Should education for physicians be tailored to Kolb’s learning styles?
A BEME review and analyses of pooled data

Group members:

Feikje van Stiphout, MD, PhD-student in medical education, and resident at the department of internal medicine, University Medical Center Utrecht

Jacobus J.H. ten Thije, BSc, medical student at the University Medical Center Utrecht

Saskia Briedé, BSc, medical student at the University Medical Center Utrecht

Carolina Keijsers, MD, clinician at the department of geriatric medicine at Jeroen Bosch Hospital, Den Bosch, and PhD-student in medical education

Paul Westers, PhD, biostatistician and methodologist at the Julius Centre Utrecht, University Medical Center Utrecht

Olle T. ten Cate, PhD, professor of medical education, University Medical Center Utrecht;

Edith ter Braak, MD PhD, endocrinologist and professor of medical education at the department of internal medicine, University Medical Center Utrecht

Institution: Department of Internal Medicine, University Medical Center Utrecht, the Netherlands

Contact address lead reviewer: Feikje van Stiphout, MD, Department of Internal Medicine, University Medical Center Utrecht, Room D01.307, Heidelberglaan 100, 3485 CX Utrecht, The Netherlands, e-mail: F.vanStiphout@umcutrecht.nl
**Introduction**

Due to the ever-increasing amount of knowledge physicians must acquire, it is essential to make education as effective as possible. One way of increasing effectiveness is tailoring education to individual needs.

Using learning styles to tailor education is appealing. It is a plausible idea that people have different styles of perceiving, processing, storing and recalling information. Aligning with these different styles may help people to learn more effective. Kolb was one of the first to describe learning styles of adult learners in his Experiential Learning Theory (ELT) in 1984. For each of his four learning styles Kolb theorized a learner’s preferred mode of perception and processing information. He suggested to apply specific educational methods for the learners of each learning style to increase effectiveness of their learning. (Figure 1). Since then the learning styles of faculty members and residents are investigated regularly with Kolb’s Learning Style Inventory (LSI) up until today. However, the evidence for current applications of learning styles have also been criticized.

When designing education for physicians: should one tailor this education to Kolb’s learning styles?

We aim to answer this question with a review of the literature regarding Kolb’s learning styles in physician’s education. We take a theoretical approach by testing three hypotheses ensuing from Kolb’s Experiential Learning Theory. These hypotheses will either be confirmed or refuted by the data from the literature. We will discuss the found implications for the use of learning styles in today’s design of education for physicians accordingly.

**Background**

Kolb’s ELT consists of four subsequent ideas. (Figure 1) Firstly, Kolb states that learning is a process in which knowledge is built by the transformation of experiences. The second idea is that this learning process is a cycle constituting of four phases: (a) concrete experience of events, (b) observation of
these events, (c) formation of abstract constructs, and (d) implementation of these constructs in everyday activities, leading back to the concrete experience of events (a). Thirdly, Kolb states that these four phases can be translated into two modes of grasping experiences: *concrete experience* (feeling) and *abstract conceptualization* (thinking), and two modes of transforming experiences: *reflective observation* (watching) and *active experimentation* (doing). Finally, these modes of grasping experiences and transforming experiences are combined to form four distinct learning styles: accommodating (doing and feeling), diverging (feeling and watching), assimilating (thinking and watching), and converging (doing and thinking). According to Kolb, learners have a preference for a certain approach to acquiring experience and transforming it, which he calls their preferred learning style.¹

This theory resulted in Kolb’s Learning Style Inventory (LSI), a questionnaire designed to determine an individual’s preferred learning style.³⁸ Since its introduction, more than a dozen of additional learning style theories and accompanying questionnaires have been produced, many of which are based on Kolb’s ELT.⁹

**Hypotheses and research questions**

Kolb formulated several hypothesis based on his ELT to improve education.¹² (Figure 1) In this review, three of these hypotheses that are of particular relevance for the application of learning styles in education for graduated physicians are investigated.

The first hypothesis is that personal factors (educational experience, basic cognitive structure) and social environment will lead to a preference in learning style.⁸

<table>
<thead>
<tr>
<th>Hypothesis I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal and social environmental factors</td>
</tr>
</tbody>
</table>
To test this hypothesis in the field of physicians education we formulated two research questions:

1a. Do physicians within the same medical specialty, leading to comparable educational experience and cognitive structure, have the same preferred learning style?

