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Mapas conceituais: percepções dos alunos sobre o uso de uma ferramenta de ensino em um curso de Farmácia

Concept mapping: student perceptions of using a teaching tool in a Pharmacy course

Mapas conceptuales: percepciones de los estudiantes sobre el uso de una herramienta de enseñanza en un curso de Farmacia

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Resumo

Os mapas conceituais consistem em diagramas que representam os relacionamentos entre conceitos e as palavras que os descrevem. O presente estudo, teve como objetivo examinar as percepções dos alunos sobre o uso de mapas conceituais em um curso de farmácia. Um grupo de estudantes de graduação, oriundos do sexto semestre, foram os participantes. Os alunos receberam os mapas conceituais antes e depois da aula teórica, também puderam preparar seus próprios mapas. De maneira geral, 97% dos estudantes fizeram uso dos mapas conceituais, 90% consideram que seu uso poderia ser útil para o aprendizado da farmacologia. 50% dos participantes consideraram a ajuda fornecida pelos mapas conceituais, para a sua aprendizagem como satisfatória, 25% como muito satisfatória e 25% como regular. Ainda, 63% dos estudantes pretendem continuar utilizando os mapas conceituais e 34% pensam em seguir usando os mapas conceituais. Portanto, o estudo demonstrou que a utilização de mapas conceituais como ferramenta de ensino para a aula de farmacologia, conseguiu despertar o interesse dos alunos pelo conteúdo.

Palavras-chave: Mapas; Farmacologia; Metodologia de aprendizagem; Graduação; Diagramas.

Abstract

Concept mapping consist of diagrams that represent the relationships between concepts and words that describe them. The present study aimed to examination of student perceptions of using concept mapping in a pharmacy course. A group of undergraduate students from the sixth semester were the participants. Students received the concept mapping before and after the theoretical class, also could make their own map. In general manner, 97% of the students made use of concept mapping, 90% consider that their use may be useful for learning pharmacology. 50% of participants considered the help provided by concept mapping for their learning as satisfactory, 25% as very satisfactory and 25% as regular. Still, 63% of students intend to continue use of conceptual maps and 34% think about continuing to use concept mapping. Therefore, the study demonstrated that use of concept mapping as a teaching tool for pharmacology class, managed to arouse students interest in contents.

Keywords: Maps; Pharmacology; Learning methodology; Undergraduate; Diagrams.

Resumen

Los mapas conceptuales consisten en diagramas que representan las relaciones entre los conceptos y las palabras que los describen. El presente estudio tuvo como objetivo examinar

las percepciones de los estudiantes sobre el uso de mapas conceptuales en un curso de farmacia. Un grupo de estudiantes de pregrado, del sexto semestre, fueron los participantes. Los estudiantes recibieron los mapas conceptuales antes y después de la conferencia, también pudieron preparar sus propios mapas. En general, el 97% de los estudiantes usaron mapas conceptuales, el 90% consideró que su uso podría ser útil para aprender farmacología. El 50% de los participantes consideró la ayuda brindada por los mapas conceptuales para que su aprendizaje sea satisfactorio, el 25% como muy satisfactorio y el 25% como regular. Además, el 63% de los estudiantes tiene la intención de continuar usando mapas conceptuales y el 34% planea continuar usando mapas conceptuales. Por lo tanto, el estudio demostró que el uso de mapas conceptuales como una herramienta de enseñanza para la clase de farmacología, logró despertar el interés de los estudiantes en el contenido.

Palabras clave: Mapas; Farmacología; Metodología de aprendizaje; Pregrado; Diagramas.

1. Introduction

The pharmacology education is a discipline that generates reflections on teaching and learning methodologies for decades (Engels, 2018). This occurs, because teaching in health sciences encompasses a number of basic disciplines. However, in recent years, there has been an increase in the amount of information in pharmacology education, rendering an already demanding subject even more challenging (Baños, Reverte & Bosch, 2002; Baumann-Birkbeck et al., 2015). In this sense, new teaching strategies have evolved from a teacher-centered process to a learner-centered process in an effort to enhance students in the pursuit of knowledge (Baumann-Birkbeck et al., 2015). Still, the teaching-learning process should strengthen the advances toward the implementation of promoting a less-strict hierarchical culture between students and their educators which is crucial to consolidation critical thinking (Basheti et al., 2015). In order for this methodological approach to take place egalitarian, learning perceptions and needs must be considered (Basheti et al., 2015). Like this, education in pharmacology poses a major challenge to teacher, even more than model used is usually the traditional teaching (Machado & Mello-Carpes, 2018).

