

**REPRESENTACIONES SOCIALES (RS) DE LOS ESTUDIANTES DE POSTGRADO
EN CIENCIAS DE LABORATORIO MÉDICO SOBRE PARASITOLOGÍA:
un análisis comparativo entre pre y post instrucción**

Karla Patricia de Oliveira Luna, PhD

karlaceatox@yahoo.com.br

<https://orcid.org/0000-0002-2746-6973>

Universidade Estadual da Paraíba (UEPB)
Campina Grande, Brazil

Nathalya Marillya de Andrade Silva, MSc

nathalyamarillya@gmail.com

<https://orcid.org/0000-0002-9636-6925>

Department of Education
Remígio, Paraíba state, Brazil

Ana L. Oliveira, DrPH

analuna@uab.edu

<https://orcid.org/0000-0003-0164-808X>

University of Alabama at Birmingham (UAB)
Birmingham, Alabama, United States

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Resumen

Parasitología constituye contenido de Ciencias de Laboratorio Médico con larga lista de parásitos de importancia médica en corto período de tiempo para preparar adecuadamente a los estudiantes. Representaciones sociales (RS) constituyen conocimientos de sentido común, creados diariamente bajo influencia de procesos comunicativos, construidos mientras desempeñamos nuestros roles en el contexto social. En curso centrado en el estudiante, es primordial comprender su conocimiento previo para enseñarles nuevas habilidades efectivamente. En este estudio, nuestro objetivo fue estudiar las RS de estudiantes de Ciencias de Laboratorio Médico relacionadas con “Parasitología” antes y después de la instrucción. Se encuestó a 14 estudiantes de Ciencias de Laboratorio Médico y se evaluó su RS relacionada con parasitología mediante un test de evocación libre y el software IRAMUTEQ. Resultados mostraron en la instrucción previa, que los estudiantes usaron palabras más relacionadas con los aspectos biológicos generales de los parásitos para describir la parasitología. Después de la instrucción, muy en línea con el contenido y objetivos del curso, los estudiantes utilizaron palabras más relacionadas con parasitología médica, como las relacionadas con morfología y diagnóstico de parásitos. Esto indica que el curso logró cambiar las RS de los estudiantes, relacionadas con la parasitología.

Palabras-clave: representaciones sociales, parasitología, enseñanza, ciencias de laboratorio médico.

The Social Representations (SR) of Graduate Medical Laboratory Science (MLS) Students about Parasitology: a comparative analysis between pre and post-instruction.

Abstract

Parasitology is part of the Medical Laboratory Science (MLS) program curriculum. A long list of parasites of medical importance need to be covered in a short amount of time to prepare these students for their professional practice. Social representations (SR) constitute commonsense knowledge, created daily under the influence of communicative processes, and constructed while we play our roles in our social contexts. In a student-centered course, it's paramount to understand students' prior knowledge to effectively teach them new skills. In this study, we aimed at describing the SR of MLS students related to "Parasitology" before and after instruction. Fourteen MLS students were surveyed, and their SR related to parasitology was assessed using a free evocation test and the IRAMUTEQ software. Results showed that in pre instruction, students used words more related to general biological aspects of parasites to describe parasitology. After instruction, well in line with the content and objectives of the course, students used words more closely related to medical parasitology as those related to the morphology and diagnosis of parasites. This indicates that the course was able to change the students' SR related to parasitology.

Key words: social representations, parasitology, teaching, medical laboratory sciences.

As Representações Sociais (RS) dos Alunos da Pós-Graduação em Ciências Biomédicas sobre Parasitologia: uma análise comparativa entre pré e pós-instrução.

Resumo

A parasitologia constitui conteúdo de Ciências Biomédicas. Educadores e alunos se deparam com uma longa lista de parasitas de importância médica a serem aprendidos em um curto período de tempo em preparação para a futura prática profissional dos alunos. As Representações Sociais (RS) constituem saberes do senso comum, construídos cotidianamente sob a influência dos processos comunicativos, e construídos enquanto desempenhamos nossos papéis no contexto social. Em um curso centrado no aluno, é essencial entender seus conhecimentos prévios para ensinar-lhes novas habilidades de maneira eficaz. Neste estudo, nosso objetivo foi estudar as RS dos alunos do CLM relacionadas à "Parasitologia" antes e depois da instrução. 14 alunos de Biomedicina foram pesquisados e suas RS relacionadas à parasitologia foram avaliadas por meio de um teste de evocação livre e do software IRAMUTEQ. Os resultados mostraram na pré instrução, que os alunos usaram palavras mais relacionadas aos aspectos biológicos gerais dos parasitas para descrever a parasitologia. Após a instrução, muito condizente com o conteúdo e os objetivos do curso, os alunos utilizaram palavras mais relacionadas à parasitologia médica, como aquelas relacionadas à morfologia e diagnóstico do parasita. Isso indica que o curso conseguiu mudar as RS dos alunos, relacionadas à parasitologia.

