Research Square

Preprints are preliminary reports that have not undergone peer review. They should not be considered conclusive, used to inform clinical practice, or referenced by the media as validated information.

Learning styles and the myths surrounding it: a systematic scoping review of the literature.

Lucas de Mendonça (ldmmfc@gmail.com)
Albert Einstein Israelite Hospital: Hospital Israelita Albert Einstein https://orcid.org/0000-0002-6516-9574

Regis Rodrigues Vieira
Hospital Israelita Albert Einstein

Michel Silvio Duailibi
Hospital Israelita Albert Einstein

Research

Keywords: Learning Styles, Medical Education, Medical Residency, Post-Graduate Medical Education

Posted Date: April 8th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-396082/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License. Read Full License

Abstract

Background: Learning style (LS) is the theoretical assumption that each individual has a better form for cognitive processing throughout learning. In medical education, LS has been studied as a tool to optimize medical learning. Teaching in the postgraduate medical environment embraces specific methodological aspects for mastering medical abilities and LS inventories have been widely used for enhance learning. However, no review has been done on this subject until this date. Therefore, a scoping review was performed to explore the extent of evidence on LS and postgraduate medical education.

Methods: a systematic scoping review was performed according to PRISMA - ScR and JBI guidelines. We searched MEDLINE, ERIC, LILACS and SCIELO virtual library on February 2020. A peer review was performed with blinding of both investigators and any divergence was resolved by consensus. Searching strategy, search terms, exclusion and inclusion criteria and data charting were structured prior to the beginning of the study. Data was summarized and collated. Analysis of the quality of the evidence was also performed using specific tools.

Results: 211 studies were obtained with the search engine after duplicates were removed. Of these, 40 were selected after applying exclusion and inclusion criteria. Two other studies were excluded post initial screening. The majority of studies were from United States. General surgery, internal medicine and family medicine were the specialties that had most studies on LS. Kolb LSI was the most used LS inventory. The majority of studies were observational with a cross sectional design (34 out of 38). Only four studies were RCTs with a low quality of evidence and a high risk of bias. It was also seen that LS may change through training, with work-hours and areas of specialty training.

Conclusion: There is a lack of high quality studies to provide reliable evidence for the utilization of LS in postgraduate medical education and it is desirable for more Cohort or Randomized Control Trials in this area for a more robust evidence.

Introduction

Learning is the basic process of human adaptation(1,2). The comforting assumption that each individual has a specific cognitive, affective and physiological trait that may enhance the learning process has been studied under the name of learning styles(3). Though this theory has been used for nearly 40 years, its validity has been controversial and despite evidence, it has shown some downsides(4,5), learning styles questionnaires are still widely used in learning environments(6,7). There are over 70 different learning styles inventories (VARK, Kolb LSI, Honey and Mumford, MBTI…) that focus on a diversity of psychological theories and its application in higher education is broad, despite not evidence based(7).

Medical education comprehends the complex task of delivering a well-qualified physician to society. It´s desired abilities are described by the six dimensions of CanMEDS framework for a good medical expert (Scholar, Professional, Communicator, Collaborator, Leader and Health advocate). To optimize learning of these complex dimensions, tailoring learning to individual learning style is a theory explored in the literature.

After graduating from medical schools, students are enrolled in many learning formats in order to initiate their first steps in a medical career(8). Though formats vary from internships, residency programs and other specialty trainings in postgraduate medical education, these phases are when doctors develop competencies under supervision towards independent practice after completion of their basic medical qualification. Knowledge translation is a key ability to be developed in this phase and learning styles has been explored as a construct for optimizing the learning process of these professionals(9).

Knowing if there is any advantage on the use of LS in medical specialty training may be of great interest to orient learning strategies and rethink its applicability in medical education. Mapping what and how studies have been using this tool in postgraduate medical education may reveal patterns that could be used to aid medical trainees in their path to becoming independent practitioners and maximize learning throughout residency. Moreover, mapping studies on the field may give bearings for further research on LS.

We sought to know if medical trainees and residents' LS may be a situational diagnostic tool to orient and organize post-graduation programs and if there is any association between training in each medical specialty and medical trainees learning styles. Despite this being widely used, no study has compiled information regarding postgraduate medical education and learning styles to our knowledge. This paper aims to map and summarize data available in international literature and review its current use.

OBJECTIVES

To deliver what has been studied on the use of learning styles in postgraduate medical education. We aimed for patterns of utilization of learning style inventories and medical specialty training as well as the impact of learning styles as a situational diagnostic tool for postgraduate medical programs. We also wanted to know how this subject is studied, by uncovering the studies designs, tools used to measure the LS, number of participants on average, the specialties that more commonly study these tools and the quality of current evidence available.

Methods

Study design: a peer-controlled scoping review was performed according to JBI and PRISMA - ScR statements(10). Differently from a systematic review, the study question was broad and a scoping review was preferred, thus registration on PROSPERO was not necessary. Descriptive synthesis of data was registered and analyzed.

Review process: we performed the review in a systematic way after defining our study questions, search method and database, study selection, charting data and summarizing results(11,12).

Research question: What is known in the literature about learning styles in postgraduate medical education? How do different medical specialties differ on their learning styles during postgraduate training? How is LS applicable in postgraduate medical education?

Searching strategy: We opted to search MEDLINE, ERIC, LILACS and SCIELO virtual databases. Two investigators (LM and MD) used the same Mesh terms and proceeded independently on study selection after definition of inclusion and exclusion criteria. Initially, title screening and abstract was performed and on selected articles exclusion and inclusion criteria were applied. Any discordance was resolved after deliberation and consensus. Data was collected until February 2020.

As for search terms the following Mesh were used: "Internship and Residency"; "Education, Medical, Graduate" and "learning". Also, we looked for all fields containing preferences and styles since there were no Mesh terms in the literature. With Boolean terms we built our search construct: (Residency or internship or graduate medical education) AND "Learning styles" and filtered by Medical Education.

Inclusion criteria were defined as: 1) Language (Portuguese, English and Spanish); 2) Clear reference of type of learning style inventory used; 3) Traditional postgraduate medical programs.

As for exclusion criteria:1) Undergraduate medical students; 2) Students that were not registered in postgraduate medical training programs; 3) Studies involving medical specialists; 4) Other healthcare students; 5) Postgraduate curricula as sample; 6) Studies that did not specify a medical specialty; 7) Learning style is not an outcome of the study; 8) Not original data.

Data extraction was peer reviewed and disagreements were resolved by consensus. Data charting was done on a purpose built MS Excel Spreadsheet and the following variables were defined for obtaining information: author (year), country; sampling population; medical specialty; study design; LS tool used; and a summary of evidence brought by each study individually.