Pharmacology is a key curriculum among a number of preclinical courses in different undergraduate and graduate of health sciences area. However, their learning is extremely important for pharmacy students (Zhou et al., 2016). In this sense, experimental pharmacology is essential for understanding drug action in the treatment of disease. Also, to pharmaceutical industry for drug discovery and development. Besides that, clinical

pharmacology is essential for prescribing practice in hospital and underpins pharmacy practice and therapeutics (Lloyd et al., 2013). The teaching and learning of pharmacology conventionally occur after the other core courses of health sciences, such as anatomy, pathology, biochemistry, chemistry and physiology (Liu et al., 2019). Likewise, clinical applications basic skills in performing pharmacology experiments, and professional knowledge of the laws and regulations of drug administration (Zhang et al., 2015). Pharmacology education needs integrated effort of multiple techniques to reach a total understanding of the action of drugs. The increasing number of drugs, changes in knowledge on general principles of mechanisms of drug action and more detailed information (particularly on the subcellular and genomic levels) regarding properties of drugs require consequently innovative approaches to undergraduate pharmacology education (Liu et al., 2019).

For students of pharmacy course, the pharmacology education differs from that of health science students, because not only they need to understand mechanisms of drug action but also must memorize numerous detailed facts regarding drug classes, individual compounds and their practical uses. Like this, traditional pharmacology teaching-learning has been criticized for neither preparing students for practice nor teaching the safe and rational use of medicines (Shah et al., 2016). Therefore, health sciences courses have a major challenge in teaching students for pharmacology.

In view of above, constructivist theory is an alternative teaching methodology to objectivist theory. In objectivist theory, experiences do not have any role in understanding and knowledge exists independently of instruction (Herrington & Herrington, 2005). In objectivism, the perception of knowledge influences the view on instruction. However, in constructivist the knowledge cannot simply transfer from one person to another because it is not a pure copy of external world (Phillips, 2000). Like this, students may express what they have learned in different ways, even if they have shared the same learning process (Tse-Kian, 2003).

In this context, the concept of learning within framework of constructivist theory (Urquhart et al., 2013), where student is an active and non-passive figure in knowledge construction. Ends up contemplating the significant learning theory proposed by Ausubel (1963), which has specific conditions such as existence of prior knowledge along with predisposition to learning. Still, according to Ausubel (1963), when considering the conditions outlined above, prior knowledge is more relevant to meaningful learning. In this sense, it is precisely the prior knowledge that concept mapping seek to rescue. Concept

mapping was developed by Novak in 1972 to promote critical thinking (Gul & Boman, 2006). Still, is a tool that can capture a pictorial record of learning process, similar to mind mapping (Buzan & Buzan, 2010). Concept mapping is concerned with the ways in which people organize and reorder new knowledge based on their past learning and understanding (Von Glasersfeld, 1984).

The methodology tool has been utilized in a range of educational disciplines (Bressington et al., 2013), as a strategy to promote learners' development of an in-depth understanding (Baugh & Mellott, 1998). Concept mapping and subsequent reflection on the series of maps are thought to help students reconsider information (Bressington et al., 2013). In sense, to promote critical analysis and deeper learning (Wheeler & Collins, 2003). The cyclical process applied in concept mapping generate reflection on their help's students engage in further meaning-making by presenting an opportunity to picture the way they have worked through trying to understand a complex subject (Gul & Bowman 2006; Bressington et al., 2013).