1b. Do residents and faculty members within the same medical specialty, with different educational experience, have a different preferred learning style?

The second hypothesis is that adults with the same preferred learning style have a similar preference for learning activities.

<table>
<thead>
<tr>
<th>Hypothesis II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preference in learning style → Preference in learning activity</td>
</tr>
</tbody>
</table>

To test this hypothesis we formulated our third research question:

2. Do physicians with the same preferred learning style have a similar preference in learning activities?

The third hypothesis is that learning is more effective if learning activities are tailored to a person’s preferred learning style.

<table>
<thead>
<tr>
<th>Hypothesis III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning activity tailored to persons preferred learning style → Improved learning effect</td>
</tr>
</tbody>
</table>

To test this hypothesis we formulated our fourth research question:
3. Do physicians learn more effectively when learning activities are tailored to their preferred learning style?

Search sources and strategies

With the help of a librarian, we designed a search syntax for electronic databases. This syntax is designed to retrieve all relevant data to answer our four research questions. The search terms are divided into three sections: (1) physicians (and synonyms) AND (2) learning styles (and synonyms) AND (3) Kolb or Kolb’s learning styles (and synonyms). We will search the following databases for relevant articles: Medline, Embase, PsychInfo and ERIC. Additionally, we will perform a related article search using Web of Science and will cross reference check for all included articles. (Table 1 and Figure 2).

Study selection criteria

For this review all study designs are considered. We include studies published in English, German and Dutch making no selection on publication date. We include studies with participants being graduated physicians: including faculty members and residents of all types of medical specialties, including general practitioners. We include all versions of Kolb’s Learning style inventory (version 1.0, 2.0, 2a, 3.0 and 3.1).\textsuperscript{3,8,10,11,12}

We exclude studies using other than Kolb’s inventory to acquire the distributions on learning styles. Studies representing the data in another way than the original four learning styles defined by Kolb are excluded.\textsuperscript{13} We exclude studies not presenting original research data such as meta-analyses, reviews, commentaries, opinions and descriptions.
**Procedure for critical appraisal and final study selection**

We screen titles and abstracts for in- and exclusion criteria with two teams of two reviewers. We will retrieve full text copies of potentially relevant studies. Authors are contacted if data is not clearly represented according to inclusion criteria.

Reviewers than systematically assess characteristics of these studies with regard to their relevance for our research questions and the ‘risk of bias’ of their study design. This will be done using a specially designed coding sheet based upon suggestions from the Cochrane Collaboration and the BEME coding sheet. 14,15 (Appendix 1, Table 2, Table 3). After critical appraisal each of these studies are assessed for eligibility for our BEME review. Studies not relevant to our research questions or scoring too high on ‘risk of bias’ will then be excluded leading to the final selection of articles that are relevant to our BEME review.

This whole process will be done by two teams of two reviewers. Discrepancies in ratings or judgement for eligibility are resolved by discussion. Involvement of a third reviewer is obtained when necessary.

**Procedure for synthesis of extracted data**

From the included studies we will extract all data relevant to our research question by two teams of two reviewers. All outcomes are combined regardless of the LSI version.

To answer research questions 1a and 1b, we will pool the extracted data on the physician’s learning styles. (Table 4) For research question 1a, a chi-square goodness-of-fit-test will be performed to investigate the distribution of the Kolb learning styles among faculty members, residents and the total group of physicians working in distinct medical specialties. As a reference for this test we use the assumption that the physicians of each specialty are evenly divided among Kolb’s four learning styles (ie. 25% assimilators, 25% convergers, 25% divergers and 25% accommodators). Afterwards we determine the preponderance of one learning style from plots of the data. (Table 5)
For research question 1b, a chi-square goodness-of-fit-test will be performed examining the difference in distribution of learning styles between residents and faculty members. Here we will use the distribution of the faculty members’ learning styles as baseline references values to compare them with the learning style distribution of the residents.

All statistical analyses will be performed with PASW Statistics 20 (SPSS, Inc., Chicago, IL, USA) choosing a significance level of p<0.05.