Palavras-chave: representações sociais, parasitologia, ensino, ciências biomédicas.

Introduction

Teaching of Parasitology in Medical Laboratory Science (MLS) Education. Many current issues we face as a society such as climate, societal and environmental changes,

globalization, drug resistance, all make the study of parasitic infections still relevant (MCKAY; SUMMERS; BURET; EMMETT *et al.*, 2019). In the area of medical parasitology there is a vast list of species to be learned. Around 300 species of helminths and 70 species of protozoans have been reported in humans with 90 species commonly being the cause of human infections (COX, 2002; EDRISSIAN; ROKNI; MOHEBALI; NATEGHPOUR *et al.*, 2016). However, even though medical parasitology is a vast field, it is usually not given proper importance and it is taught along with other microbes within microbiology courses (COX, 2002; DAVID, 2017). Even if a smaller number of the 90 most common species cause most of the infections in humans, there is still a long list of parasites for students to learn in medical parasitology courses in a short amount of time, posing a challenge for instructors and students.

In MLS programs, Parasitology is part of the microbiology/infectious diseases training. Medical Parasitology in MLS education is usually taught in conjunction with mycology and virology, along with a laboratory course where students can apply the concepts they learn in the classroom. In the US, professionals involved in the clinical laboratory testing for diagnosis of human parasitological infections can hold an associate degree (MLT), an undergraduate degree (MLS), a master's degree, and even a doctoral degree (DCLS). Even though a lot of progress has been made in the molecular testing for microbes and the use of artificial intelligence, parasitological diagnosis still relies mostly on knowledgeable, well trained, skilled microscopists (LINDER; LUNDIN; THORS; LEBBAD *et al.*, 2008).

In MLS education, it is paramount that the knowledge of students shifts from a “biology” mindset, constructed during general microbiology courses, to a more “human and laboratory medicine” mindset. Many students have had general microbiology courses before they embark on their MLS specific courses, however, as part of their MLS education they are being trained to perform clinical laboratory diagnosis of human parasites. Therefore, a lot of emphasis is given in MLS education related to parasitology into collection and preservation of specimens, performing different available tests, and knowing morphological identification of parasites, all dictated by the future scope of practice of the students.

Errors in clinical laboratory parasitological testing can result in misdiagnosis, can increase, or extend the length of morbidity and even be life-threatening (KOLODZIEJ; TUSZYNSKA-BOGUCKA; DZIENKOWSKI; BOGUCKI *et al.*, 2021; PALMIERI; ELSWAIFI; FRIED, 2011). In addition, the lack of trained professionals in clinical laboratory

diagnosis of parasitic infections can contribute to the underdiagnosis of such infections of public health importance (PALMIERI; ELSWAIFI; FRIED, 2011). The impact of the knowledge of medical parasitology goes beyond the proper care of single individuals and extends to the efforts for control of these infections in the population, since control activities usually rely on identification and treatment of infected individuals (PALMIERI; ELSWAIFI; FRIED, 2011).

On the student side, the challenges of internationalization, social economic and emotional pressures, differences in background, call for flexible and accessible learning experiences (JABBAR; GASSER; LODGE, 2016). In addition, these student characteristics stress the importance of a student-centered approach, which usually incorporates active learning, to parasitological education (DAVID, 2017; JABBAR; GASSER; LODGE, 2016). Given all these challenges in the teaching and learning of parasitology, it is paramount that instructors know their target audience (their students) and apply the best pedagogical techniques to make teaching and learning more effective.

In the teaching of sciences, it is important to understand the common knowledge of incoming students about the course subject, so instructors can use that information for designing courses that address this common knowledge to make instruction more effective. This is also relevant to parasitology, a discipline with a large body of knowledge taught in a decreasing available amount of time (JABBAR; GASSER, 2018; STROMBERG, 2002).

Social Representations Applications in Education and in the Teaching of Science

Social Representations (SR) consists of commonsense knowledge, created daily, under the influence of communicative processes, by common people, teachers, students, etc., playing their role in their social context. Commonsense knowledge, even though not the focus of formal education (academic knowledge), is also part of our students' knowledge repertoire. In the educational arena, SR gains importance by helping educators better understand how students view the objects of their studies. In the classroom, educators have an opportunity to influence students through construction and modification of their SR related to the course content, which are the product of our actions and communication to ourselves and to the community (SILVA, 2019).