Therefore, concept mapping consists of diagrams that represent the relationships between concepts and words that describe them. Are generally elaborated in hierarchical form and may present arrows between concepts, since they seek to relate the concepts presented (Semsar et al., 2019). The implementation of concept mapping includes: assimilating new concepts in circles or boxes; creating hierarchical arrangements between concepts and sub-concepts; and identifying relationships between concepts and sub-concepts that can be connected with lines or linking words (Rochmawati & Weichula, 2010). Still, concept mapping end up generating a meaningful learning that differs from mechanical, where one has a short period of memory, which ends up causing a low retention of learning and knowledge.

In addition, concept mapping corroborates with theories that seek to optimize teaching and learning, including clinical practice. Such as theory described by Russell and Burch (1992), the three principles (replacement, reduction and rejection). The applied concept aims to decrease the use of animals through substitution by other techniques for teaching in pharmacology, physiology and other basic disciplines (Altermann et al., 2016). It is proven that concept mapping has contributed to the enhancement of undergraduate clinical judgment skills (Gerdeman et al., 2013). In view of above, the present study aimed to examination of student perceptions of using concept mapping in pharmacy course a South American country.

2. Methods

Population and sample

A group of undergraduate students from the sixth semester of pharmacy course a South American country. was the target public. Twenty-two students participated of study.

Inclusion criteria

The inclusion criterion for participation was to be a regular student of sixth semester of pharmacy course a South American country. Students had the methodology of concept mapping applied in discipline of pharmacology.

Ethical aspects

The Institutional Ethics Committee in Research approved this proposal (Institutional Review Board no. 1.694.106).

Data collection methods and instruments

This study was performed during second semester of 2016 year. Data were collected in classroom during the pharmacology discipline. The activity was performed and applied by pharmacology teacher with the aid of a tutor (pharmacy student in last semester of course), being carried out in two stages (All students were subjected to all stages).

First stage

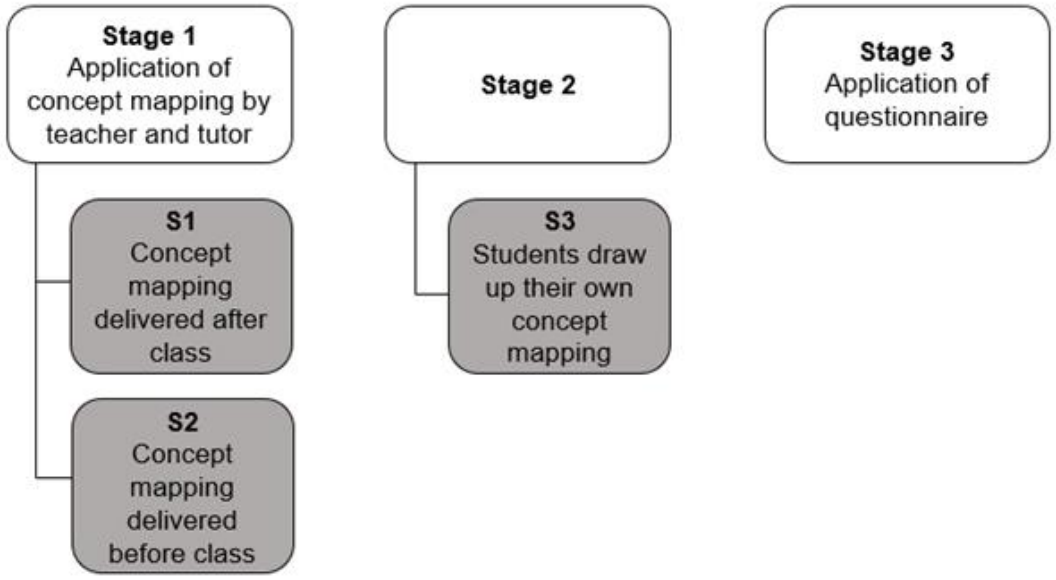
In this stage, concept mapping were introduced according to three strategies: strategy one (S1), delivered before theoretical class, delivered after lecture (S2) or students constructed their own concept mapping after theoretical class (S3) **(Figure 1)**. Concept mapping remained in possession of students after the end of pharmacology class.

