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Evidence of the Effectiveness of Teaching and Learning Active Methods in Health Courses: Systematic Review and Meta-analysis

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Keywords: active methods; traditional methods; health; meta-analysis; systematic review

Abstract

Background: This systematic review and meta-analysis aims to estimate the evidence of the effectiveness of the active teaching and learning methods in health majors.

Methods: We systematically searched four major databases (i.e., PubMed/MEDLINE, LILACS, Scielo and ERIC). This review was according to the PRISMA method and registration in PROSPERO (CRD42018094054). This review included studies to compare active teaching and learning methods to the traditional methods in the different health majors. We consider all original articles published in the databases until April 29th, 2020. Data were analyzed using R software. The pooled estimates with 95% confidence intervals (CIs) were presented using a forest plot. Higgins and Egger's tests were used to assess heterogeneity and publication bias, respectively. Primary estimates were pooled using a random-effects meta-analysis model.

Results: Of the total of 27 identified articles 16 studies met the inclusion criteria and were included in this meta-analysis. The included studies sample size ranged from 18 to 379. The

total sample was 4031 undergraduates from four health courses. The combined meta-analysis was 67% (95% CI: 0.13-0.54).

Conclusions: Our finding suggested that evidence exists of the effectiveness of the active teaching and learning methods when compared to the traditional methods in the health courses.

Introduction

The new paradigm of teaching, learning and evaluation to which the 21st century society is subjected implies significant epistemological, pedagogical and psychosocial changes. The focus is to prepare students for the dynamism of the contemporary world, which interferes with life and work conditions as well as the production of knowledge (Cotta et al., 2015; Cotta & Costa, 2016a, 2016b). Therefore, innovative teaching must implement professional development methods with a humanistic focus centred on the human being (students, teachers, community and other professionals), transcending the traditional technicist model to models based on active, interpretive, critical and reflective participation (Cotta & Costa, 2016b; Roget & Serés, 2014).

It is observed in health courses that international guidelines recommend the formation of generalist, critical, reflexive, creative, and humanized professionals with social responsibilities to work in universal, integral and equitable systems, based on the demands of local communities without losing sight of the global demands (Cotta et al., 2015; Cotta & Costa, 2016a). Thus, the use of active methods has increasingly been pointed out as an alternative for the exercise of reflexive, critical, creative and innovative professional training. However, it is necessary to implement studies that evaluate the evidence of the effectiveness of active teaching and learning methods when compared to traditional methods.

Effectiveness is understood as the effect of an activity and its final results, benefits and consequences for a particular group or study population when compared to the established objectives as well as the sustainability of the process and the initiative (Frye & Hemmer, 2012; Organización Mundial de la Salud [OMS], 2007). In turn, evidence characterizes the product of a complex combination of observation, experimentation (empirical evidence), and theoretical argument (Organización Mundial de la Salud [OMS], 2007). Thus, to meet these needs, a systematic review and meta-analysis of studies that evaluated the active methods compared to the traditional methods was carried out. The objective of this study was to evaluate the evidence of the effectiveness of the use of active teaching and learning methods in health majors. With this goal based on PICOS, we aimed to compare the active method of teaching, learning and evaluation with the traditional method to evidence its effectiveness in observational studies and intervention with students of health courses. We also sought to answer the following research question: Is there evidence of the effectiveness of active teaching and learning methods?

Methods

Protocol and Registration

This review was planned and conducted in accordance with the methods proposed in the Preferred Reporting Items for Systematic Reviews and Meta-Analyzes guide (PRISMA) (Moher et al., 2009), whose theme was the analysis of evidence of the effectiveness of active methods compared to the traditional teaching and learning methods of health courses worldwide.

This review was registered under the International Prospective Register of Systematic Reviews (PROSPERO) under protocol number CRD42018094054 (Link protocol and registration).

Data source ad searches

To find potentially relevant studies, we systematically searched four major databases (i.e., PubMed/MEDLINE, LILACS, SciELO and ERIC). Additionally, the reference lists of eligible studies were checked for additional articles. The search was conducted by two authors (ESF and KPS) independently. Studies identified through systematic search were retrieved and managed using Micosoft Excel. The search from the above-mentioned databases was conducted using the following terms: “problem-based learning” AND “education” OR “education measurement” AND “teaching” AND “teaching methods”. April 29th, 2020 was the date of our last search.