The response rate was defined as the amount of total included participants divided by the total number of invitations or eligible students at screening. Studies that didn´t specify this information were labeled as “not available” in supplementary table 1. The number of participants was defined as the number of residents that responded to the questionnaires, while the number of evaluations was defined as the amount of evaluations that were used in the study analysis.

Data analysis: Learning styles of different medical specialties postgraduate programs were highlighted and discussed according to the type of learning style analysis and its utility in each program. We sought to see deficiencies in current evidence regarding our study questions. Studies that brought more than one population of interest (i.e. college or undergraduate study) and medical residents were also included, however, we have focused on the data primarily from these last ones to build our table.

To define study design, we have used a previously published article(13). We have also explored the quality and biases in the included studies using known tools to analyze the risk of bias such as ROBINS I for clinical non-randomized and quasi-randomized trials(14). This was performed in a blind manner by two of the authors (LM and RV). Disagreements were resolved by a third party (MD).

Results

Two studies were excluded after title and abstract screening because one of them was about junior doctors (UK) training(15), who are not residents per se and the other exclusively included residency coordinators (16). At total, 38 studies were included and summarized. The years of these articles in this study ranged from 1978 to 2019.

What is known in the literature about learning styles and postgraduate medical education?

Overall, we selected 38 studies with a total number of participants of 3357 residents (average 88,34; range 13-461). Most of the studies were designed as cross-sectional (n=34; 89%) with surveys being the main tool of data collection. Data was collected mainly through internet survey servers and in some studies, social media was used for population assessment. The total number of LS evaluations compiled was 3663 (average 96,39; range 13-461). Both an analytical approach and a pure descriptive approach were seen in studies. Response rates were variable, although high on average (84,4%, range 54-100%). Other fourteen studies (20, 22, 24, 26, 28-32, 34, 42, 46, 48, 52 e 54) haven’t described a response rate and one RCT(42) had its number of participants pre-defined and excluded part of the eligible participants during randomization.

Randomized clinical trials (RCT) represented four studies with a total of 285 LS evaluated, (average of 71,25 per study - range 18 to 121). Analysis of the risk of bias using ROBINS I showed that all the four studies had a high risk of bias. Three out of the four RCT used the Felder and Solomon's Index of Learning Style (ILS) and one used the VARK (Visual, Aural, Read/write, and Kinesthetic) questionnaire.

The outcomes used, vary among studies, but usually the LS were evaluated as secondary outcomes. The most used tool to analyze LS was the Kolb Learning style inventory with a total of 20 studies (52%), followed by the VARK questionnaire and the Felder and Solomon (three studies each). The Honey Alonso and the Vermunt Inventory of Learning Styles (ILS) was used in two studies each and eight other studies used different LS inventories (see table 1 for all LS inventory used).

The specialties that most studied LS were general surgery (n=10), followed by internal medicine (n=6) and family medicine (n=5). In a subdivision by clinical and surgical specialties, we found that 23 (56%) were in clinical areas and 17 (41,5%) in surgical areas.

As for countries, United States of America was the place with the most studies (n=27; 69%). Canada was the second, (n=4; 10,2%), United Kingdom the third (n=3; 7,6%), Argentina was the fourth (n=2; 5%), followed by Mexico, Taiwan and Chile (n=1; 2,5% each).

How do different medical specialties differ on their learning styles during postgraduate training?

Table 1 summarizes results of individual studies. Overall, residents from surgical specialties, (general surgery, ophthalmology, orthopedics, head and neck and neurosurgery) are more activists and show a tendency to prefer a converging learning style on Kolb LSI. Only one study directly compared learning styles of surgical residents and internal medicine residents with similar results despite differences amongst the groups were not significant. Family medicine residents showed a tendency to prefer more abstract forms of learning, whereas internal medicine residents had a tendency to prefer more sensing and reflective learning styles. As the field of specialties narrowed, there was an inclination towards active learning styles with a more concrete component than an abstract one.

What was the quality of evidence found?

Using previously described tools(55) for cross sectional studies, we can conclude that the majority of studies were of low quality with a high risk of bias. Most of the studies haven't set up inclusion and exclusion criteria and even when it did, usually the residents that left their residency program were excluded from analysis. Also, we have seen that some of the studies used more than one population, such as medical students and faculties, which can under power studies results for post-graduation.

There was also an important structural methodological difference among the studies starting with the huge variance seen in the tools used to measure LS (see table 1).

How is it applicable in postgraduate medical education?

A summary of evidence brought by each study individually can be seen in table 1.

As for a general appraisal of the studies, we can divide studies as cross sectional and RCT. Further information regarding individual aspects of studies, were explored bellow.

Discussion

The purpose of this study was to summarize and gather the evidence regarding learning styles in medical postgraduate programs and medical residency. In our review, we found that most of the studies were performed in the USA, Canada and UK which makes it unrealistic to extrapolate this data to other countries.

Regarding specialties, LS were more studied in the family medicine/GP, internal medicine and general surgery so far. This may be explained partially because these specialties are more common, which by consequence, have more trainees than the others. Another possibility might be that these areas produce more in medical education research.

In surgery and internal medicine, since these specialties in general are a prerequisite for further subspecialties, these postgraduate students form a wider and more heterogeneous population cluster of LS. For example, we found that most general surgery trainees had a multimodal learning style when VARK was surveyed differently from the general population. This finding may be obscured by the study population heterogeneity.

On the other hand, despite being a heterogeneous population, the only LS dimension that was preferred from general surgery trainees was the activist dimension. Therefore utilizing this information may provide ways to improve residents' learning curve in order to have less impact in patients morbidity and mortality undergoing surgical procedures by residents(56,57).

Regarding subjects' participation, we could see that the studies had a high response rate. However, fifteen studies (20, 22, 24, 26, 28-32, 37, 42, 46, 48, 52 e 54 – for full data, see complementary table 1) haven't described anywhere what the response rate was on the surveys they have sent, which in turn can represent a strong selection bias and may reduce even more the external validity of data.

About LS inventories used, we have found a great variety of tools among the studies. In total we have found thirteen different tools used. The Kolb LSI was the most used overall and especially in the cross sectional studies. This is one of the most popular tools to analyze one's LS. Kolb LSI was developed in 1964 by David Kolb and addresses four dimensions on one's learning style (Concrete experience, Reflective observation, Abstract conceptualization and Active Experimentation)(58). The classic version of the Kolb Learning Style Inventory differentiates four learning styles types: Accommodating, Assimilating, Converging and Diverging. As seen in this review, surgical specialties were mainly active learners exhibiting converging and accommodating LS.

Differently, the tool most used in the RCTs was the Felder and Solomon's Index of Learning Style (n=3, 75%), which might be partially explained by the fact that these three studies were from the same study group (40–42).