Concept mapping were elaborated previously by tutor and teacher (S1 and S2 strategy), done in a unidimensional way using the tool Cmap Tools (v. 6.01.01), developed by the Institute for Human and Mechanical Cognition. For characterization of concept mapping,

the sources that appeared in literature indicated as basic bibliography of pedagogical project of pharmacy course South American country (2014) were used.

The structure of maps was constructed hierarchically, following a pattern in which the higher concept indicates larger aspects and specific aspects are presented at a lower level.

Figure 1. Represents a summary diagram of how the study occurred.



Source: Authors.

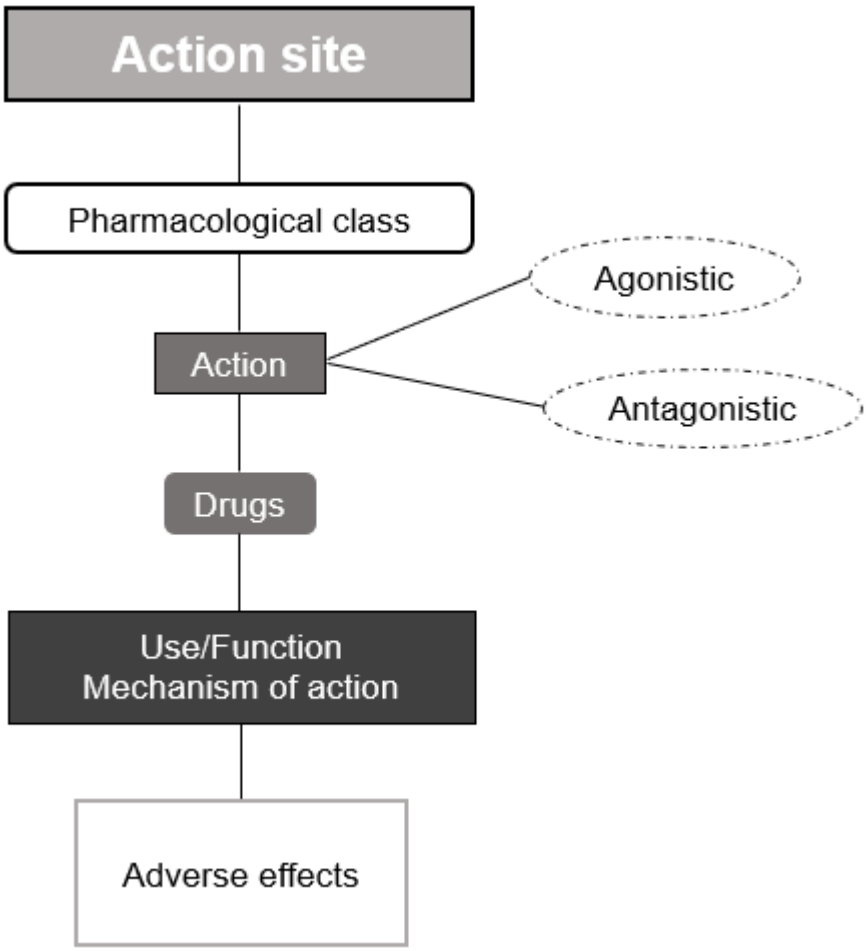
Layout of concept mapping

For layout of maps, they all contained first a rectangle with a blue border and a green background where the drugs action site was mentioned. Located in upper part of map, after that information was inserted a rectangle with orange border and transparent background, in which was the name of pharmacological class.

Almost in a central position on map was the representation of drugs action (agonistic or antagonistic), in a black-bordered rectangle with a blue background. After that, there was a yellow ellipse for name of the drug along with its administration routes, followed by a rectangle of green border, inferior to ellipse and connected to it by a continuous line indicating the relation, where it was described its use and/or function.

Finally, a rectangle with a red border and transparent background, still lower and also connected by line, where the main adverse effects were located (schematic representation of concept mapping is located in Figure 2).

Figure 2. Schematization of the standardization of concept mapping from which the later ones were elaborated. Pattern generated with Cmap tools (v. 6.01.01).



Source: Authors.