SR is a social cognitive construct. Lahlou & Abric describe SR as “an organized set of cognitive elements” (LAHLOU; ABRIC, 2011). The importance of SR in teaching and learning relies on the fact that for a social group, in this case, a group of students, there is no separation

between the shared SR and the object. According to Wachelke (2012), “the object can only be accessed through a representation; for a given social actor, that representation “is the object”. According to the same author, the function of SR “include providing knowledge about the object to the group, maintaining group identity, guiding action and practices regarding the object, and justifying those practices” (WACHELKE, 2012).

Abric (1993) was the first (LAHLOU; ABRIC, 2011; LO MONACO; PIERMATTÉO; RATEAU; TAVANI, 2017) to propose an internal organization of SR. According to that author, SR can be described by two elements: the central core and the peripheral elements. Each one of these two elements have a specific, yet complementary function (ABRIC, 1993). The central core is composed by a small number of terms that are extensively shared by the group. These terms are related to past experiences (collective memory) and ideologies (system of norms) of the group and form an unit that is stable and resistant to change (ABRIC, 1993; DANY; URDAPILLETA; LO MONACO, 2015; LO MONACO; PIERMATTÉO; RATEAU; TAVANI, 2017; WACHELKE, 2012; WOLTER, 2018). The peripheral elements are flexible elements that do not belong to the central core and function to protect it from contradictions and to regulate the central core. Differently from the central core, the peripheral elements represent experiences that are more recent in time and more amenable to changes (ABRIC, 1993; DANY; URDAPILLETA; LO MONACO, 2015; LO MONACO; PIERMATTÉO; RATEAU; TAVANI, 2017; WACHELKE, 2012; WOLTER, 2018).

Since the development of the theory of social representations (Moscovici, 1961), SR are thought to rarely change in short periods of time, but this change can be observed (SÁ, 2002). As indicated by Flamment (1994), SR prescribers (or representation objects) are influenced by social changes as a result of the evolution of the social practices (FLAMENT, 1994). Therefore, as a social practice, educational processes can also produce significant changes after short periods of time, once the instructor is committed to investigation, innovation, students' autonomy and content update (SÁ, 2002).

As discussed above, SR consists of a simple and effective tool to investigate and evaluate educational processes inside and outside the classroom since they can reveal how changes to students' social-cognitive views can be achieved over time, with the intervention of the teaching and learning process. In this regard, the objective of the present study was to evaluate the changes of social representations among MLS students related to parasitology before and after

instruction. In other words, can the SR of MLS students related to parasitology after instruction contain terms related to the content emphasized in the course such as morphological characteristics of parasites, parasite genus and species that cause human infection, and diagnostic test?

Methodology

Study participants and course

Study participants were 14 graduate students in the Medical Laboratory Science (MLS) program taking an infectious diseases course during the summer semester of 2021, which includes a section in human parasitology. All students in the class were invited to participate in the activity and received points for answering the anonymous survey. All participants agreed to have their data included in this publication. IRB application was submitted to the University of Alabama at Birmingham and the activity was considered exempt (IRB # 30007632).

Infectious Diseases is a 3-credit hour, in-person, lecture-based course for master level students. The course is delivered during the summer semester over 14-weeks. Classes are weekly (3-hours long) and the course content is divided into four blocks of which parasitology is the first block. Medically important protozoan and helminths are covered over 3 weeks (9 hours total). Lectures are supplemented with student-centered, active-learning activities such as case-studies, “muddiest point” assignments, weekly homework, pop-up questions during lectures, and discussion posts, in order to stimulate students’ participation and metacognition. Since parasitology is a visual discipline (PFEIFFER; JABBAR, 2019; STROMBERG, 2002), the use of parasite images during lectures, in in-lecture quizzes, and in exams is emphasized in the curriculum. Students also concurrently take a one credit-hour laboratory-based course to practice the knowledge they are learning in the lecture-based course. The concurrent laboratory-based course provides students with a close to “real-world” setting of a student laboratory where they can practice laboratory techniques for the diagnosis of parasitological infections.