Regardless of study design, methods of standardization and data should be pursued in future research in this field to increase external validity and to make feasible for a systematic review to compile studies and increase robustness of evidence. So far and with the studies that we have found, it seems not possible to do that because of strong methodological differences amongst the studies.

As for the results found, seven studies have tried to correlate LS with scores in summative assessments (17,23,29,30,32,34,49), however only four have found a positive result (17,23,34,49) despite having major methodological difference. For example, Kimatian et al(17) used the Vermunt inventory of LS and found a positive correlation to test scores to a more direct learning in anesthesiology residents whereas, residents with an indirect approach had negative correlation with test scores. Tuli et al 2017(49) used Kolb LSI and found that pediatric residents with active-experimentation LS performed better on a first year standardized residency test. Kim et al(34) found that general surgery residents that had dominant aural LS in VARK questionnaire showed lower scores on standardized test, whereas read/write learners had higher scores.

As we can see, the studies hardly can be comparable due to powerful methodological differences. Not to mention the fact that the four studies that had found a positive result had a cross sectional design. A natural consequence of that is the fact that these results may have been influenced by confounder's bias. For example, the fact that a dominant aural learner scored lower in a written exam than his fellow who learns better by reading or writing, may represent a strong confounder since the written exam itself may favor the last kind of student, hampering findings previously described(34). Further studies in this field may take that in account and perform studies with stronger power such as cohort studies and RCT. Finally, the fact that studies with positive result are more likely to be published(59) brings another issue, since we may have not been able to find more studies with negative results that may not have been published.

One other study have tried to correlate which are the LS at more risk to fail or quit surgery residency(30) and showed that residents that had transferred themselves to a non-surgical program were more likely to learn by observation in Kolb LSI, concluding that this residents were at more risk of leaving surgical specialties and should be prioritized. However, this result is not definitive since it happened in a subgroup analysis and might be heavily biased and underpowered.

Two studies(30,31) found a positive correlation of the activists LS of general surgery residents with number of cases performed during residency, however once again this maybe partially explained by the fact that if the standard approach to surgical residents are focused exclusively on active surgery, residents with different LS may feel discouraged to enroll in academic activities.

In our opinion, trying simply to correlate learning styles with different parameters like test scores, number of cases operated or risk to fail may be a deterministic thought that does not help to improve the learning process. On the contrary, the variety of LS amongst the residents may improve one's process of learning by increasing satisfaction and showing representativeness among the different cognitive processes. We believe that studies should focus on strategies to adapt the learning process to specific LS clarifying this process to the students, which by itself may improve learning.

Although it is hard to produce high quality evidence studies in the medical education field due to specific methodological issues such as difficulty to define and measure outcomes and blinding of subjects and researchers, a shift towards more robust studies is urgently needed. For that objective be fulfilled, more randomized control trials should be pursued, since purely descriptive cross-sectional studies will not improve current evidence.

Limitations

As for limitation, some countries may not have been found in our study since we limited language in our inclusion criteria. We opted to restrict the language to English, Spanish and Portuguese due to researcher's familiarity.

Our review encountered difficulties in obtaining data from studies especially concerning type of specialty training, learning style distribution among studied population and obtaining articles prior to 1980. We did not find studies in other European countries well known for research production in medical education such as the Netherlands(60).

The quality of evidence was affected mainly due to study design and methodology. There is an urgent need for better performed randomized control trials in education and surrounding learning styles that is not different. Even in the four RCT encountered, a more robust methodology could have aided in a more secure result.

Another issue that may have hindered our research was the fact that some studies have more than one population as sample. We chose to dissect post-graduation data from the rest of the sample, which could have underpowered these studies individually. However, this method may have showed a more representative picture of what is known regarding post-graduation students and residents´ LS.

Lastly, since our study was designed as a scope review, our study delimitation was wide, with three objective questions, which could have made it more difficult to summarize and compare the data we have found. However, as we can see from our results, our study design has showed itself adequate, due to the huge heterogeneity found, amongst the studies. With the data we have gathered, seems unrealistic for a systematic revision to be made in the LS field.

Conclusion

High quality evidence surrounding the applicability of LS on medical residency and post-graduation is scarce. Further studies are urgently needed on this matter, especially randomized control trials and cohort studies. We are aware of the challenges on medical education research, but a conclusion surrounding applicability of LS on post-graduation seems implausible with the research done so far. The quality of all of the studies found was low with a high risk of bias due to methodological problems More robust research on this field is possible with studies using stronger methodological features.

List Of Abbreviations

ILS – Inventory of Learning Styles, Kolb LSI – Kolb Learning Style Inventory, LS – Learning Styles, MBTI - Myers–Briggs Type Indicator, RCT – Randomized Control Trial, VARK - Visual, Aural, Read/write, and Kinesthetic

Declarations

ETHICS APPROVAL

Since this is a scope review of already published papers, the approval by an ethics committee was not necessary.

CONSENT FOR PUBLICATION

Not applicable

AVAILABILITY OF DATA AND MATERIALS

The datasets generated and/or analyzed during the current study are available in:

MEDLINE - https://pubmed.ncbi.nlm.nih.gov/

ERIC - https://eric.ed.gov/

LILACS - https://lilacs.bvsalud.org/

SCIELO - https://scielo.org/

ACKNOWLEDGEMENTS

We acknowledge the contributions made by Daiana Bonfim, Patricia Tempski and Fernanda Magalhães Arantes-Costa on the project design. We thank Jesus Duque Golding for the final English review.

COMPETING INTERESTS

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported.

FUNDING

The authors are currently hired assistant physician at Hospital Israelita Albert Einstein which granted institutional support. There was no additional specific funding for this research.

AUTHORS' CONTRIBUTIONS

MSD was responsible for conceiving and designing the study; MSD and LM performed the systematic search, data extraction, interpretation and drafted the manuscript. LM and RRV performed the quality review of the studies. RRV contributed to the manuscript. All authors have reviewed and approved the manuscript submission.