Second stage

Students answered a questionnaire composed of twenty questions: 14 objective, 2 discursive and 4 practices, but which admitted discursive responses as complementary to chosen alternative. The questionnaire was divided into two parts, the first one referring to concept mapping provided by teacher and tutor. The second part referring to concept mapping elaborated by students, as well a comparison between the availability and construction of concept mapping. This stage was carried out at the end of activity, after pharmacology semester evaluation.

Data Analysis

Statistical analysis was performed based on answers given by students to questionnaire of stage 2 (descriptive statistics). The results are presented as a percentage. Microsoft® Office Excel 365® is software used by statistical analysis.

3. Results

All students agreed to participate in proposed activity. The following contents were approached by concept mapping: drugs that interfere in blood tissue (S1), drugs for endocrine system (S2) and antibiotics (S3).

Questionnaire responses

Taking into account the responses obtained from questionnaire at end of activity with 22 students. 97% of students made use of concept mapping, 90% consider that their use may be useful for learning pharmacology and 10% believe that its use can not be useful. 50% of participants considered the aid provided by concept mapping for their learning as satisfactory, 25% as very satisfactory and 25% as regular.

Regarding timing of the delivery of maps, 56% of participants assessed that receiving after the content is delivered, is more productive than previous delivery. In contrast to delivery of map, ready or elaboration of map itself, only 22% considered adapting better elaboration of concept mapping itself. More than 88% of participants considered concept mapping provided by teacher and tutor satisfactory or very satisfactory. As 80% of class considered the aid provided by use of concept mapping as satisfactory or very satisfactory. Still, 63% of students intend to continue use of concept mapping and 34% think about continuing to use concept mapping (Results showed in Table 1).

Table 1. Results of questionnaire applied to students.

Questions	Responses of students (percentage)
Use of conceptual maps provided	97%
Students who consider the use of conceptual maps useful for learning pharmacology	90%
Students that considered the aid provided by conceptual maps for their learning as very satisfactory	25%
Students that considered the aid provided by conceptual maps for their learning as satisfactory	50%
Students that considered the aid provided by conceptual maps for their learning as regular	25%
Students that preferred to receive conceptual maps after the content is delivered	56%
Students who preferred to draw their own conceptual maps	22%
Students that considered conceptual maps provided by teacher and tutor satisfactory or very satisfactory	88%
Students that considered the aid provided by use of conceptual maps as satisfactory or very satisfactory	80%
Students that intend to continue use of conceptual maps	63%
Students that think about continuing to use conceptual maps	34%

Source: Authors.

Through the discursive questions present in questionnaire, some participants pointed out the maps provided as "of great utility", helping to differentiate and elucidate each class of drugs better, improving the understanding of the discipline.

4. Discussion and Conclusion

In present study, we presented concept mapping a teaching tool for students in discipline of pharmacology. According to MacDonald and Saarti (2006), learning a topic full of facts like pharmacology should be less of a chore and more of a pleasurable experience. In this sense, significant learning seems to expose itself as a good method for this purpose (Carr-lopez et al., 2014).

In first stage, occurred the delivery of concept mapping produced by teacher and tutor. Making it possible to compare students preference for reception of maps before or after pharmacology class and in which of these methodologies the student better adapted. In the study conducted by Carr-Lopez et al. (2014), also realized in students of pharmacy course but in fifth semester, was adopted the same methodology for delivery of concept mapping to students. In relation to concept mapping, it was also possible to evaluate the impact of tool available to students on layout, configuration, design and theoretical quality. We highlight that the studies by Carr-Lopez et al. (2014) and Laight (2006) emphasize the importance of student feedback regarding the qualitative assessment of teaching tool.

For S3, concept mapping were developed by students themselves after instructions given by teacher and tutor. Thus, at this stage the students were already able to use a new teaching tool, which induces a constructivist learning process, going according to Urquhart (2013) methodology. In addition, this new teaching tool enables students to develop critical thinking and a pleasurable search for knowledge. In study of Theising et al. (2014), they evaluated the impact of the use of methodological tools on students in the sixth semester of pharmacy course and also highlight that concept mapping help to develop critical thinking. Similarly, in study of Miesner et al. (2012), was reported the impact of methodological tools on the increase in pursuit of knowledge in pharmacy students.