Data collection & analysis

In this study we used the structural approach to the study of SR of MLS students (group) related to Parasitology (object of the SR in question) (ABRIC, 1993; 2003; LO MONACO; PIERMATTÉO; RATEAU; TAVANI, 2017). To assess the content of the SR of MLS students related to parasitology, we collected data using a multiple response free word association test

which is one of the most common methods used for this purpose (DANY; URDAPILLETA; LO MONACO, 2015), and allows us to learn the cognitive units (cognemes) that describe the SR of MLS students related to parasitology (LAHLOU; ABRIC, 2011; WOLTER, 2018). Data was collected through a self-administered survey (Qualtrics®). The survey included questions about previous parasitology courses taken, and a free word association test (Table 1). The free word association test is a technique where participants of the study are asked to evoke words they consider important in relation to a given word /phrase or the inductor term/phrase. In this case, the word given was “parasitology”. In summary, participants were asked to list 6 words that came to their minds when they heard the word “Parasitology”. Data was collected before the beginning of instruction in the parasitology section of the course (May 12), and after the completion of the Parasitology Module (June 9) which includes an exam. Data was exported from Qualtrics® and the words evoked by students were categorized (Table 2). This text *corpus* was used in a lexicographical analysis to generate a prototypic analysis and an analysis of similarity (CAMARGO; JUSTO, 2013; DANY; URDAPILLETA; LO MONACO, 2015; WOLTER, 2018) using IRAMUTEQ, the free software with open code, developed by Ratinaud (2009) (RATINAUD, 2009).

The prototypical analysis identifies the content and structure of social representations (central core and peripheral elements) using two criteria: the frequency and the order of evoked words (WACHELKE; WOLTER; RODRIGUES MATOS, 2016). The product of the prototypical analysis is a four quadrant diagram representing four dimensions of the social representations structure: 1. upper left quadrant which groups the words with high frequency and low evocation order, and probably constitutes the central core of a social representation; 2. upper right quadrant is the first periphery and it gathers the words with high frequency and higher evocation order; 3. the lower left quadrant is the contrast zone and integrates the readily evoked elements that present below average frequency; and 4. the lower right quadrant is the second periphery where are present the less frequent evocations with higher evocation order (CAMARGO; JUSTO, 2013; DANY; URDAPILLETA; LO MONACO, 2015; WOLTER, 2018).

In this study, data was also used to generate a similarity analysis using the same IRAMUTEQ software. The analysis of similarity presents a graphic (tree) with connections between the words that constitute the *corpus* analyzed. These connections in the tree can present

a variety of thickness: the thickest line shows the most evoked terms, with more connections established among them. This analysis highlights connections among elements that structure the SR of the studied group by relating the number of co-occurrence (number of the links between two specific items) and the number of participants of the study (SÁ, 1996). In this regard, it is possible to identify opposite blocks and elements strongly connected. It is important to highlight that although the similarity analysis shows connections among those elements (words evoked), it doesn't show how those elements relate to each other (WOLTER; WACHELKE; NAIFF, 2016). The similarity analysis is based on "the idea that an SR is a set of cognitive elements, interconnected with each other". Therefore, it assesses the relationship between the terms that form a group's SR (if they go well or not with each other), but it does not inform the nature of this relationship (LO MONACO; PIERMATTÉO; RATEAU; TAVANI, 2017).

Results and Discussion

Characteristics of the Study Population

In the current study, we assessed the social representations, or commonsense knowledge, of MLS graduate students related to the inductor term/object "parasitology" pre and post instruction during the summer semester of 2021. All 14 students in the cohort filled the survey. MLS student cohorts are usually small, and 14 students is considered a medium to large enrollment for an MLS program. Irrespective of the size of the student cohort, all students in the class participated in the survey (response rate of 100%). Students in this cohort were young adults with most of the students being female. In summary, the majority of students have not had a parasitology course in their undergraduate programs. Only two students had a parasitology course before (Table 1).

Table 1 - Characteristics of participants in a study of the social representations (SR) of Medical Laboratory Science (MLS) students about “Parasitology” (N=14).

Survey Question	Student Answers
Do you think that your future profession as a clinical lab professional is related to Parasitology?	Yes: 10 No: 1 Not sure: 3
How many undergraduate level Parasitology courses have you had?	0: 12 1: 2 2: 0 ≥3: 0
What is your degree?	Biology (5) Biomedical Science (2) Microbiology (2) Masters in Public Health (1) Unanswered (4)
Have you had any graduate level Parasitology courses?	Yes: 0 No: 14

Source: Elaboration by authors.

Description of the Social Representations of the Students Related to Parasitology

After instruction, we observed a change in the SR of MLS students related to parasitology. Post-instruction, words evoked by students related to parasitology composed less categories when compared with pre-instruction (Table 2). This change shows a different organization of the words evoked by the students reflecting the influence of the educational process on the commonsense of the students related to parasitology. The removal of some categories that presented distant medical parasitology concepts shows that the educational process was effective. Details of the SR change are presented in the prototypical analysis and analysis of similarity.