References

1. Houwer JD, Barnes-Holmes D, Moors A. What is learning? On the nature and merits of a functional definition of learning. Psychon Bull Rev, 2013; 20(4):631-642. https://doi.org/10.3758/s13423-013-0386-3 Accessed Aug 21, 2020
2. Friedlander MJ, Andrews L, Armstrong EG, et al. What can medical education learn from the neurobiology of learning?: Acad Med, 2011; 86(4):415-420. https://doi.org/1097/ACM.0b013e31820dc197 Accessed Aug 26, 2020
3. Caetano C, Luedke R, Antonello ICF. The Importance of Identifying Learning Styles in Medical Education. Rev Bras Educ Méd, 2018; 42(3):189-193. https://doi.org/1590/1981-52712015v42n3rb20170111r1ingAccessed Aug 15, 2020
4. Newton PM. The learning styles myth is thriving in higher education. Front Psychol, 2015; 6:1908. https://doi.org/3389/fpsyg.2015.01908 Accessed Aug 23, 2020
5. Pashler H, McDaniel M, Rohrer D, Bjork R. Learning styles: concepts and evidence. Psychol Sci Public Interest, 2008; 9(3):105-119. https://doi.org/11111/j.1539-6053.2009.01038.x Accessed Aug 11, 2020
6. Stander J, Grimmer K, Brink Y. Learning styles of physiotherapists: a systematic scoping review. BMC Med Educ, 2019; 19(1):2. https://doi.org/1186/s12909-018-1434-5 Accessed Aug 17, 2020
7. Cassidy S. Learning styles: an overview of theories, models, and measures. Educ Psychol, 2004; 24(4):419-444. https://doi.org/1080/0144341042000228834Accessed Aug 18, 2020
8. Lister J. The history of postgraduate medicine education. Postgrad Med J, 1994; 70(828):728-731. https://doi.org/10.1136/pgmj.70.828.728Accessed Aug 02, 2020

9. Damarell RA, Tieman JJ. How do clinicians learn about knowledge translation? An investigation of current web-based learning opportunities. JMIR Med Educ, 2017; 3(2):e12. https://doi.org/2196/mededu.7825 Accessed Aug 31, 2020
10. Peters MDJ, Godfrey C, McInerney P, et al. Chapter 11: Scoping Reviews (2020 version). In: Aromataris E, Munn Z, ed. JBI Manual for Evidence Synthesis. Adelaide: JBI; 2020.
11. Munn Z, Peters MDJ, Stern C, et al. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. BMC Med Res Methodol, 2018; 18(1):1-7. https://doi.org/10.1186/s12874-018-0611-x Accessed Aug 25, 2020
12. Arksey H, O'Malley, L. Scoping studies: towards a methodological framework. Int J Soc Res Methodol, 2005; 8(1):19-32. https://doi.org//10.1080/1364557032000119616 Accessed Aug 13, 2020
13. Grimes DA, Schulz KF. An overview of clinical research: the lay of the land. Lancet, 2002; 359(9300):57-61. https://doi.org/10.1016/S0140-6736(02)07283-5 Accessed Aug 27, 2020
14. Sterne JA, Hernán MA, Reeves BC, et al. Robins-I: a tool for assessing risk of bias in non-randomised studies of interventions. BMJ, 2016; 355: i4919.https://10.1136/bmj.i4919 Accessed Aug 18, 2020
15. Modi N, Williams O, Swampillai AJ, et al. (2015). Learning styles and the prospective ophthalmologist. Med Teach, 2015; 37(4):344-347. https://doi.org/10.3109/0142159X.2014.948827 Accessed Aug 07, 2020
16. Yates J. Intern evaluation strategies in family medicine residency education. Fam Med, 2013; 45(6):387-391. PMID: 23743938
17. Kimatian S, Lloyd S, Berger J, Steiner L, McKay R. Undirected learning styles and academic risk: analysis of the impact of stress , strain and coping with a measure of academic achievement consistently show. J Educ Perioper Med, 2017; 19(2):E603. PMID: 28824936
18. Eosakul ST, Wong V, Ku CM, Mitchell JD. Learning preferences of first-year anesthesiology residents during their orientation month: a single-institution study. A A Pract, 2019; 12(3):88-92. https://doi.org/10.1213/XAA.0000000000000880 Accessed Aug 26, 2020
19. Lima AA, Bettati MI, Baratta S, et al. Learning strategies used by cardiology residents: assessment of learning styles and their correlations. Educ Health, 2006; 19(3):289-297. https://doi.org/10.1080/13576280600937788 Accessed Aug 01, 2020
20. Napoli J, Formosa MI, Urssi L. Evaluación comparativa de los estilos de aprendizaje en estudiantes de pregrado de Patología, médicos residentes y profesionales de la carrera docente. Rev Asoc Med Argentina, 2020; 123(4):18-22. http://www.ama-med.org.ar/descargacontenido/90 Accessed Aug 22, 2020
21. Stratman EJ, Vogel CA, Reck SJ, Mukesh BN. Analysis of dermatology resident self-reported successful learning styles and implications for core competency curriculum development. Med Teach, 2008; 30(4):420-425. https://doi.org/10.1080/01421590801946988c Accessed Aug 18, 2020
22. Fredette J, O'Brien C, Poole C, Nomura J. Do emergency medicine residents and faculty have similar learning styles when assessed with the Kolb learning style assessment tool? Del Med J, 2015; 87(4):109-112. PMID: 26027408
23. Blake G, Montgomery D, Walley E, Beebe D, Replogle W. Residents' formal knowledge acquisition and preferred learning styles. Fam Med, 1995; 27(1):35-38. PMID: 7720949
24. Sadler GR, Plovnick M, Snope FC. Learning styles and teaching implications. J Med Educ, 1978; 53(10):847-849. https://doi.org/10.1097/00001888-197810000-00011 Accessed Aug 03, 2020
25. Cook DA, Smith AJ. Validity of index of learning styles scores: multitrait-multimethod comparison with three cognitive/learning style instruments. Med Educ, 2006; (9):900-907. https://doi.org/10.1111/j.1365-2929.2006.02542.x Accessed Aug 21, 2020
26. Curtis P, Taylor G, Harris M. How preferred learning approaches change with time: a survey of GPs and GP Specialist Trainees. Educ Prim Care, 2018; 29(4):222-227. https://doi.org/10.1080/14739879.2018.1461027 Accessed Aug 23, 2020