In last stage, a questionnaire was applied to evaluate the impact of methodological tool on students. Through open questions, students were able to present their opinion regarding concept mapping available in pharmacology discipline. Still, students were questioned regarding the elaboration of concept mapping and about comparison of receiving and elaborating the maps. Given the above, the students reported a fragility of methodological

tool, which was use of software. These results corroborate with other studies performed with health sciences students, who also reported the same difficulty (Hager et al. 2016; Bressington et al., 2018; Alfayoumi, 2019). In addition, each group of students was responsible for only one topic. It may result in a more superficial knowledge regarding the other subjects covered in concept mapping (Semsar et al., 2019).

Considering that learning should preferably be student-oriented and organized from the needs pointed out by students (Wright, 2011; Davies, 2010). The present study demonstrates through results obtained and testimonials of students, that the use of conceptual maps favored learning of pharmacological concepts. It is Known that, the teaching of pharmacological concepts in different undergraduates in health sciences courses is known to be a major challenge (Elizabeth & Tinnon 2014; Liu et al. 2019), but especially pharmacy students must master these concepts to perform their profession with excellence.

Besides that, considering that classes correspond to traditional curriculum (class followed by a test) are no longer being used to detriment of what students choose as they will learn (Engels, 2018), the concept mapping proved to be an excellent methodological tool. Again, this methodological teaching tool has proved to be an important alternative to the objectivist teaching methodology in which knowledge is only transmitted to students independently of the impact of their learning process (Baines & Edwards 2018; Mukherjee et al., 2018). In addition, there is possibility of using concept mapping in learning of other disciplines, since they can be applied in other contents. Therefore, this is corroborated by result that 63% of students intend to continue using of concept mapping. Similar results are presented in the studies of Liu et al. (2012) and Hager et al. (2019).

Moreover, the main limitation of study was the number of participating students. At the institution where study was developed, the curriculum structure for undergraduate courses limits the entry of one class per year, and one of the inclusion criteria of study was precisely to be a regular student of sixth semester, reducing the sample number. However, sample was representative because the institution graduates around twenty pharmacy students annually. In addition, the study of Theising et al. (2014) also used a similar sample number. Thus, although the sample number represents a limitation, it does not influence the quality and reliable data presented in study. Despite the limitation, the study demonstrated that use of concept mapping as a teaching tool for pharmacology class, managed to arouse students interest in contents. Moreover, most of students intend to continue using concept mapping. Therefore, the teaching tool can be useful in teaching of health sciences.

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References

Alfayoumi, I. (2019). The impact of combining concept-based learning and concept-mapping pedagogies on nursing students' clinical reasoning abilities. *Nurse Education Today*, 72, 40–46. DOI: 10.1016/j.nedt.2018.10.009

Altermann, C., Neves, B. S., & Mello-Carpes, P. B. (2016) The inclusion of undergraduate students in physiology outreach activities improves their physiology learning and understanding skills. *Advances in Physiology Education*, 40, 529–532. DOI: 10.1152/advan.00012.2016

Ausubel, D. P. (1963). The psychology of meaningful verbal learning. *New York: Grune & Stratton*, 255.

Baines, S., & Edwards, J., (2018). A constructivist grounded theory research project studying music therapy as an anti-oppressive practice in long-term and psychiatric residential care. *The Arts in Psychotherapy*, 60, 1-8. DOI: 10.1016/j.aip.2018.04.003

Baños, J. E., Reverte, M., & Bosch, F. (2002). Teaching of pharmacology in the 21st century: new challenges and opportunities. *Trends Pharmacology Sciencies*, 23, 294–296. DOI: 10.1016/s0165-6147(02)02018-7

Basheti, I. A., Natsheh, A. I., Ammari, G., Khater, S., Qunaibi, E. A., & Bosnic-Anticevich, S. Z. (2015). Education on correct inhaler technique in pharmacy schools: barriers and needs. *Tropical Journal of Pharmaceutical Research,* 14,715–722. DOI: 10.4314/tjpr.v14i4.22

Baugh, N. G., & Mellott, K. G. (1998). Clinical concept mapping as preparation for student nurses' clinical experiences. Journal of Nurse Education, 37, 253–256.