For research question 2, we will summarize all evidence regarding preferences in learning activities for physicians with distinct learning styles. We will rate ‘the strength of findings’ on a scale from 1-5 (‘1 = very low’ up to ‘5 = very high’) based on the original study’s design and quality. (Appendix and Table 3).

For research question 3, we will summarize all evidence regarding a change in learning effect of education tailored to learning styles. We will rate ‘the strength of findings’ on a scale from 1-5 (‘1 = very low’ up to ‘5 = very high’) based on the original study’s design and quality. Additionally we will rate the outcome measure used in the ordinal studies according to the level of Kirckpatrick’s Hierarchy.16 (Appendix 1, Table 4)

**Procedure for presentation and elaboration of results**

We will present our results in clear tables and figures as much as possible. Because of the quantitative aspect of our research question 1a and 1b, we expect that this to be easier for the findings of these research questions. For our research question 2 and 3 we expect the results both to be quantitative and qualitative. Hence we will use relatively more space in the ‘discussion’ section of our BEME review, to relate to them.
Possible practical implications of review results

Research question 1a and 1b

- Will create an overview of physicians learning styles per specialty, comparing residents and faculty members.

- Will add to the a learners understanding of one’s own learning style compared to those of surrounding colleagues.

- Will stimulate (or prevent) future research with Kolb’s LSI in specialties that have not yet (or already) been investigated.

- If we find differences in the distribution of learning styles among residents and faculty members, this will be of interest to those that want to ‘match’ or ‘deliberately mismatch’ faculty members with residents according to their learning style.

- If we find differences in the distribution and there is one very predominant learning style in a specialty (and we find evidence justifying hypotheses 2 and/or 3) it will be interesting to investigate the effect of an educational interventions tailored to a specialism’s predominant learning style.

Research question 2 and 3 will create an overview of evidence of the implications of Kolb’s learning styles in physician’s education.

If we find high quality evidence proving that the applications of Kolb’s learning styles in physician’s education will increase educational efficiency:

This will:
(1) inspire future educational designers to design educational interventions based on these learning styles.

(2) Provide an overview of educational interventions per learning style that will increase educational efficiency in physician’s education.

(3) Justify the future applications of Kolb’s LSI in today’s education and future research settings.

If we find high quality evidence denying that the applications of Kolb’s learning styles in physician’s education will increase educational efficiency:

This will be a strong signal to educators, learners and researchers in the field of physician’s education to spend their resources on other ventures than using Kolb’s LSI to increase educational efficiency.

If we find no high quality evidence that the applications of Kolb’s learning styles in physician’s education will increase educational efficiency:

This will:

(1) Stimulate researchers to use our findings from research question 1a and 1b to start new high quality research towards hypotheses 2 & 3.

(2) Be a strong signal to educators and learners in the field of physician’s education to spend their resources on other ventures than using Kolb’s LSI to investigate their learning style.

Project timetable

December 2013: topic registration & protocol submission
January-April 2014: pilot search in electronic databases + pilot testing the coding sheets + discussion
first version of protocol with BEME board → adjusting search strategy and coding sheets accordingly

April 2014: submission final version of review protocol

May-June 2014: Screening titles and abstracts, critical appraisal of articles, discussion between
reviewers, and statistical analysis

July 2014: summary of the data

August 2014: report to BEME

Conflict of interest

There are no conflicts of interest of any of the review group members.

Plans for updating the review

After completion we plan to update the review after 5 years.
Figure 1: Kolb’s Experiential learning theory (ELT) and its theoretical educational applications

**Concrete Experience**
- Active experimentation (doing)
- Transforming experience (how we do things)

**Reflective Observation**
- Reflective observation (watching)
- Concrete experience (feeling)

**Abstract Conceptualisation**
- Abstract conceptualisation (thinking)

**Active Experimentation**
- Converger: best at finding practical uses for theories and ideas
  - Preferred learning activities: simulations, practical applications, experimenting with new ideas

- Accommodator: learn from hands-on experience
  - Preferred learning activities: setting goals, field work, testing out different approaches to complete a project

- Assimilator: gather a wide range of information while putting it into logical form
  - Preferred learning activities: reading, attending lectures

- Diverger: learn best in situations that call for generation of ideas
  - Preferred learning activities: brainstorming sessions, group discussions, working in groups