27. Lesmes-Anel J, Robinson G, Moody S. Learning preferences and learning styles: a study of Wessex general practice registrars. Br J Gen Pract, 2005; 51(468):559-564. PMID: 11462316
28. Quillin RC, Cortez AR, Pritts TA, et al. Surgical resident learning styles have changed with work hours. J Surg Res, 2015; 200(1):39-45. https://doi.org/10.1016/j.jss.2015.06.046 Accessed Aug 18, 2020
29. Contessa J, Ciardiello KA, Perlman S. Surgery resident learning styles and academic achievement. Curr Surg, 2005; 62(3):344-347. https://doi.org/10.1016/j.cursur.2004.09.012 Accessed Aug 22, 2020
30. Quillin RC 3rd, Pritts TA, Hanseman DJ, Edwards MJ, Davis BR. How residents learn predicts success in surgical residency. J Surg Educ. 2013 Nov-Dec;70(6):725-30. doi: 10.1016/j.jsurg.2013.09.016. PMID: 24209648.31.
31. Cortez AR, Dhar VK, Sussman JJ, Pritts TA, Edwards MJ, Quillin RC. Not all operative experiences are created equal: a 19-year analysis of a single center's case logs. J Surg Res [Internet]. 2018;229:127–33. Available from: https://doi.org/10.1016/j.jss.2018.03.07
32. Mammen JMV, Fischer DR, Anderson A, James LE, Nussbaum MS, Bower RH, et al. Learning Styles Vary Among General Surgery Residents: Analysis of 12 Years of Data. J Surg Educ. 2007;64(6):386–9.
33. Engels PT, De Gara C. Learning styles of medical students, general surgery residents, and general surgeons: Implications for surgical education. BMC Med Educ. 2010;10(1).
34. Kim RH, Gilbert T, Ristig K. The effect of surgical resident learning style preferences on american board of surgery in-training examination scores. J Surg Educ [Internet]. 2015;72(4):726–31. Available from: http://dx.doi.org/10.1016/j.jsurg.2014.12.009
35. Preece RA, Cope AC. Are Surgeons Born or Made? A Comparison of Personality Traits and Learning Styles Between Surgical Trainees and Medical Students. J Surg Educ [Internet]. 2016;73(5):768–73. Available from: http://dx.doi.org/10.1016/j.jsurg.2016.03.017
36. Jack MC, Kenkare SB, Saville BR, Beidler SK, Saba SC, West AN, et al. Improving education under work-hour restrictions: Comparing learning and teaching preferences of faculty, residents, and students. J Surg Educ [Internet]. 2010;67(5):290–6. Available from: http://dx.doi.org/10.1016/j.jsurg.2010.07.001
37. Kim RH, Gilbert T, Ristig K, Chu QD. Surgical resident learning styles: Faculty and resident accuracy at identification of preferences and impact on ABSITE scores. J Surg Res [Internet]. 2013;184(1):31–6. Available from: http://dx.doi.org/10.1016/j.jss.2013.04.050
38. Cook DA. Reliability and validity of scores from the index of learning styles. Acad Med, 2005; 80(10 Suppl):97-101. https://doi.org/10.1097/00001888-200510001-00026 Accessed Aug 29, 2020
39. Adesunloye BA, Aladesanmi O, Henriques-Forsythe M, Ivonye C. The preferred learning style among residents and faculty members of an internal medicine residency program. J Natl Med Assoc, 2008; 100(2):172-177. https://doi.org/10.1016/s0027-9684(15)31205-0 Accessed Aug 19, 2020.
40. Cook DA, Thompson WG, Thomas KG, Thomas MR, Pankratz VS. Impact of self-assessment questions and learning styles in web-based learning: a randomized, controlled, crossover trial. Acad Med, 2006; 81(3):231-238. https://doi.org./10.1097/00001888-200603000-00005 Accessed Aug 12, 2020
41. Cook DA, Thompson WG, Thomas KG, Thomas MR. Lack of interaction between sensing-intuitive learning styles and problem-first versus information-first instruction: a randomized crossover trial. Adv Health Sci Educ, 2009; 14(1):79-90. https://doi.org/10.1007/s10459-007-9089-8 Accessed Aug 29, 2020
42. Cook DA, Gelula MH, Dupras DM, Schwartz A. Instructional methods and cognitive and learning styles in web-based learning: report of two randomised trials. Med Educ, 2007; 41(9):897-905. https://doi.org/0.1111/j.1365-2923.2007.02822.x Accessed Aug 22, 2020
43. Lai HY, Lee CY, Chiu A, Lee ST. The preferred learning styles of neurosurgeons, neurosurgery residents, and neurology residents: implications in the neurosurgical field. World Neurosurg, 2014; 82(3-4):298-303. https://doi.org/10.1016/j.wneu.2014.04.067 Accessed Aug 05, 2020

44. Richard RD, Deegan BF, Klena JC. The learning styles of orthopedic residents, faculty, and applicants at an academic program. J Surg Educ, 2014; 71(1):110-118. https://doi.org/10.1016/j.jsurg.2013.05.011 Accessed Aug 07, 2020
45. Caulley L, Wadey V, Freeman R. Learning styles of first-year orthopedic surgical residents at 1 accredited institution. J Surg Educ, 2012; 69(2):196-200. https://doi.org/10.1016/j.jsurg.2011.09.002 Accessed Aug 18, 2020
46. Chin CJ, Roth K, Rotenberg BW, Fung, K. Emergencies in otolaryngology-head and neck surgery bootcamp: a novel Canadian experience. Laryngoscope, 2014;124(10): 2275-2280. https://doi.org/10.1002/lary.24754 Accessed Aug 21, 2020
47. Laeeq K, Weatherly RA, Carrott A, et al. Learning styles in two otolaryngology residency programs. Laryngoscope, 2009; 119(12):2360-2365. https://doi.org/10.1002/lary.20655 Accessed Aug 16, 2020
48. Ahmed A, Wojcik EM, Ananthanarayanan V, Mulder L, Mirza KM. (2019). Learning styles in pathology: a comparative analysis and implications for learner-centered education. Acad Pathol, 2019; 6:237428951985231 https://doi.org/10.1177/2374289519852315 Accessed Aug 11, 2020
49. Tuli SY, Thompson LA, Saliba H, et al. Pediatric residents' learning styles and temperaments and their relationships to standardized test scores. J Grad Med Educ. 2011; 3(4):566-570. https://doi.org/10.4300/jgme-d-10-00147.1 Accessed Aug 12, 2020
50. Vaughn LM, Baker RC. Do different pairings of teaching styles and learning styles make a difference? Preceptor and resident perceptions. Teach Learn Med, 2008; 20(3):239-247. https://doi.org/10.1080/10401330802199559 Accessed Aug 09, 2020
51. Varela DADV, Malik MU, Laeeq K, et al. Learning styles in otolaryngology fellowships. Laryngoscope, 2011; 121(12):2548-2552. https://doi.org/10.1002/lary.21898 Accessed Aug 11, 202
52. Kosower E, Berman N. (1996). Comparison of pediatric resident and faculty learning styles: implications for medical education. Am J Med Sci, 1996; 312(5):214-218. https://doi.org/10.1016/s0002-9629(15)41818-x Accessed Aug 11, 2020
53. Juárez-Muñoz IE, Gómez-Negrete A, Varela-Ruiz M, et al. Estilos de aprendizaje en médicos residentes y sus profesores en un hospital de pediatría. Rev Med Inst Mex Seguro Soc, 2013; 51(6):614-619. PMID: 24290010 Accessed Aug 23, 2020
54. Echaurren EIE. (2014). Caracterización de estilos de aprendizaje en residentes de urología. Rev Chil Urol, 2014; 79(4):26-33. http://www.revistachilenadeurologia.cl/urolchi/wp-content/uploads/2015/01/Revista_urologia_ed_04-2014_01_Dr_Elias.pdf Accessed Aug 19, 2020
55. Moola, S., Munn, Z., Tufanaru C, et al. (2020). Chapter 7: Systematic reviews of etiology and risk. In: Aromataris E, Munn Z, ed. *JBI Manual for Evidence Synthesis*. Adelaide: JBI; 2020. https://doi.org/10.46658/JBIMES-20-08 Accessed Aug 09, 2020
56. Gofton WT, Papp SR, Gofton T, Beaulé PE. Understanding and taking control of surgical learning curves. Instr Course Lect, 2016; 65:623-631. PMID: 27049228 Accessed Aug 23, 2020
57. Subramonian K, Muir G. The "learning curve" in surgery: what is it, how do we measure it and can we influence it? BJU Int, 2004; 93(9):1173-1174. https://doi.org/10.1111/j.1464-410X.2004.04891.x Accessed Aug 16, 2020
58. Kolb AY, Kolb DA. The Kolb Learning Style Inventory 4.0 - a comprehensive guide to the theory, psychometrics, research on validity and educational applications. Kaunakakai: EBLS; 2013. Accessed Aug 23, 2020
59. Easterbrook P, Berlin JA, Gopalan R, Matheuws DR. Publication bias in clinical research. Lancet, 1981; 337 (8746):867-872. https://doi.org/10.1016/0140-6736(91)90201-y Accessed Aug 17, 2020
60. Custers M, Cate OT. (2018). The history of medical education in europe and the united states, with respect to time and proficiency. Acad Med, 2018; 93(3):49-54. https://doi.org/10.1097/ACM.0000000000002079 Accessed Aug 20, 2020