Table 2 - Categorization of words evoked by participants in a study of the social representations (SR) of Medical Laboratory Science (MLS) students about “Parasitology” before and after instruction (N=14).

PRE		POST	
Category	Evoked terms	Category	Evoked terms
PARASITE	worms, parasite, parasites, helminth, Amoeba, Amoebas, protozoa, tapeworm, bacteria, fungus.	PARASITE	Nematodes, Parasite, protozoan, Parasites, Fluke, flukes, Blood protozoan, worms, Helminths, filariae, Protozoa, Hookworms, Amoeba, Giardia, Fungi, Roundworms, Balantidium Coli, Flatworm, Cestodes, H. histolytica
ILLNESS	infection, Malaria, illness, diarrhea.	ILLNESS	Infection, Malaria, Meningitis, malaise
SPECIMEN	blood, feces, stool.	SPECIMEN	Blood, stool, feces
HUMAN	human		
MORPHOLOGY	grubs, eggs, larvae, eggs.		Egg, eggs, Larvae, larva, Spores, Trophozoite, cyst, cysts, Suckers
GROSS	gross		
IMMUNITY	immune response, IgE.		
INTESTINAL	intestine, GI tract, intestinal.	INTESTINAL	Intestinal,
HOST/PARASITE RELATIONSHIP	parasite host relationship, competition, non-mutual, commensalism, symbiosis, natural selection, nutrient, toxic, thief, living thing that lives off something, blood sucker, dependents, malicious.	HOST/PARASITE RELATIONSHIP	Host, hosts, Relationship, Feeding Organism, commensalism, harm, Reservoirs
TRANSMISSION	water, dirt, mosquito, infectious.	TRANSMISSION	Vectors, transmission, Dogs
CELL	intercellular, intracellular.	CELL	Unicellular, prokaryote
ECTOPARASITE	louse, tick, spider, bug, bugs.	ECTOPARASITE	bugs
FOREIGN	alien, foreign.		
		BIOLOGY	Biology, organism, organisms, study of
		MIND CONTROL	Mind control
		SPONGEBOB	Spongebob

Source: Elaboration by authors.

Prototypic analysis

Central Core

As mentioned before, the central core is a set of small, coherent, and stable terms that represent the consensus of the group about an object. The central core quadrant contains terms evoked with high frequency (the most frequently evoked) and low order of evocation (terms more promptly evoked) and most likely represent the central core of the SR of students related to parasitology (ABRIC, 1993; DANY; URDAPILLETA; LO MONACO, 2015; LO MONACO; PIERMATTÉO; RATEAU; TAVANI, 2017; WACHELKE, 2012; WOLTER, 2018). In the current study, the central core pre-instruction contained only the words “parasite” and “illness”. “Parasite” stayed in the central core post-instruction, however, “illness” moved to the second periphery area. Since a change in one element of the central core, means a change in central core (WACHELKE, 2012), we observed a change in the core elements of the SR of MLS students related to parasitology post-instruction.

For a SR to be formed by a group, it is necessary that a new object be presented to them, in their social context (WACHELKE, 2012). Therefore, the introduction of new concept in the classroom is a driving force for generation of a SR related to that object by the group of students. Other characteristics necessary for an object to generate a SR by a group, also relates to education: object must have a “concept function for the group”, the object must be a “communication topic”, and the object must be “associated with a level of social practices” (WACHELKE, 2012).

Besides the instruction itself, or the presentation of a new object, there are some characteristics of this group that are worth noting that might have helped promoting the transformation in the SR of the students related to parasitology, including changes in more stable parts of the SR as the central core. First, most students did not have a parasitology course before, therefore, when confronted with the medical parasitology module of the infectious diseases course, there was an incentive for a SR to be created/transformed. Second, based on the answers to the question “Do you think that your future profession as a clinical lab professional is related to Parasitology?”, where only one student answered “no” (Table 2), we can observe a motivation to understand the “object” (course content) due to the valorization of the object by the students and how close to the object the students feel (ERNST-VINTILA; DELOUVÉE; ROLAND-LÉVY, 2011).