Study selection criteria

The following studies were considered eligible: original articles; from anywhere of world; undergraduate student from health majors (in any period or age); type of intervention the use of any active methods of teaching and learning; type of control the use of any traditional methods; all published and unpublished articles; articles in English, Portuguese and Spanish; publication date: without limit of date. For meta-analysis were considered eligible those that presented the sample number, mean and respective standard deviation (SD). Filters were used, if available. The search strategies were designed with the help of a professional librarian. Articles that were not fully accessed after at least two email contacts of the principal investigator were excluded.

Screening process

We included all academic community based original studies. All titles/abstracts identified in the electronic databases were screened by 2 authors (ESF, KPS) independently of one another. Discrepancies were resolved by discussion. All potentially relevant full texts were screened by 2 authors (ESF, KPS) independently of one another. Discrepancies were resolved by discussion. In the case of discrepant judgements, a third author (RMMC) was involved.

Data extraction process and quality assessment

Analysis of the eligibility of original articles to evaluate active methods compared to traditional methods was performed independently by two authors (ESF, KPS) using a

pre-defined eligibility criterion to ensure consistency. The data extraction form was prepared using a Microsoft™ Excel spreadsheet. Disparities between authors were resolved through discussion once the source of disagreements were identified. In the first phase, studies with duplications between and within databases were excluded. Subsequently, refinement was carried out to select the studies related to the topic addressed by reading the titles. In the second phase, we read the abstract. In the last phase, the articles selected in the reading of the titles and abstract, were read in their entirety.

The following information were extracted from each primary article: number of undergraduate students (sample size means and age), intervention design (type of study, intervention and outcomes), data collection instrument, study location, region, publication year, study design, sample size, and first author. This information was summarized in a standard data extraction template.

Evaluation of methodological quality

The measure of effectiveness and quality of the methods used in each article was evaluated using an adapted scale proposed by an instrument from Kirkpatrick's (1998) (Lau et al. 2006; Steme et al., 2011). This instrument allows for the evaluation of learning by means of the type, quality of the studies and effectiveness of descriptive and qualitative findings. Thus, in this study, the adopted criteria included: student's perception of the active method; change in knowledge and skills; behavior change; change in critical thinking; student's satisfaction with the intervention.

For each criterion met, the study received a point. Therefore, high quality studies received score between 4 and 5 points; moderate quality received 3 points; low quality received between 0 and 2 points. However, this quality evaluated of the articles is not an exclusion criterion, but rather a parameter to measure the effectiveness and heterogeneity.

Heterogeneity and publication bias

The presence of statistical heterogeneity within the included studies was checked using I-square statistics and Cochran's-Q test. Accordingly, heterogeneity was classified as low, moderate, or high when the values of I-square were 25, 50, and 75%, respectively (Higgins, 2003). Additionally, the dispersion of individual results in the forest plot was also used to evaluate the presence of heterogeneity visually. Egger's weighted regression test at a p-value < 0.05 and the funnel plot was used to assess the presence of publication bias.

Data analysis

The results were synthesized using meta-analysis from the difference between the sample number of the intervention and control group, standardized mean and respective SD.
As the studies included in the meta-analysis used different scales to evaluate the methods used, we standardized the mean and SD on a seven-point Likert scale to measure the effect size and compare them equivalently.

Correlations were grouped in random-effect meta-analysis. A random effect model was used to calculate the odds ratio (OR) for each outcome found and the Cochran Q test. The statistical significance of the overall effect size of the use of the active methods (intervention) was determined by the 95% confidence interval (CI) and significance level of 5%.

Further statistical analyses such as subgroup analyses, meta-regression was performed to identify the possible sources of heterogeneity. Furthermore, sensitivity analysis using a random effects model was performed to assess the influence of a single study on the overall pooled estimate. At last, results were presented in tables and forest plots. All analyzes were performed using Software R for Windows (Development Core Team, 2009).