Table

Author	Study Design	Learning Style Inventory	Medical Specialty	Number of participants/number of evaluations Analyzed	Country	Summary of Evidence
Kimatian S. et al 2017(17)	Cross-sectional	The Vermunt Inventory of Learning Styles (ILS)	Anesthesiology	296/142	USA	Higher scores on Meaning Directed Learning correlated positively with higher in-training examination (ITE) scores while higher Undirected and lower Meaning Directed patterns related negatively to standardized test. Undirected learning patterns was associated with higher rates of stress, strain and negatively associated with coping, whereas directed LS was related to higher scores on coping, and lower scores of stress and strain.
Eosakul S T et. al 2019(18)	RCT	VARK	Anesthesiology	18/18	USA	Informing residents about their preferred learning style did not change resource utilization. Thirteen residents had >1 modality of learning preference. Only 5 residents maintained the learning style through the study (1 year and 3 months).
de Lima A et al. 2006(19)	Cross-sectional	The Vermunt Inventory of Learning Styles (ILS)	Cardiology	161/149	Argentina	Concrete thought is more common in cognitive processes; Self-regulation is more common in regulation strategies; Vocation is more common in learning orientations and utilization of learning is more common on mental models. In summary there is a tendency to be application oriented.
Napoli J. et al. 2010(20)	Cross-sectional	Honey Alonso	Clinical vs. Surgical Specialties	170/59	Argentina	Both groups had no significant difference and presented similar

						distribution of LS frequencies: most of residents preferred reflexive, theoretical and pragmatic learning styles. In surgical specialties, there was a discrete tendency over activist learning style.
Stratman E. et al. 2008(21)	Cross-sectional	Learning Style Inventory	Dermatology	190/130	USA/ Canada	Preference of active learning was significantly higher than passive learning activities (p=0.002). The three highest rated activities include (1) hands-on, direct experience; (2) addressing patient problems; and (3) teaching/explaining to others. The three lowest rated activities include (1) competing with others for grades, (2) keeping a diary or daily log, and (3) being questioned in an intimidating manner.
Fredette J. et al 2015(22)	Cross-Sectional	Kolb LSI	Emergency, Internal and Family Medicine	38/38	USA	66% of the residents had the converging LS, while 16% had the converging LS and 18%, the assimilating LS. A similar profile was seen in the faculty staff.
Blake G et al 1995(23)	Cross-sectional	Meyers-Briggs (MBTI)	Family Medicine	36/36	USA	Residents with Feeling/judgment as preferred LS scored higher in the exams than the thinking/perceiving counterparts; Intuitive residents demonstrated no advantage over sensing residents.
Sadler G R et al. 1978(24)	Cross-sectional	Kolb LSI	Family Medicine	108/108	USA	Prevalence of LS was: 43 (40%) accomodators; 17 (16%) diverger; 34 (31%) Converger; 14 (13%) Assimilator. Tendency of more active engagement on activities.
Cook D A et	Cross-	Index of	Family	89/32 (14 FM; 18	USA	Data support the

al. 2006 (a) (25)	sectional/ Comparative tool study	Learning Style (ILS) KOLB LSI and LSTI (Pelley´s learning styles type inventory)	Medicine and Internal Medicine	IM)		validity for determining Learning styles of Family Medicine, Internal Medicine residents using ILS, LSI and LSTI
Curtis P et. al. 2018(26)	Cross-sectional	ASSIST	Family Medicine/ General Practioner	461/461	UK	Residents showed the following LS: Deep 83 (18%); Strategic 105 (22%); Surface 20 (4,3%); Deep + Strategic 155 (33,6%); Deep + Surface 38 (8,2%); Surface + Strategic 16 (3,4%); Equal 44 (9,6%). GP and GP specialist trainees have a preferred learning approach to Deep and Strategic.
Lesmes-Anel et al. 2001(27)	Cross-sectional	Honey and Mumfort Learning Style Inventory (LSQ)	General Practice	57/42	UK	Predominant LS was reflector-theorist; Mean score: activist 8.9 (range 1 to 19, SD 3.8), theorist 10.3 (range 3 to 18, SD 3.4), pragmatist 11.1 (range 5 to 17 SD = 2.9) reflector 12.9 (range 3 to 20, SD 3.7);
Quilin RC et.al. 2015(28)	Cross Sectional	Kolb LSI	General Surgery	115/411	USA	KOLB changed after institution of 80 hour workweek institution. Surgical residents maintained more action based learners. Before: Converging 59.0%/ Assimilating 19.1%. After: Coverging 43.9%/ Accomodating 40.4% ($p<0.005$)
Contessa J. et al 2005(29)	Cross Sectional	Kolb LSI	General Surgery	16/16	USA	Converging LS (7/16) was the most common, followed by accomodating (5/16), assimilating (3/16) and diverging (1/16). Grades in standard test did not differ statiscally, although a trend was seen with higher grades from converging LS.