**Reflective Observation**
- Converger: best at finding practical uses for theories and ideas
  - Preferred learning activities: simulations, practical applications, experimenting with new ideas

- Accommodator: learn from hands-on experience
  - Preferred learning activities: setting goals, field work, testing out different approaches to complete a project

- Assimilator: gather a wide range of information while putting it into logical form
  - Preferred learning activities: reading, attending lectures

- Diverger: learn best in situations that call for generation of ideas
  - Preferred learning activities: brainstorming sessions, group discussions, working in groups
Figure represents the learning cycle as proposed by Kolb’s ELT. The LSI ranks the learners preferred way of “transforming experience” and “grasping information” along the two axes. This leads to a segment resembling his predominant learning style. Kolb formulated several hypothesis based on the ELT that could improve education. For example he theorized typical learners characteristics and “preferred learning activities” for each learning style. These are represented in the dark shaded boxes.
†Adapted from Kolb and Kolb[1]

References:
<table>
<thead>
<tr>
<th>Databases</th>
<th>Hits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medline†</td>
<td>135</td>
</tr>
<tr>
<td>Embase†</td>
<td>115</td>
</tr>
<tr>
<td>PsychInfo</td>
<td>161</td>
</tr>
</tbody>
</table>

Table 1 Database search

Date pilot search: 29-01-2014

(physician OR physicians OR doctor OR doctors OR specialist OR specialists OR clinician OR clinicians OR clinical OR medical OR medicine OR practitioner* OR intern OR interns OR resident OR residents OR faculty OR faculties OR consultant OR Consultants OR healthcare* OR hostpialist OR hospitalists OR surge* OR urolog* OR orthopaed* OR orthoped* OR otolaryng* OR ototorhinolaryng* OR ENT OR neurotolog* OR gynaeocollog* OR gynecolog* OR obstetric* OR anaeesthes* OR anesthes* OR neonatolog* OR paediatric* OR pediatric* OR patholog* OR dermatolog* OR venerolog* OR ophthalmolog* OR oculist* OR psychiatric* OR radiolog* OR neurolog* OR pneumono* OR pulmono* OR internal* OR geriatr* OR cardiol* OR gastroenterolog* OR gastrolog* OR infectolog* OR infectolog* OR immunolog* OR nephrolog* OR nefrolog* OR endocrinolog* OR haematolog* OR hematolog* OR oncolog* OR rheumatolog* OR reumatolog* OR intensivist* OR rehabilitation* OR occupational* OR genetic* OR microbiolog* OR practic* OR physician[MeSH] OR medicine[MeSH] OR faculty[MeSH] OR “Internship and residency”[MeSH])

AND

(“learning style” OR “learning styles” OR “learning preference” OR “learning preferences” OR “cognitive style” OR “cognitive styles” OR “learning questionnaire” OR “learning questionnaires” OR “Education, Medical”[MeSH] OR learning[MeSH] OR “teaching/methods”[MeSH])

AND

(Kolb OR Kolb’s OR Kolbs OR accommodator OR accommodators OR diverger OR diverser OR assimilator OR assimilators OR converger OR convergers OR “concrete experience” OR “concrete experiences” OR “reflective observation” OR “reflective observations” OR “abstract conceptualisation” OR “abstract conceptualisations” OR “abstract conceptualization” OR “abstract conceptualizations” OR “active experimentation” OR “active experimentations” OR “learning style inventory” OR “learning style inventory”)
(learning style OR learning styles OR learning preference OR learning preferences OR cognitive style OR cognitive styles OR learning questionnaire OR learning questionnaires).ti,ab.

AND
(Kolb or Kolbs or accommodator or accommodators or diverger or divergers or assimilator or assimilators or converger or convergers or concrete experience or concrete experiences or reflective observation or reflective observations or abstract conceptualisation or abstract conceptualization or abstract conceptualisations or abstract conceptualizations or active experimentation or active experimentations or learning style inventory or LSI).ti,ab.

