how to structure information hierarchically, how to write or draw information, for handmade mind maps; or how to use mind map software, for mind maps made with a computer.

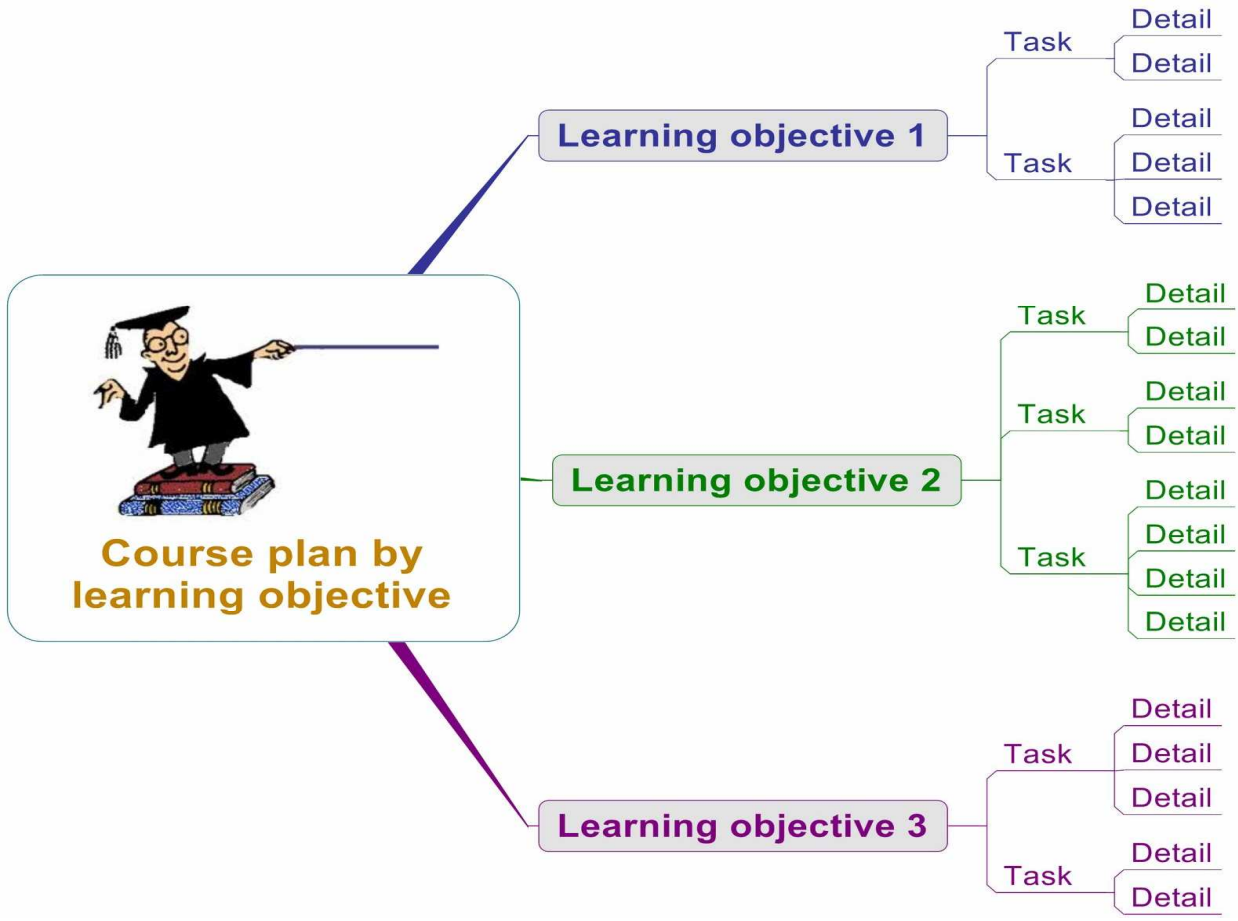


Figure 4. Mind map elaborated with MindManager Lite 7 software, of a course plan by learning objectives.

CONCLUSION

It can be suggested that the use of mind maps as an aid in medical education is a potentially valid tool that can be used by students and teachers for multiple purposes. It is a technique that can be easily taught and learned and requires no equipment or high costs. Since the combined use of learning methods could compensate for the limitations of different individual methods, enabling a richer learning experience for students, mind maps can be an attractive resource that, added to the repertoire of active strategies in teaching and learning, can help medical students to learn and organize information faster. This learning-teaching strategy deserves to be further explored as a tool to aid in active learning.

Conflicts of Interest

The authors declare that they have no conflict of interest.

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