Quilin RC et.al. 2013(30)	Cross Sectional	Kolb LSI	General Surgery	126/441	USA	Residents with converging and accommodating learning styles performed more cases when compared to the assimilating and diverging LS. Each unit increased in the Active Experimentation-Reflective observation score was correlated with the number of major cases performed by 3.3. Of the 15 residents who transferred to a non-surgical program were more likely to be assimilating and diverging (p=0.04). No correlation was seen between LS and grades on standardized tests.
Cortez R. A. et al. 2018(31)	Cross Sectional	Kolb LSI	General Surgery	106/106	USA	The LS was divided as follow: Accommodators (65.1%), convergers (21.7%), assimilators (8.5%) and divergers (4.7%); Sub-category analyses shown that action based learners operated more cases significantly than observational learners at the end of graduation. They have performed more general surgery and subspecialty also then they fellow observational learner.
Mammen J.M. 2007(32)	Cross Sectional	Kolb LSI	General Surgery	91/325	USA	LS divided as follow: converging (185, 57%), assimilating (58, 18%), accommodating (44, 14%), and diverging (38, 12%); Difference was found between Female and male regarding: the accomodating LS (Female - 38% vs male -11%) and the assimilating LS (Female 0 vs. 26%

						Male);. On the follow up, only 15 (58%) residents changed their LS to the converging, and only two changed from converging to another LS. No significant changes were noted in the learning style by resident year; no correlation between LS and standardised test scores was seen.
Engels P. T. et al 2010(33)	Cross-sectional	Kolb LSI	General Surgery	40/31	Canada	The predominant learning styles of the residents were convergent and accommodative. First year residents had less prevalence of converging and acommodating learning style than the others residents.
Kim RH et.al. 2015(34)	Cross-sectional	VARK	General Surgery	53/53	USA	VARK Multimodal 51%; Kinestesic 19%; Read/Write 15%; Aural 6%; Visual 9%; Dominant aural and read/write learners had the lowest and highest mean ABSITE scores, respectively (p=0.03).
Preece RA et al. 2016(35)	Cross-sectional	24-item self-reported Learning Style Inventory (LSI)	General Surgery	37/37	UK	The visual modality was the predominant preferential LS 54.1%, while 32.4% had multiple rather than singular preferred learning styles;
Jack M. C. et al 2010(36)	Cross-sectional	Kolb LSI	General Surgery	96/96	USA	Surgical residents preferred active learning (p=0.053), whereas faculty preferred reflective learning (p=0.01). Residents preferred student centered learning style more often than faculty members or medical students.
Kim RH et.al. 2013(37)	Cross-sectional	VARK	General Surgery	29/29	USA	Prevalence of VARK was: Multimodal 62%; kinesthetic (K).14%; Read/Write

						14%; Aural 3%; Visual 7%
Cook D. 2005(38)	Cross-sectional/ Comparative tool study	Felder's Index of Learning Styles and Pelley's Learning Styles Type Indicator	Internal Medicine	192/138	USA	The correlation between the two methods of assessment for both active-reflective/reflective-extravert, introvert and sensing intuitive dimensions are significant and relatively large. One third of the residents changed their learning style after one year;
Adesunloye B. et al. 2008(39)	Cross-sectional	Kolb LSI	Internal Medicine	42/31	USA	Prevalence of LS was: Assimilator 42%; Convergers 32%; Accommodators 16%; Divergers 10%. Compared with faculty, no statistical difference was seen.
Cook D A et al. 2006(40)	RCT	Felder and Solomon's Index of Learning Style (ILS)	Internal Medicine	123/121	USA	Learning styles scores were not significantly associated with web course format preference and post-test scores. There was a discrete tendency towards a reflective and visual learning preference.
Cook D A et al. 2009(41)	RCT	Felder and Solomon's Index of Learning Style (ILS)	Internal Medicine	123/88	USA	Prevalence of LS were as follow: Sensing 39 (45%); Intermediate 30 (34%); Intuitive 18 (21%). No significant interaction between sensing-intuitive learning styles and knowledge scores. No association between format preference and sensing-intuitive learning style scores.
Cook D et al 2007(42)	RCT	Felder and Solomon's Index of Learning Styles (ILS)	Internal Medicine and Family medicine	58/58 (50 IM; 8 FM)	USA	No difference in performance was seen when comparing performance of students in questions on case-based questions

						tailored to one`s LS; No distinction in results was made between students and residents, hampering data extraction
Lai H. Y. et al 2014(43)	Cross-sectional	Kolb LSI	Neurosurgery (NS) and Neurology (N)	24/22 NS residents and 19/17 N Residents	Taiwan	NS residents preferred diverging LS (41%) followed by assimilating LS (32%), accommodating (18%) and converging (9%). N residents were predominantly assimilating (76%), followed by diverging (12%), converging (6%) and accommodating (6%). The results were statistically different between the groups
Richard R D. et.al 2014(44)	Cross-sectional	Kolb LSI	Orthopedy	14/14	USA	Converging (53,5%) was the learning style most encountered among residents. Accomodating (18,3%), diverging (18,3%) and assimilating (9,9%) followed in sequence.
Caulley L. et al 2012(45)	Cross-sectional	Kolb LSI	Orthopedy	13/13	Canada	Orthopedy residents had the LS as follows: converging (53.8%), assimilating (23.1%), accommodating (15.4%), and diverging (7.7%); they also showed a high tendency toward the learning skill of abstract conceptualization combined with active experimentation. It was seen a transition from action-oriented learning to more reflective learning styles with age and postgraduate education.
Chin C. J. et al. 2014(46)	Cross Sectional	Kolb LSI	Otolaryngology Residents	28/28	Canada	Active experimentation was preferred over reflective

						observation, Learning styles was used as a secondary outcome to complement and justify intervention design.
Laeeq K. et al 2009(47)	Cross Sectional	Kolb LSI	Otolaryngology-Head and Neck Surgery	46/43	USA	Most common LS was converging (55%), followed by accommodating (18%), assimilating (14%), diverging (7%) and 4% had a balanced LS spanning the four types.
Ahmed A. et al. 2019(48)	Cross-sectional	Kolb LSI	Pathology	49/49	USA	The LS for pathology residents were: Converging (40%), Diverging (22%), accommodating and assimilating (19%). For fellows, Assimilating (41%), Diverging (25%), converging and accommodating (17%). No difference was found between the two groups.
Tuli S. Y. et al 2011(49)	Cross-sectional	Kolb LSI	Pediatric	86/75	USA	The predominant learning style for pediatric residents was converging 44% (33 of 75), followed by assimilating (25%), diverging (16%) and acommodating (14,7%). The residents with active-experimentation LS (convergers and accommodators) performed better on the first year standardized residency test; No other correlation was seen.
Vaughn L.M et al 2008 (50)	Cross-sectional	Grasha–Vaughn Medical Resident Learning Styles Scale (G-VMRLSS).	Pediatric	45/44	USA	This LS tool grades the residents in each domain as low, moderate or high, which made possible to each resident as having more than one LS. The most common LS found was collaborative (n=42), followed by independent (n=19),