Legend
Syntax terms were searched in title/abstract only.
† Relevant 'Mesh-terms' (for Pubmed) and 'Emtree-terms' (for EMBASE) were added to the search in these databases.
†† Same search items as used in PsychINFO database
**Figure 2. Flowchart of literature search (pilot search: 29-01-2014)**

**Inclusion criteria:**
1. Participants are licensed physicians.
2. Kolb's LSI is used to determine learning styles.
3. Original study

**Exclusion criteria:**
1. Outcome presented in another way as Kolb's original four learning styles.
2. Review papers
3. Meta-analysis
4. No full text available
5. Language other than English, German or Dutch.

Legend:
*2 articles were abstracts for conference presentations.*
Appendix 1. Should education for physicians be tailored to Kolb’s learning styles?
A BEME review and analyses of pooled data

SYSTEMATIC REVIEW CODING SHEET

Coding Sheet Guide:
Part 1-6, 9 and 12 of this coding sheet are mandatory and need to be filled in as complete as possible
Part 7 and 8 of this coding sheet are optional and only need to be filled in if part 6 states to do so
Part 10 and 11 of this coding sheet are optional and only need to be filled in if part 9 states to do so

1. (Mandatory) Administrative

Reference number: ________________________ Reviewer: ______________________

Type: □ Book □ Journal article □ Official publication
       □ Comment □ Lecture □ Report
       □ Conf. Paper □ Letter □ Statistical data
       □ Editorial □ News □ Test
       □ Guideline □ Non-peer review □ Thesis
       □ Interview

Citation Information:
Authors: __________________________________________________________________________
Title: ______________________________________________________________________________
Publication: __________________________________________________________ Vol; Issue; Pages __________

Search Method:
□ Electronic □ Grey literature
□ Hand □ Recommendation

2. (Mandatory) Research design

Non-comparative studies

<table>
<thead>
<tr>
<th></th>
<th>Implied</th>
<th>Stated</th>
<th>Historical</th>
<th>Implied</th>
<th>Stated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Action-based</td>
<td></td>
<td></td>
<td>Narrative</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case series</td>
<td></td>
<td></td>
<td>Observation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expert opinion</td>
<td></td>
<td></td>
<td>Survey</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Focus group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comparative studies

<table>
<thead>
<tr>
<th></th>
<th>Implied</th>
<th>Stated</th>
<th>Case control</th>
<th>Implied</th>
<th>Stated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-sectional</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single group study</td>
<td></td>
<td></td>
<td>Cohort study</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before &amp; After</td>
<td></td>
<td></td>
<td>Prospective</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time series</td>
<td></td>
<td></td>
<td>Retrospective</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Trials
Non-randomized  □  □
Randomized  □  □

Review*
Implied  □
Stated  □

Meta-analysis*
Implied  □
Stated  □

*If research design is a review or meta-analysis discontinue critical appraisal for this study
→ Study will be used during the cross-reference check.

3. (Mandatory) Data collection methods

☐ Interview  ☐ Patient outcomes
☐ Observation  ☐ Questionnaire
☐ Opinion  ☐ Data from simulation
☐ MCQ Exam

4. (Mandatory) Results of the use of the LSI (used to answer research questions 1 & 2)

a. Describe aim of the study
☐ = stated  ☐ = implied

b. Used LSI version: __________________________
☐ no information provided

c. Country / localisation of study _______________________
☐ no information provided

d. Setting of study (hospital, primary care, etc) _______________________
☐ no information provided

e. Start year of study: _____________________________
☐ no information provided

f. Total study duration: _____________________________
☐ no information provided

g. Central tendency of age distribution of participants (median, mean or other information given):_________________________
☐ no information provided

h. Gender of participants (%men): _____________________________
☐ no information provided

i. Medical specialty of investigated physicians: _____________________________
☐ no information provided
j. Study differentiates between faculty members and residents among participating physicians
   □ yes □ no □ no information provided

k. Extract all provided information on the number of invited physicians, number of participating physicians and missing data from participating physicians from the article.