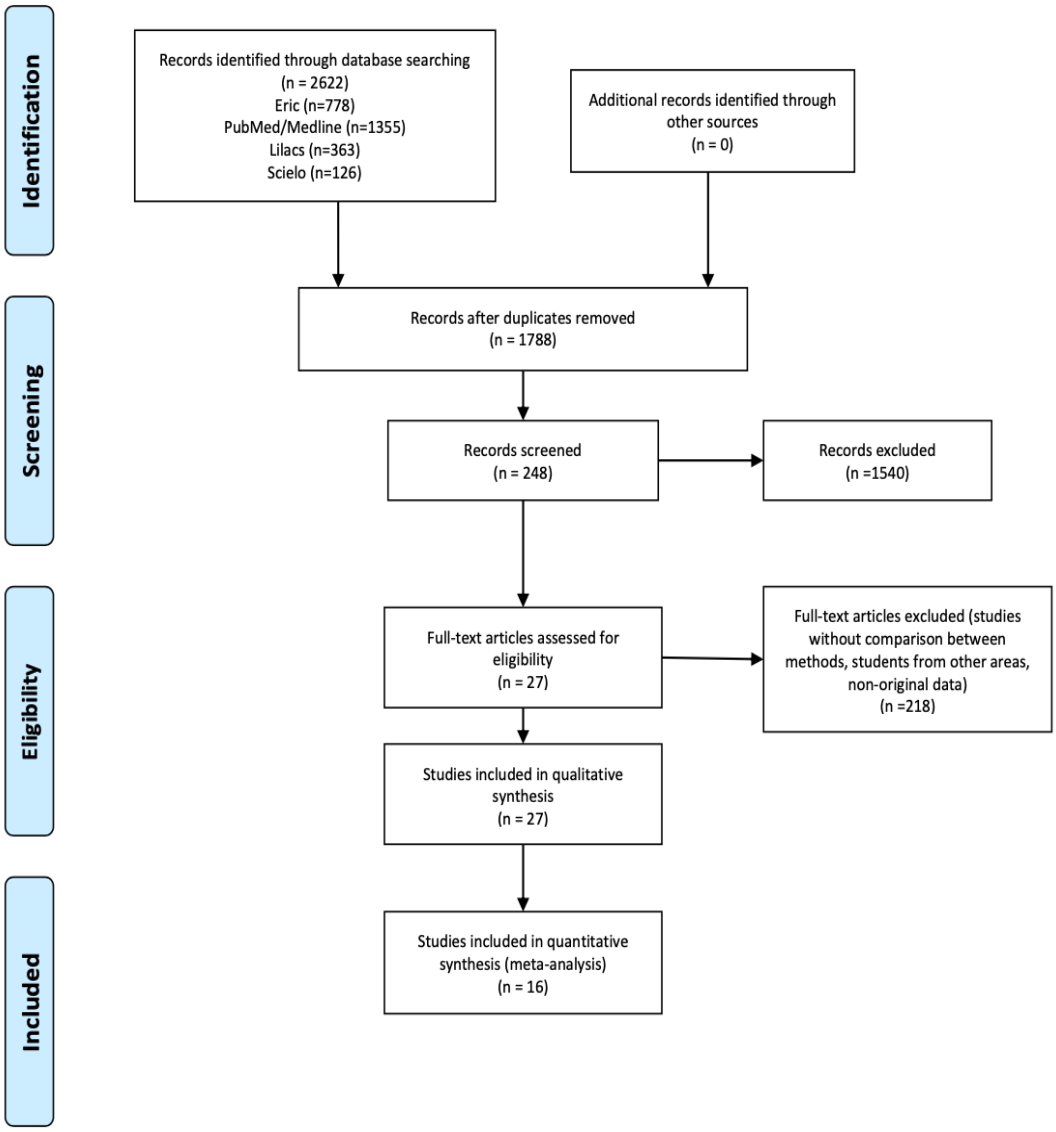
Results

Search results and study selection

According to the definition of the descriptors, the search in the literature revealed 2,622 studies. After exclusion of duplicates and by the title selection criteria, 248 papers met the standards of eligibility. Then, the abstracts were read and 27 studies remained (Ahmed et al., 2018; Alamrani et al., 2018; Arrue et al., 2016; Berger et al., 2019; Bleske et al., 2014; Choi et al., 2014; Dombrowski et al., 2018; El-Banna et al., 2020; Everly, 2013; Frota et al., 2011; Gouzi et al., 2019; Gurpinar et al., 2005; He et al., 2019; Isherwood et al., 2020; Johnston et al., 2009; Kamat et al., 2012; Lee, 2018; Lin et al., 2010; Liu et al., 2018; Masocatto et al., 2019; McLean et al.,2016; Ozbiçakçi et al., 2004; Parland et al., 2004; Peine et al., 2016; Prado et al., 2011; Seifert et al., 2019; Soltanimehr et al., 2019).