						competitive (n=7), dependent and participant (n=1 each). Mixed preference was defined as having more than on LS and was seen on 19 residents.
Varela DA et. al. 2011(51)	Cross-sectional (analytical)	Kolb LSI	Pediatric Otolaryngology (PO) and otology - neurotology (ON)	10/10 PO and 16/16 ON	USA	PO and ON fellows (60% of each group) preferred a learning style that was “balanced” across all four styles. For ON fellows, 35% preferred converging and 5% preferred accommodating styles. For PO fellows, converging and accommodating styles accounted for 20% each.
Kosower E et. al 1996(52)	Cross Sectional	Kolb LSI	Pediatrics	17/17	USA	Pediatrics residents showed prevalence of 40.5% as Concrete Experience, 40.5% as active experimentation as dominant strategies. Abstract conceptualization represents 19%. As for LS, the distribution was: diverger 50%, accomodator 30 %, converger 15% and assimilator 5%.
Juárez-Muñoz I. E. et al 2013(53)	Cross-sectional	Honey-Alonso	Pediatrics and subspecialties	99/99	Mexico	The LS in women resident was reflector (49 %, n=25), theorist (37 %, n=19) and pragmatist (14 %, n=7), whereas men ´s LS was theorist and reflector (37.5 %, n=18 each), pragmatist (23 %, n=12) and active (2 %, n=1). Subgroup analysis showed that the most common LS in pediatrics was reflector (n=27), theorist (n=15), pragmatist (n=9) and one activist, while in the surgical field the LS were more balanced

						between reflector, theorist and pragmatist (n=5, 4 and 5 respectively); Regarding clinical subspecialties, the LS seen was: theorist (n=17), reflector (n=12) and pragmatist (n=4).
Echaurren E I E, et al. 2014(54)	Cross-sectional (analytical)	Kolb LSI	Urology	20/20	Chile	Regarding the resident group, there was balance between LS, with a trend towards accommodator (38%). The other values are not available in the article, only comparison between studied groups (under graduation, interns and masters students). Residents were less prompt to value abstract conceptualization and more prompt to value concrete experience comparing to the other groups.

Table 1 – Show summarizes of all included studies (full table on Supplementary table 1). RCT – Randomized Control trial

Figures

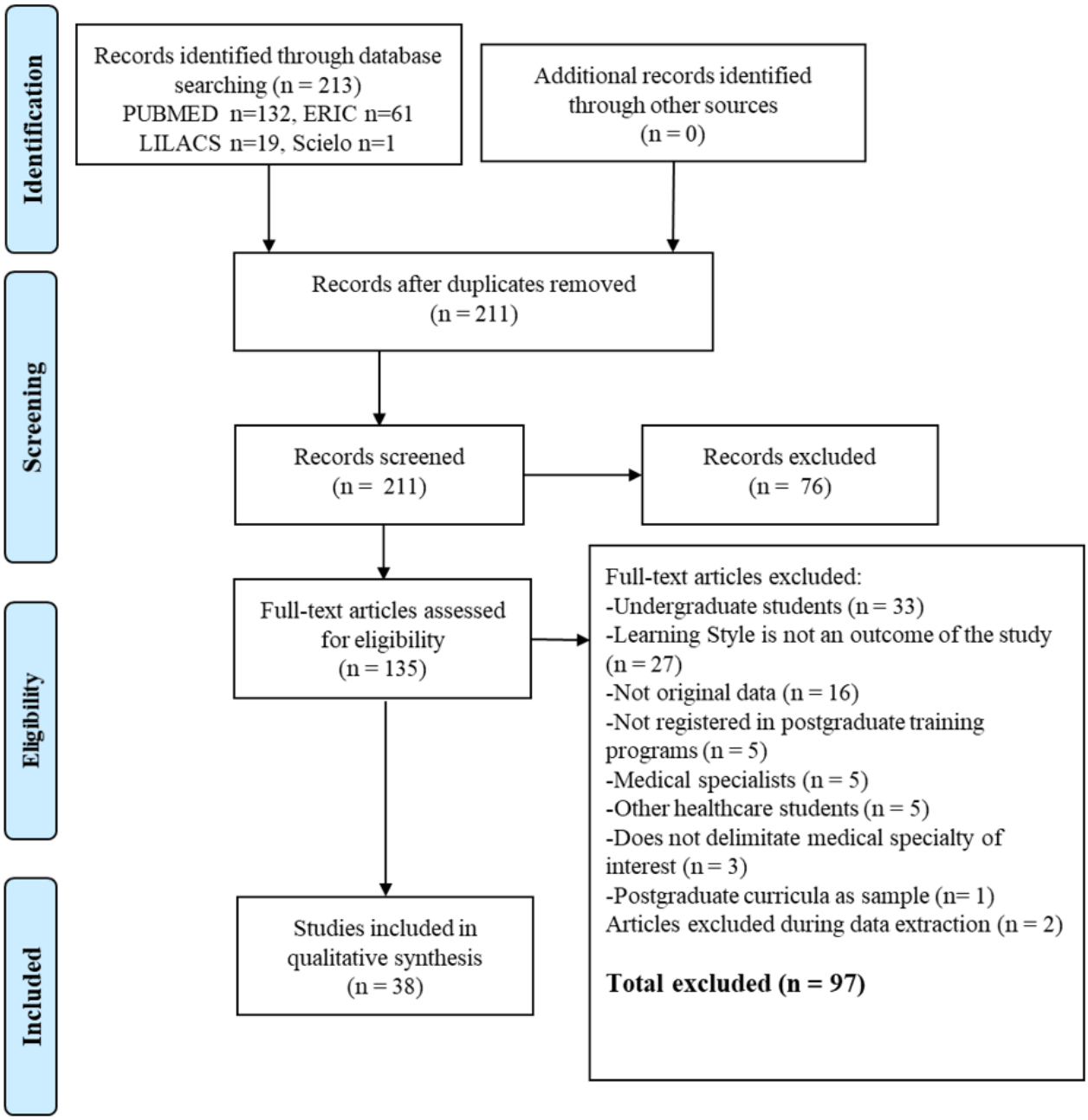

Figure 1

PRISMA 2009 Study Flow Diagram – LS and post graduation Medical Education

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Table1Copia.xlsx