<table>
<thead>
<tr>
<th></th>
<th>Faculty</th>
<th>Residents</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of invited physicians</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of participating physicians</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Response rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Missing data from participating physicians</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

l. Results of distribution of learning styles of physicians
   (document separately for each specialty)

1e Specialty: _______________________________

<table>
<thead>
<tr>
<th>Learning Styles</th>
<th>Faculty members</th>
<th>Residents</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assimilator</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Converger</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accomodator</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diverger</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2e Specialty (if multiple specialties are included in study): _______________________________

<table>
<thead>
<tr>
<th>Learning Styles</th>
<th>Faculty members</th>
<th>Residents</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assimilator</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Converger</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accomodator</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diverger</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(add tables for 3e, 4th, 5th, etc specialty if needed)

5. (Mandatory) Critical Appraisal for use of LSI (used to answer research questions 1 & 2)

   a. Relevance

   i. Domain
   □ = Participants are licensed physicians of predefined medical specialties
   □ = Participants are licensed physicians without predefined medical specialties
   □ = Participants are no licensed physicians (leading to exclusion of article from review)

   ii. Determinant
   □ = Version 3.0 or 3.1 of Kolb’s LSI was used
   □ = Any other version of Kolb’s LSI was used
   □ = Another LSI was used (leading to exclusion of article from review)
iii. Outcome
☐ = The LSI outcomes are presented as one of four of Kolb’s learning styles per participating medical specialty for faculty members and residents separately
☐ = The LSI outcomes are presented as one of four of Kolb’s learning styles without differentiation per medical specialty or without differentiation between faculty members and residents
☐ = The LSI outcomes are represented in another way (leading to exclusion of article from review)

b. Risk of Bias

i. Blinding (information bias)
☐ = Participants were blinded towards LSI outcome while filling in the LSI
☐ = No blinding
☐ = Unclear, no information provided

ii. Missing data (selection bias)
☐ = <5% missing data, or missing data are not likely to influence learning style distribution among physicians
☐ = 5-10% missing data, or missing data might have influenced the learning style distribution among physicians
☐ = >10% missing data, or missing data are likely to influence learning style distribution among physicians
☐ = Unclear, no information provided

6. (Mandatory) Does the study investigate a association between physicians’ learning styles and physicians’ preference in learning activities? (used to answer research questions 3)
☐ = Yes, continue with 7 and 8
☐ = No, continue with 9

7. (Optional) If the study investigates an association between physicians’ learning style and their preference in learning activity, then fill in the following items on the design and results of the study:

a. Describe how the preference for a certain learning activity was tested/determined.

b. Describe the outcome measure for preferred learning activities.

c. Collect the results of the investigated association for the four learning styles of Kolb. (document relative risks (RR), Odds ratio, confidence interval and p-value id provided)
   i. Assimilators preferred the following learning activity/activities:

   ii. Convergers preferred the following learning activity/activities:
iii. Accomodators preferred the following learning activity/activities:

iv. Divergers preferred the following learning activity/activities:

d. Summarise the significant findings.

e. Rate the strength of findings.

Low  ----------------------------->  High
1 2 3 4 5

1 – No clear conclusions can be drawn.
2 – Results ambiguous, but there appears to be a trend.
3 – Conclusions can probably be based on the results.
4 – Results are clear and very likely to be true.
5 – Results are unequivocal.

8. (Optional) If the study investigates an association between physicians’ learning style and their preference in learning activity, then critically appraise the following items:

a. Relevance
i. Determinant
☐ = Preferred learning activities are investigated in relation to each of Kolb’s four learning styles separately
☐ = Preferred learning activities are investigated in relation to a combination of Kolb’s learning styles
☐ = Preferred learning activities are not investigated in relation to Kolb’s learning styles (leading to exclusion from review for answer to question 3)

ii. Outcome
☐ = The learning style preferences are presented in relation to all of Kolb’s four learning styles separately
☐ = The learning style preferences are presented in relation to a combination of Kolb’s learning styles
☐ = The learning style preferences are not presented in relation to Kolb’s learning styles (leading to exclusion from review for answer to question 3)

b. Risk of Bias
i. Binding (information bias)
☐ = Participants were unaware of their learning style at the time learning preferences were collected
☐ = Participants were aware of their learning style at the time learning preferences were collected
☐ = Unclear, no information provided

ii. Standardised intervention (information bias)
☐ = Learning preferences were collected in a standardised way among all studied physicians
☐ = Learning preferences were collected in different ways among studied physicians
☐ = Unclear, no information provided