Of these, none were deleted after reading in entirety. When the studies eligible for the systematic review did not present the necessary results for meta-analysis, an attempt was made to contact the authors of the articles. After this contact, for meta-analysis, only 16 studies met the required criteria (Alamrani et al., 2018; Berger et al., 2019; Choi et al., 2014; El-Banna et al., 2020; Gouzi et al., 2019; Gurpinar et al., 2005; He et al., 2019; Johnston et al., 2009; Kamat et al., 2012; Lee, 2018; Lin et al., 2010; Liu et al., 2018; Ozbiçakçi et al., 2004; Peine et al., 2016; Prado et al., 2011; Soltanimehr et al., 2019). The flow diagram shown in Figure 1 illustrates the selection of studies.

Figure 1 - Flow diagram of bibliographic research and selection process of studies in a systematic review



From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta-*A*nalyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit www.prisma-statement.org.

Figure 1 - Flow diagram of bibliographic research and selection process of studies in a systematic review

Characteristics of eligible studies

The total sample was 4031 undergraduates from four health courses. In some studies, the students were evaluated simultaneously in both methods (active and traditional). Those studies were conducted between 2004 and 2020. The included studies sample size ranged from 18 to 379. (Table 1).

Table 1 - Characteristics of the studies included in the systematic review

AUTHOR	YEAR OF THE RESEARCH	COUNTRY	DRAWING	GRADUATION COURSE	COLLECTION INSTRUMENT	ACTIVE METHODS	SAMPLE SIZE (n)	QUALITY SCORE
Lin et al. (2010)[11]	2005	China	Randomized control	Nursing	Teaching Plans, Skill Scale Learning Satisfaction Survey, Pre and Post Test	PBL	142	3,5
Johnston et al. (2009)[12]	2007	China	Randomized control	Medicine	Traditional classes and attitude and behavior questionnaire	PBL	129	1
Prado et al. (2011)[13]	2007 - 2008	Brazil	Crossover control	Medicine	Questionnaire	PBL	144	5
Everly (2013)[14]	2010 - 2011	USA	Case control	Nursing	Pre-recorded classes, slides, multiple-choice questionnaire and Likert scale	Pre-recorded lessons, quiz.	139	3,5
Özbıçakçı et al. (2014)[15]	2013	Peru	Case control	Nursing	Likert scale questionnaire	PBL	157	4
Gurpinar et al. (2005)[16]	2002	Peru	Transversal	Medicine	Questionnaire of multiple of knowledge in public health	PBL	134	5
Arrue et al. (2007)[17]	2014 - 2015	Spain	Case control	Nursing	Declarative and argumentative knowledge through pre and post tests	PBL	57	4
Choi et al. (2014)[18]	2014	Korea	Case control	Nursing	Scales for critical thinking and problem solving through pre and post tests	PBL	90	3
McLean et al. (2016)[19]	2013 - 2014	Canada	Transversal	Medicine	Likert scale questionnaire; pre and post tests	Flipped Classroom	54	5
Kamat et al. (2012)[20]	2012	India	Case control	Medicine	Pre and posttest with multiple choice questions	CBT	179	5
Frota et al. (2011)[21]	2010	Brazil	Transversal	Odontology	Electronic Questionnaire	E-Portfolio	60	5
Paine et al. (2016)[22]	2015	Germany	Randomized trial	Pharmacy	Pre and posttest questionnaire	Self-taught learning	244	3
Bleske et al (2014)[23]	2011 – 2012	USA	Cohort	Pharmacy	Questionnaire with multiple choice questions	TBL	182	4
McParland et al (2004)[24]	2004	England	Cohort	Medicine	Questionnaire	PBL	379	3
Berger et al. (2019)[25]	2010 - 2011	Germany	Prospective Cohort	Medicine	Questionnaire, direct observation	PBL	112	1
AlAmrani et al. (2017)[26]	2016	Saudi Arabia	Randomized control	Nursing	Pretestandposttest	Simulation-basedlearning	30	1,5
Lee (2018)[27]	2016	South Korea	Quasi-experimental	Nursing	Self-Leadership Questionnaire, Clinical competence skills pretest/posttest, Problem-solving ability pretest/posttest, Communication competence pretest/posttes, Critical thinking ability pretest/posttest	TBL	183	4
El-Banna (2019)[28]	2019	United States	Cohort	Nursing	Standardizedcriterion-referencedexaminations	TBL	338	0,5
Masocatto et al. (2019)[29]	2017	Brazil	Cross Seccional	Medicine	Likertscale	TBL	193	3
Seifert et al. (2019)[30]	2019	Germany	Cohort	Odontology	Theoretical test, self-assessment questionnaire, Virtual patient design and Likert scale	CBL	57	1,5
Liu et al. (2018)[31]	2019	China	Randomizedcontrol	Odontology	Questionnaire (likert scale), practical test	Online Peer-Review System	66	2
Dombrowski et al. (2018)[32]	2018	Germany	Quasi-experimental	Medicine	Questionnaire(likertscale)	E-learning and flipped classroom	212	4
Gouzi et al. (2019)[33]	2019	France	Randomized	Medicine	Questionnaire(likertscale)	Simulation-basedlearning	80	1,5
Yuan He et al. (2019)[34]	2017	China	Randomized	Pharmacy	Questionnaire(likertscale)	Flipped classroom	137	4,5
Isherwood et al. (2019)[35]	2017 - 2018	United Kingdom	Randomizedcontrol	Odontology	Questionnaire, semi-structured interviews	E-learning	61	4,5
Ahmed et al. (2018)[36]	2017	Iran	Randomized Control	Medicine	Number of procedural steps completed and number of errors made	Self-guided practice	18	3
Soltanimehr et al. (2019)[37]	2018	Iran	Randomized Control	Odontology	Questionnaire with multiple choice questions	E-learning	39	3