When “illness” went from the central core to the second periphery after instruction, it shows it is possible to change the central core even in a short period. The term “illness” migrates from the central core to the second periphery, which shows that students, after instruction, have learned that the outcome of a parasitic infection in humans has a wide range of possibilities from very mild infections to death. In addition, they learned that not all parasitic infections elicit an overt disease state in humans, i.e., not all parasitic infections present with clinical symptoms (some are asymptomatic). According to Moscovici, through conflict is how innovation happens (MOSCOVICI; LAGE; NAFFRECHOUX, 1969). The course in this case, is the innovation in these students' lives, as for many of them, it was the first time they heard about parasites. With the change in the central core related to parasitology, we can also conclude that this educational intervention was effective (met the course objectives) since the central core post-instruction was more uniform, specific, and related to the course content. It only contained the category “parasite” showing words that represent parasite classifications (trematode, nematode, protozoa) and the genus and species of parasites of medical importance instead of more general microbiology terms taught in general biology/microbiology courses (taken previously by students in their undergraduate program). In case when the situation drives to a new practice and this is irreversible, there will be a tendency for a change of the conditional prescriptors of the representation (FLAMENT, 1994). In this particular case, we consider the module Parasitology a prescriptor of this type, once we are dealing with science, a practice where laws and paradigms, although changeable, represent the truth. Furthermore, the ‘new practice’ is considered irreversible, as shown by the change on the central core, as it is innovative, by giving new information to the students. This is important to note, because, as discussed before, the central core is the area of the SR more resistant to change (ABRIC, 1993). The central core has two basic functions: generator function (which gives significance to the SR) and organizer function (responsible for the stabilization and uniformization of the SR). Although, according to Sá (1996) the stability presented by the central core can identify basic differences among SR, characterizing it as the identity of the SR (SÁ, 1996). Once more, as a social practice, teaching shows that it is possible to change representations from students even in short periods of time, as observed in this study.

Figure 1. Prototypical analysis of the social representations (SR) of medical laboratory students (MLS) related to parasitology pre and post instruction (N=14).

Pre			Post		
<= 3,47 Rangos > 3,47			<= 3,48 Rangos > 3,48		
< 6,38 Frequencies >= 6,38	Core area	First periphery	< 9,88 Frequencies >= 9,88	Core area	First periphery
	Parasite – 27-2.6 Illness – 8-2.9	Host Parasite/Relationship – 13-4.2 Ectoparasites – 7-4.4		Parasite – 41-2.9	Morphology – 10-4.0
	Contrasting elements	Second periphery		Contrasting elements	Second periphery
	Morphology – 5-3.0 Specimen – 3-3.3 Human – 2-2.0	Transmission – 5-4.6 Intestinal – 4-4.8 Foreign – 3-4.0 Gross – 2-4.5 Cell – 2-6.0 Immunity – 2-3.5		Biology – 4-2.0	Host parasite/Relationship – 8-4.8 Illness – 6-4.2 Specimen – 5-3.8 Transmission – 3-6.0 Cell – 2-5.0

Source: Elaboration by authors.

First Periphery

This area called “first periphery” contains terms evoked with high frequency and high order of evocation. Words in this zone are associated with the central core but are not part of it. Before instruction, this area contained the categories “host parasite relationship” and “ectoparasites” showing a strong association with the central core. Since the investigation of host-parasite relationship is not the focus of the infectious diseases course, but it is a basic concept in general microbiology course (to be a parasite the host-parasite relationship has to cause detriment to the host), the cognomen “host parasite relationship” went to the second periphery, i.e, became having a more distant relation with the central core “parasite”. Also, the term “ectoparasites” appearing in the first periphery shows that those students frequently socio-cognitively link ectoparasites to this relationship (host-parasite). “Ectoparasites” did not appear in the post analysis, showing that they have lost this thought once the course is directed to other types of parasites (not the focus of the course). Ectoparasites was covered in the infectious diseases course only in a recorded, not mandatory lecture. The first periphery post-instruction included only the category “morphology” that was before instruction in the zone of contrast (meaning it was highly associated with individual SR, not reflecting the consensus of the group). “Morphology” was a content emphasized during the course for each parasite species taught since the course is part of a program for professionals who will be responsible for the identification of human parasites in various specimens. That concept was internalized by the students since “morphology” post-instruction was more frequently evoked than pre-instruction (when it appeared in the zone of contrast), now showing a closer relation with the group’s central core SR “parasite” (whole student group’s consensus).