iii. Standardised outcome measure (information bias)
☐ = Learning preferences in relation to Kolb’s learning styles are presented in a standardised way for all studied physicians
☐ = Learning preferences in relation to Kolb’s learning styles are presented in different ways for studied physicians
☐ = Unclear, no information provided

iv. Missing data (selection bias)
☐ = <5% missing data, or missing data are not likely to influence association between physicians’ learning style and learning preference
☐ = 5-10% missing data, or missing data might have influenced the association between physicians’ learning style and learning preference
☐ = >10% missing data, or missing data is likely to have influenced the association between physicians’ learning style and learning preference
☐ = Unclear, no information provided

v. Confounders
Rate the possibility that confounders might have influenced the relationship between learning styles and preference in learning activities. (Possible confounders: age, gender, educational level)

<table>
<thead>
<tr>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

9. (Mandatory) Does the study investigate an association between a learning activity tailored to the physicians’ learning style and learning effect? (used to answer research questions 4)
☐ = Yes, continue with 10 and 11.
☐ = No, continue with 12

10. (Optional) If the study investigates the association between a learning activity tailored to physicians’ learning styles and the effect of the learning activity, then fill in the following items on the design and results of the study:

a. Describe how learning activities are tailored to the physician’s learning style.

b. Describe the outcome measures for the learning effect.

c. Collect the results of the investigated associations for the four learning styles of Kolb. (document relative risks (RR), Odds ratio, confidence interval and p-value if provided)

i. Assimilators experienced the learning activity (1), with the effect (2)
   (1) ________________________________________________________________
   (2) ________________________________________________________________

ii. Convergers experienced learning activity (1), with the effect (2)
   (1) ________________________________________________________________
d. Summarise the significant findings.


e. Rate the strength of findings.

Low .......................... High
1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

1 – No clear conclusions can be drawn.
2 – Results ambiguous, but there appears to be a trend.
3 – Conclusions can probably be based on the results.
4 – Results are clear and very likely to be true.
5 – Results are unequivocal.

f. Rate the outcome measure according to Kirkpatrick’s Hierarchy that was used in the study the learning effect.²

☐ Level 1 Reaction – When learning activity is tailored to the physicians’ learning style, the physicians’ feel different about the learning activity (more satisfaction, more motivated and interested)

☐ Level 2 Learning - – When learning activity is tailored to the physicians’ learning style, the physicians’ acquired more knowledge, improved skills or changed attitudes

☐ Level 3 Behavior - When learning activity is tailored to the physicians’ learning style, the physicians’ changed their behaviour in daily practice

☐ Level 4 Results - When learning activity is tailored to the physicians’ learning style, the physicians’ provided better care for patients

11. (Optional) If the study investigates the association between a learning activity tailored to physicians’ learning styles and the effect of the learning activity, then critically appraise the following items:

a. Relevance

i. Determinant

☐ = Learning activities are tailored to one of Kolb’s four learning styles
☐ = Learning activities are tailored to a different ordering of Kolb’s learning styles
☐ = Learning activities are not tailored to Kolb’s learning styles (leading to exclusion from review for answer to question 4)

ii. Outcome

☐ = The learning effect is presented in relation to all of Kolb’s four learning styles
The learning effect is presented in relation to some of Kolb’s learning styles

= The learning effect is not presented in relation to Kolb’s learning styles (leading to exclusion from review for answer to question 4)

b. Risk of Bias

i. Standardised intervention ((information bias))

☐ = Standardised tailored learning activities for physicians with the same dominant learning style
☐ = Learning activities varied for physicians with the same dominant learning style
☐ = Unclear, no information provided

ii. Standardised outcome measure (information bias)

☐ = Learning effect were measured in a standardised way for all studied physicians
☐ = Learning effect were measured in different ways for studied physicians
☐ = Unclear, no information provided

i. Missing data (selection bias)

☐ = <5% missing data, or missing data are not likely to influence association between tailored learning activity to physicians’ learning style and learning effect
☐ = 5-10% missing data, or missing data might have influenced the association between tailored learning activity to physicians’ learning style and learning effect
☐ = >10 % missing data, or missing data is likely to have influenced the association between tailored learning activity to physicians’ learning style and learning effect
☐ = Unclear, no information provided

iii. Confounders

Rate the possibility that confounders might have influenced the relationship between tailored learning activity to physicians’ learning style and the learning effect. (Possible confounders: age, gender, educational level)