Note. *PBL: Problem Based Learning; TBL: Team Based Learning; CBT: Case Based Teaching; CBL: Case-based learning*

Of the 27 articles analyzed in entirety, the most used active method was the Problem-Based Learning (PBL) (38.7%) (Arrue et al., 2016; Berger et al., 2019; Choi et al., 2014; Gurpinar

et al., 2005; Johnston et al., 2009; Lin et al., 2010; Ozbiçakçi et al., 2004; Parland et al., 2004; Prado et al., 2011), the most used designs in the studies were randomized case-control (38.7%) (Ahmed et al., 2018; Alamrani et al., 2018; He et al., 2019; Isherwood et al., 2020; Johnston et al., 2009; Lin et al., 2010; Liu et al., 2018; Peine et al., 2016; Soltanimehr et al., 2019).

The most used instrument for comparison among methods were questionnaires (53.3%) (Berger et al., 2019; Bleske et al., 2014; Dombrowski et al., 2018; Everly, 2013; Frota et al., 2011; Gouzi et al., 2019; Gurpinar et al., 2005; He et al., 2019; Isherwood et al., 2020; Johnston et al., 2009; Lee, 2018; Lin et al., 2010; Masocatto et al., 2019; McLean et al.,2016; Ozbiçakçi et al., 2004; Parland et al., 2004; Peine et al., 2016; Prado et al., 2011; Seifert et al., 2019; Soltanimehr et al., 2019). Eight studies address active methods in nursing courses (Alamrani et al., 2018; Arrue et al., 2016; Choi et al., 2014; El-Banna et al., 2020; Everly, 2013; Lee, 2018; Lin et al., 2010; Ozbiçakçi et al., 2004), eleven in medicine course (Ahmed et al., 2018; Berger et al., 2019; Dombrowski et al., 2018; Gouzi et al., 2019; Gurpinar et al., 2005; Johnston et al, 2009; Kamat et al., 2012; Masocatto et al., 2019; McLean et al.,2016; Parland et al., 2004; Prado et al., 2011), five in dentistry course (Frota et al., 2011; Isherwood et al., 2020; Liu et al., 2018; Seifert et al., 2019; Soltanimehr et al., 2019) and three in the pharmacy course (Bleske et al., 2014; Parland et al., 2004; Peine et al., 2016).