Second Periphery

This zone presents terms with low frequency of evocation (less evoked) and high sequence of evocation (less promptly evoked). As stated for the first periphery, words in this quadrant are not part of the central core but are related to it. Words in the second periphery are less closely related to the central core than words in the first periphery. Pre-instruction data showed that the second periphery included the greatest number of categories (n=6): “transmission”, “intestinal”, “foreign”, “gross”, “cell”, and “immunity”. The categories “Transmission” and “cell” continued in the second periphery post instruction while “intestinal”, “foreign”, “gross”, and “immunity” did not appear in the post-instruction dataset (and are also the focus of the course). “Transmission” and “cell” appear in this zone in both and pre and post-instructions because they are still relevant to the students SR related to parasitology, however, the terms had a lower frequency and speed of evocation in post analysis (Figure 1), meaning that the students understood that not all parasites transmit diseases, and not all of them are composed of one cell. Transmission is a concept worked in the course since it relates also to prevention of infections. In addition, the framework used in the course to introduce all parasites in the curriculum is to divide them in protozoan (single cell parasites, introduced first in the course) and helminths (multicellular parasites, introduced after protozoans). The post instruction data showed 5 categories: “host parasite relationship” (was in first periphery pre-instruction), “illness” (central core pre-instruction, now supports the central core but is not part of it), “specimen” (was in the zone of contrast pre-instruction), “transmission” (stayed in the second periphery from pre-instruction), and “cell” (stayed in the second periphery from pre-instruction).

Contrasting elements

This quadrant (or zone) contains the terms with low frequency (less evoked) and low sequence of evocation (most promptly evoked). This zone includes terms that are more related to individuals or subgroups, as opposed to the consensus of the whole group. Pre-instruction elements in the contrasting elements zone included the categories “morphology”, “specimen”, and “human”. “Morphology” went to the first periphery, and “specimen” to the second periphery. The fact that the terms “morphology” and “specimen” post-instruction are more closely related to the group SR related to parasitology is strong evidence that the SR of MLS students, after instruction, became more in line with the concepts related to medical parasitology and the clinical diagnosis of parasitic infections, which is in line with the objectives of the

course. The term “human” did not appear post instruction, which is expected since all the parasitology included in this course relates to humans. The post analysis showed that the zone of contrast only included the category “Biology” which was a new category. Although this zone shows low frequency and sequence of evocations it is important to notice that this new term was added by the students linking biology to the science that studies parasites, parasitology. This shows that some individuals in the group still use the cognitive term “biology” to represent “parasitology”.

Similarity analysis

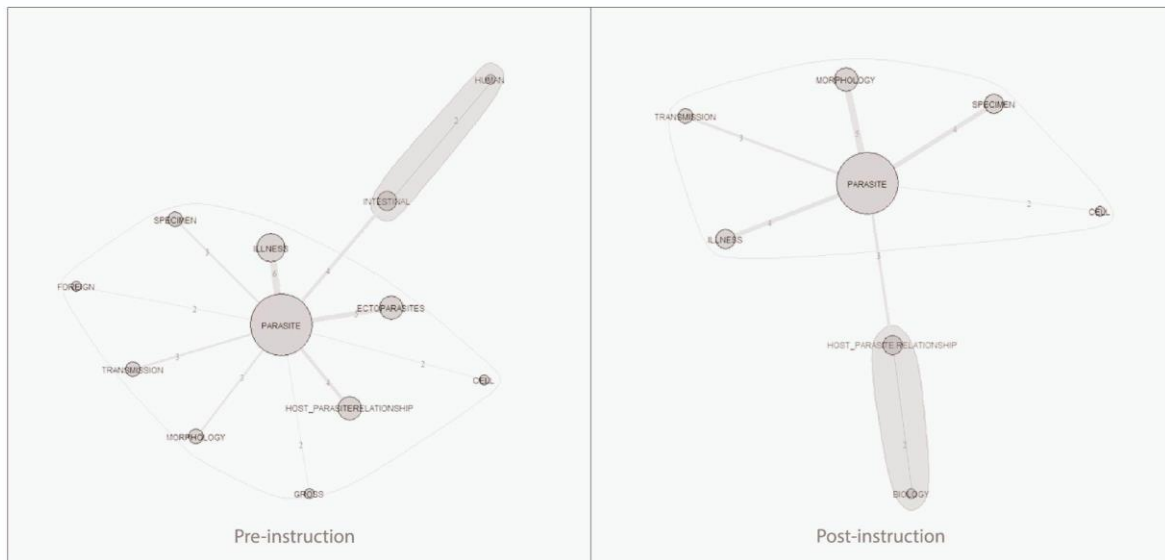
The similarity analysis performed by IRAMUTEQ also represents the structure of the social representations of the group surveyed, through the maximum similarity tree, a graph formed by colored vertices in which the size of the vertice is proportional to the frequency of the evocations and the edges indicate the strength of co-occurrence between the evocations (CAMARGO; JUSTO, 2013). With this similarity analysis, it is possible to identify the evocations that stand out and the relationships that arise from them (SILVA, 2019).