Baumann-Birkbeck, L., Karaksha, A., Anoopkumar-Dukie, S., Grant, G., Nirthanan, S., & Owen, S. (2015). Benefits of e-learning in chemotherapy pharmacology education. *Currents in Pharmacy Teaching and Learning,* 7, 106–111. DOI: 10.1016/j.cptl.2014.09.014

Bressington, D. T., Wong, W., Lam, K. K. C., & Chien W. T. (2018) Concept mapping to promote meaningful learning, help relate theory to practice and improve learning self-efficacy in Asian mental health nursing students: A mixed-methods pilot study. *Nurse Education Today,* 60, 47–55. DOI: 10.1016/j.nedt.2017.09.019

Bressington, D., Mui, J., & Wells, H. (2013). The effects of medication-management training on clinicians' understanding and clinical practice in Hong Kong – a concept mapping study. *Nurse Education Today,* 33, 969-975. DOI: 10.1016/j.nedt.2012.10.021

Buzan, T., & Buzan, B. (2010). The Mind Map Book: Unlock your Creativity, Boost your Memory, Change your Life. *Pearson Education Ltd.*, London.

Carr-lopez, S. M., Galal, S. M., Vyas, D., Patel, R. A., & Gnesa, Eh. (2014). The utility of concept maps to facilitate higher-level learningin a large class room setting. *American Journal of Pharmacy Education,* 78, 170. DOI: 10.5688/ajpe789170

Davies, M. (2010). Concept mapping, mind mapping and argument mapping: what are the differences and do they matter? *Journal Higher Education,* 62, 279–301. DOI: 10.1007/s10734-010-9387-6

Elizabeth, A., & Tinnon, R. N. (2014). Scavenger hunt: A creative teaching strategy to introduce pharmacological concepts and ethical concerns. *Teaching and Learning in Nursing,* 9:104–107. DOI: 10.1016/j.teln.2014.03.004

Engels, F. (2018). Pharmacology education: Reflections and challenges. *European Journal of Pharmacology*, 833, 392–395. DOI: 10.1016/j.ejphar.2018.06.032

Gerdeman, J. L., Lux, K., & Jacko, J. (2013). Using concept-mapping to build clinical judgment skills. *Nurse Education in Practice*, 13, 11–17. DOI: 10.1016/j.nepr.2012.05.009

Gul, R., & Boman, J. (2006). Concept-mapping: a strategy for teaching and evaluation in nursing education. *Nurse Education in Practice*, 6, 199–206. DOI: 10.1016/j.nepr.2006.01.001

Hager, K. D., Kolar, C., & Janke, K. K. (2016). Concept mapping, reflective writing, and patch work text assessment in a first-year pharmaceutical care course. *Currents in Pharmacy Teaching and Learning*, 8, 492–500. DOI: 10.1016/j.cptl.2016.03.006

Herrington, A., & Herrington, J. (2005). What is an authentic learning environment? *Authentic learning environments in higher education*, 1-15. DOI: 10.4018/978-1-59140-594-8.ch001

Laight, D. W. (2006). Attitudes to concept maps as a teaching/learning activity in undergraduate health professional education: influence of preferred approach to learning. *Medical Teacher*, 28, e64–e67. DOI: 10.1080/01421590600617574

Liu, L., Du, X., Zhang, Z., & Zhou, J. (2019). Effect of problem-based learning in pharmacology education: A meta-analysis. *Studies in Educational Evaluation*, 60, 43–58. DOI: 10.1016/j.stueduc.2018.11.004

Lloyd, H., Hinton, T., Bullock, S., Babey, A.M., Davis, E., & Fernandes, L. (2013). An evaluation of pharmacology curricula in Australian science and health-related degree programs. *BMC Medical Education*, 13, 153. DOI: 10.1186/1472-6920-13-153

MacDonald, E., & Saarti, J. (2006). Blues for the lecture theatre—the pharmacology songbook. *Bioscience Education*, 1-7. DOI: 10.3108/beej.2006.07000003