Twelve studies were considered of high quality (Arrue et al., 2016; Berger et al., 2019; Dombrowski et al., 2018; Frota et al., 2011; Gurpinar et al., 2005; He et al., 2019; Isherwood et al., 2020; Kamat et al., 2012; Lee, 2018; McLean et al.,2016; Ozbiçakçi et al., 2004; Prado et al., 2011), eight of moderate quality (Ahmed et al., 2018; Choi et al., 2014; Everly, 2013; Lin et al., 2010; Masocatto et al., 2019; Parland et al., 2004; Peine et al., 2016; Soltanimehr et al., 2019) and seven of low quality (Alamrani et al., 2018; Berger et al., 2019; Gouzi et al., 2019; Johnston et al., 2009; Liu et al., 2018; Seifert et al., 2019). The characteristic of "student's perception of active methods" presented a prevalence of 85.7%, followed by "change in knowledge and skill" (85.7%) and "student satisfaction with the intervention method" (71.4%). A "behavior change" was observed in 57.1% of the studies and a "stimulation of critical thinking" in 50.0%.

Nine studies did not evaluate student's perceptions of the active methods. The changes of knowledge and skills were not evaluated in only three studies, which used the pre-recorded lectures and class quizzes. Regarding behavior changes, fifteen articles were able to measure this skill. Sixteen articles did not evaluate the critical thinking developed by the students and six articles did not evaluate the student's satisfaction regarding the methods used in the intervention.

Meta-analysis

The meta-analysis was calculated according to the comparison of mean, SD and sample size between each study. The combined OR of the standardized means comparisons was 0.33 (95% CI: 0.13-0.54), indicating that the chance that active teaching and learning methods are more effective than traditional methods is 67% higher (Figure 2).

The general scores (OR) of the 16 articles of active teaching and learning methods (intervention group) and traditional methods (control group) revealed that, according to Cochran's Q test, p <0.01 and I^2 = 96%. This shows a high heterogeneity between the studies, however indicates the rejection of the null hypothesis, giving evidence to the effectiveness of the active methods regarding the student's perception of the intervention, critical thinking, improvement of knowledge and skill, behavior, and student satisfaction with the intervention.