In this study, results from the similarity analysis agreed with the prototypical analysis in relation to which terms are most likely part of the central core and which terms are peripheral elements in the SR related to parasitology of MLS students and shed more light into the relationship between the terms which forms that SR. According to the similarity analysis before instruction, the term “parasite” is the great organizing axis of the social representations, and strongly associated with the elements “illness”, “ectoparasite”, and “host parasite/relationship”. That is identified by the thickness of the edges among the words evidencing the proximity between the elements that make up the central core and the first periphery indicated in the quadrants of the prototypical analysis. The central element “parasite” is also related to the peripheral elements “intestinal” and “human” which in the prototypical analysis were part of the second periphery and the contrast zone respectively.

The post-instruction similarity tree evidences the change in the structure of the central core of the students’ social representations about parasitology, through the new strong co-occurrence connections established from the central element “parasite”. We verified that this element presents intense co-occurrence strength with the elements: “morphology”, “specimen” and “illness”. Thus, we can observe, post-instruction, that the central element “parasite” associated with the element “morphology”, constitute the basis of the social representations of

the students related to parasitology. In addition, the similarity analysis tree post-instruction shows the elements “host-parasite relationship” and “biology” as peripheral elements of the SR. The similarity analysis and the prototypical analysis show a shift in SR post-instruction in accordance with the focus of the course syllabus.

Figure 2. Similarity analysis of the social representations (SR) of medical laboratory students (MLS) related to parasitology pre and post instruction (N=14).



Source: Elaboration by authors.

Conclusion

We observed a short-term change in the SR of master level MLS students related to parasitology after instruction. As any other study, our study presents some strengths and limitations. First, in terms of strengths, to our knowledge this is the first study to measure change in SR pre and post instruction. Second, all the methods used to understand SR are only able to give an approximation of what the phenomenon of SR really is. Therefore, studies like ours, which use more than one method of analysis, can have a better picture of SR of a specific group (MLS students) about a specific object (Parasitology) (WOLTER, 2018).

Regarding limitations, to be part of the central core, the word does not need to be the one evoked with higher frequency (most salient; a quantitative aspect of the word), but the one with highest meaning to the representation (a qualitative aspect of the word) (DANY; URDAPILLETA; LO MONACO, 2015). Even though we used sound and traditional methodology in the analysis of SR, it is important to point out that the methodology we used

does not permit us to say with certainty that these words/concepts are part of the central core, only that they are most likely part of the central core since we did not perform a test of centrality (DANY; URDAPILLETA; LO MONACO, 2015). This study represents a single cohort of master students in the MLS program in an American university and therefore cannot be generalized. The specific SR related to parasitology may vary in student populations of other schools/programs, however, the methodology reported here can be implemented to assess common knowledge of a topic in any student population to inform teaching and learning.

The function of SR is to provide a group identity, and to guide group behavior (LAHLOU; ABRIC, 2011). After effective teaching and learning in a specific area such as medical/diagnostic parasitology, students should change their social representation to reflect a more cohesive professional identity (since sharing a SR means having shared values about a specific object) (WOLTER, 2018), professional vocabulary related to parasitology, and a sense of belonging to the group of clinical laboratory professionals.

According to Rouquette (2000), practice changes social representations of social groups and, as a social practice, teaching is capable of changing students' thoughts about science, once this practice is developed responsibly, focused on the students' apprehension of knowledge and protagonism (ROUQUETTE, 2000). Teaching being a social practice, it is also responsible for transformation of social representations as well as students' behavior. The description of SR related to course content is a scientific sound, and cost and time effective method to be used as the first step to learn more about the common knowledge of students. Information about the SR of student cohorts related to the main course topics can be used by the instructor to inform and evaluate curriculum in order to make teaching and learning more effective.

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Autoras:

Karla Patricia de Oliveira Luna

PhD, is a professor at the State University of Paraíba, Brazil. Dr. Luna researches on Teaching and Learning in Sciences and Biology. Her main research line is on Social Representations.

Contact: karlaluna@servidor.uepb.edu.br

Nathalya Marillya de Andrade Silva

MSc, is a Science Teacher with the Department of Education in the municipality of Remígio, Paraíba, Brazil. MSc Silva researches on Teaching and Learning in Sciences and Biology. Her main research line is on Social Representations. Contact:

nathalya_marillya@hotmail.com

Ana Lucia Oliveira

DrPH, is an Assistant Professor at the University of Alabama at Birmingham (UAB). Dr. Oliveira's main areas of research are Teaching and Learning, Infectious Diseases, and Public Health. Contact: analuna@uab.edu

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