Machado, R. S., & Mello-Carpes, P. B. (2018). The use of an open-ended, student led activity to aid in the learning and understanding of action potential. *Advances in Physiology Education*, 42, 324–328. DOI: 10.1152/advan.00101.2017

Miesner, A. R., Grady, S., & Trewet, C. B. (2012). Use of student pharmacist peer feedback during journal club in an advanced pharmacy practice experience. *Currents in Pharmacy Teaching and Learning*, 4, 165–173. DOI: 10.1016/j.cptl.2012.04.005

Mukherjee, S. M., Cabrera, A., & Silva, M. A., (2018). Evaluation of group concept mapping during advanced pharmacy practice experiences. *Currents in Pharmacy Teaching and Learning*, 10, 1616–1623. DOI: 10.1016/j.cptl.2018.09.009

Phillips, D. C. (2000). Constructivism in Education. Chicago: University of Chicago Press.

Rochmawati, E., & Weichula, R. (2010). Education strategies to foster health professional students' clinical-reasoning skills. *Nursing & Health Sciences*, 12, 44–250. DOI: 10.1111/j.1442-2018.2009.00512.x

Russel, W. M. S., & Burch, R. L. (1992). The principles of humane experimental technique. *London: Universities Federation for Animal Welfare (UFAW)*, ISBN: 0900767782.

Semsar, K., Brownell, S., Couch, B. A., Crowe, A. J., Smith, M. K., Summers, M. M., Wright, C. D., & Knight, J. K. (2019) Phys-MAPS: a programmatic physiology assessment for introductory and advanced undergraduates. *Advances in Physiology Education*, 43, 15-27. DOI: 10.1152/advan.00128.2018

Shah, N., Desai, C., Jorwekar, G., Badyal, D., & Singh, T. (2016). Competency-based medical education: An overview and application in pharmacology. *Indian Journal of Pharmacology*, 48, S5–S9. DOI: 10.4103/0253-7613.193312

Theising, K., Wu, K., & Sheehan, AH. (2014). Impact of peer assessment on student pharmacists' behaviors and self-confidence. *Currents in Pharmacy Teaching and Learning*, 6, 10–14. DOI: 10.1016/j.cptl.2013.09.020

Tse-Kian, K. N. (2003). Using multimedia in a constructivist learning environment in the Malaysian classroom. *Australian Journal of Educational Technology,* 19, 293-310. DOI: 10.14742/ajet.1721

Urquhart, R., Cornelissen, E., Lal, S., Colquhoun, H., Klein, G., Richmond, S., & Witteman, H.O. (2013). A community of practice for knowledge translation trainees: an innovative approach for learning and collaboration. *Journal of Continuing Education in the Health Professions,* 33, 274–281. DOI: 10.1002/chp.21190

Von Glasersfeld, E., (1984). An introduction to radical constructivism. In: Watzlanick, P. (Ed.), The Invented Reality. Norton, New York, 17–40.

Wheeler, L. A., & Collins, S. K. (2003). The influence of concept mapping on critical thinking in baccalaureate nursing students. *Journal of Professional Nursing,* 19, 339–346. DOI: 10.1016/S8755-7223(03)00134-0

Wright, G. B. (2011). Student-centered learning in higher education. *International Journal of Teaching and Learning in Higher Education,* 23, 92-97.

Zhang, Y., Zhou, L., Liu, X., Liu, L., Wu, Y., & Zhao, Z. (2015). The effectiveness of the problem-based learning teaching model for use in introductory Chinese undergraduate medical courses: A systematic review and meta-analysis. *PloS One,* 10, e0120884. DOI: 10.1371/journal.pone.0120884

Zhou, J., Zhou, S., Huang, C., Xu, R., Zhang, Z., & Zeng, S. (2016). Effectiveness of problem-based learning in Chinese pharmacy education: A meta-analysis. *BMC Medical Education,* 16, 23. DOI: 10.1186/s12909-016-0546-z

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Marcelo Gomes de Gomes – 15%

Nathália Tonn – 15%

Roberto Pires Porto – 15%

Jonatas Cristian Rodrigues – 15%

Camila Oliveira Pacheco – 15%

Sandra Elisa Haas – 25%