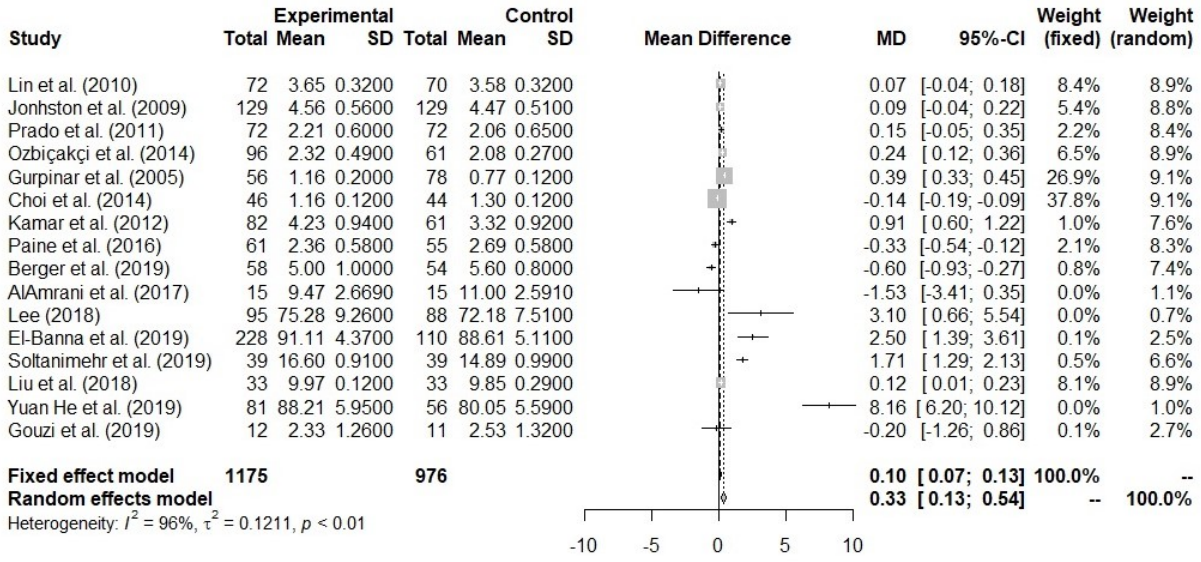


Figure 2 - Forest plot of the studies included in the analysis of random effect

Meta regression and publication bias

A series of subgroup analyzes were performed using the extracted data to identify the high heterogeneity found. However, the product found was not explained by the risk of polarization results. By meta-regression, none of the variables of the subgroups analyzed were able to explain the causes of the high heterogeneity found in the analysis of the studies (p> 0.05). We believe that this result is due to the difference between the sample of each study, as well as the size of the effect of each study, which is relative according to the method and course used.

Funnel plot asymmetry (Figure 3) was assessed using Egger's weighted regression test to examine the presence of publication bias. However, no statistically significant of publication bias was detected (p = 0.790).

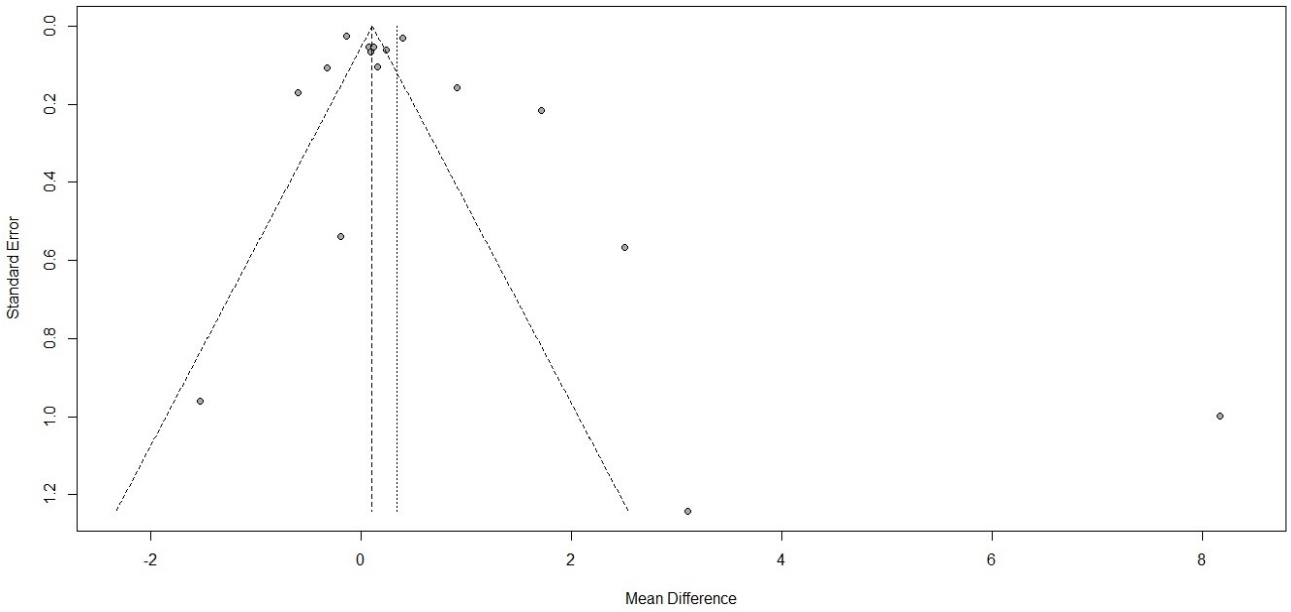


Figure 3 - Funnel plot: the intervention done in each study by the standard deviation

Discussion

This systematic review and meta-analysis of a combination of studies was conducted to analyze evidence of the effectiveness of active methods comparison to traditional methods in health majors. The analyzed articles met more than half of each of the criteria used to evaluate them and the evidence of the effectiveness of the active teaching and learning methods was proven to be higher (67%) when compared to the traditional teaching and learning methods.

High heterogeneity was present in all the analyzes (96%), which calls for caution in the result extrapolation. To verify the source of this result, we performed the analysis of possible subgroups followed by a meta-regression. The results found in these tests suggest that the high heterogeneity found may be due to the natural differences between the subjects included in the selected studies, such as the types of majors, the reduced sample size, the methodological design and the type of comparison.

The meta-analysis revealed that active teaching and learning methods (PBL, pre-recorded lectures/quiz class, e-portfolio, self-instructional learning, self-taught learning, simulation-based learning, flipped classroom, TBL and CBT) are more effective than traditional methods to improve the student's critical thinking, satisfaction and perception of the improvement of skill and knowledge, which resembles other studies present in the literature (Cotta & Costa, 2016).

Although only three article addresses the flipped classroom (McLean et al., 2016;

Dombrowski et al., 2018; He et al., 2019), this method is widely used mainly in the medical field and, according to a study by Chen et al. (2017) and Gostelowet al. (2018), it has achieved successful results when compared to lectures and the acquisition of knowledge and performance in practical courses within the major. The study by Lin and Lu et al. (2010), which received the highest quality score in this review, reported the use of the flipped classroom as a key factor in the use of the active methods by students (perception), higher educational gains, independent learning and deeper involvement related to the satisfaction in deep and active learning, which coincides with the findings of the literature that employed these methods (Cotta & Costa, 2015).

As for the portfolio, the findings of this systematic review coincide with the studies developed by Cotta et al. (2016a; 2016b) which evaluated the portfolio as a teaching, learning and evaluation method within the framework of professional development focused on cognitive and metacognitive skills, reaching concrete results that the process of its construction stimulated the capacity of analysis, synthesis, self-knowledge, criticism, reflection, creativity and autonomy.

This study revealed results that indicate the active teaching and learning methods as evidently approved by the students, as reported by Lin and Lu et al. (2010), who found improvements in the development of independent learning skills, in critical-reflexive thinking, in time management and in the group work and whose results confirm the findings of Cotta et al. (2017).

In some studies, even though there was no significant difference between the two methods evaluated, the active methods presented a high degree of student satisfaction regarding the exercise of critical thinking after the interventions. Similar results were found in the meta-analysis developed by Lee et al. (2018), in which there was a significant increase in critical thinking after the applied interventions.

The acquisition of critical thinking is a skill that, according to Lee et al. (2017) and Cotta et al. (2015; 2016), should not be isolated as it is necessary to value the cognitive and metacognitive skills as well as the students' willingness to use them in order to improve in critical thinking. Therefore, when assessing the quality of the studies, adding this critical thinking criteria to the students' satisfaction and perception about the teaching and learning process with the active methods, high quality and significant results are found. In the present systematic review, 50% of the studies evaluated this competency in a positive way, which raised the final quality of the studies for meta-analysis.

However, our review has some limitations. Firstly, the impossibility of including 11 studies of this systematic review in the meta-analysis, because them did not present measurement data of central tendency and dispersion (mean and standard deviation) among the studied methods. Thus, it is important for the journals of the field to indicate as criteria the inclusion of such data in the analysis for future studies. Secondly, we were unable to find studies conducted in some regions of the world. As strengths of this systematic review and meta-analysis, the following traits are distinguished: the rigor in the research process, abstraction and analysis of the studies and the inclusion of a pre-specified and registered protocol in the PROSPERO database. We considered papers published in English, Spanish and Portuguese

language.

Conclusion

This systematic review and meta-analysis demonstrated that the active teaching and learning methods used in these studies were significantly different from the traditional methods. That is, the intervention favored an increase in the prevalence of the outcome. The findings of this study proved to be positive with improvements of critical thinking, student satisfaction, as well as improvements in the knowledge and skills acquisition process and in the behavior change perceived by students.

Thus, this systematic review and meta-analysis proved the effectiveness of the active methods, a discovery that can serve as subsidies for its development, both for university management and for teachers' strategies in student development, assisting in the implementation of integrated and innovative curricula.

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