Low  -------------------------->  High

1 2 3 4 5

12. (Mandatory) Fill in the following fields for all studies

a. Additional comments on methodological quality of the study

b. Primary conclusions (Please summarize the primary conclusions of the study)

c. Overall impression of article (Please make any additional comments regarding the overall strengths and weaknesses of the document)
d. Additional relevant articles found by screening references


e. Is this study relevant to the needs of this review

☐ = yes
☐ = no
If not, explain reason for exclusion


13. References

<table>
<thead>
<tr>
<th>Country</th>
<th>Medical specialty</th>
<th>Total number of physicians</th>
<th>Relevance</th>
<th>Risk of bias</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Domain</td>
<td>Determinant</td>
</tr>
<tr>
<td>Study 1</td>
<td></td>
<td></td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Study 2</td>
<td></td>
<td></td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Legend:

**Relevance**
- **Domain:** + = Participants are licensed physicians of predefined medical specialties, - = Participants are licensed physicians without predefined medical specialties.
- **Determinant:** + = Version 3.0 or 3.1 of Kolb's LSI was used, - = Any other version of Kolb's LSI was used
- **Outcome:** + The LSI outcomes are presented as one of four of Kolb’s learning styles per participating medical specialty for faculty members and residents separately, - = The LSI outcomes are presented as one of four of Kolb’s learning styles without differentiation per medical specialty or without differentiation between faculty members and residents

**Risk of bias**
- **Blinding:** + = Participants were blinded towards LSI outcome while filling in the LSI, - = No blinding, □ = Unclear, no information provided
- **Missing data:** + = <5% missing data, or missing data are not likely to influence learning style distribution among physicians, +/- = 5-10% missing data, or missing data might have influenced the learning style distribution among physicians, - = >10 % missing data, or missing data are likely to influence learning style distribution among physicians, □ = Unclear, no information provided.
- **Response rate:** Percentage of physicians that participated in the study from those that were invited to participate. ? = Not enough data to calculate response rate
Table 3 Additional critical appraisal of studies investigating an association between physicians’ learning style and their preference in learning activity (used to answer research questions 3)

<table>
<thead>
<tr>
<th>Medical specialty</th>
<th>Total number of physicians</th>
<th>Relevance</th>
<th>Risk of bias</th>
<th>Strength of findings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Determinant</td>
<td>Outcome</td>
<td>Blinding</td>
<td>Standardised intervention</td>
</tr>
<tr>
<td>Study 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Legend:

Relevance
Determinant: + = Preferred learning activities are investigated in relation to each of Kolb’s four learning styles separately, - = Preferred learning activities are investigated in relation to a combination of Kolb’s learning styles
Outcome: + = The learning style preferences are presented in relation to all of Kolb’s four learning styles separately, - = The learning style preferences are presented in relation to a combination of Kolb’s learning styles

Risk of bias
Blinding: + = Participants were unaware of their learning style at the time learning preferences were collected, - = Participants were aware of their learning style at the time learning preferences were collected, □ = Unclear, no information provided
Standardised intervention: + = Learning preferences were collected in a standardised way among all studied physicians, - = Learning preferences were collected in different ways among studied physicians, □ = Unclear, no information provided
Standardised outcome measure: + = Learning preferences in relation to Kolb’s learning styles are presented in a standardised way for all studied physicians, - = Learning preferences in relation to Kolb’s learning styles are presented in different ways for studied physicians, □ = Unclear, no information provided
Missing data: + = <5% missing data, or missing data are not likely to influence association between physicians’ learning style and learning preference, +/- = 5-10% missing data, or missing data might have influenced the association between physicians’ learning style and learning preference, - = >10 % missing data, or missing data is likely to have influenced the association between physicians’ learning style and learning preference, □ = Unclear, no information provided
Confounders: Rated possibility that confounders might have influenced the association between learning styles and preference in learning activities on a scale from 1 to 5. (1= lowest, 5=highest)

Strength of findings
Rated strength of findings of the association on a five point scale. (1 = no clear conclusions can be drawn, 2 = results ambiguous, but there appears to be a trend, 3 = conclusions can probably be based on the results, 4 = results are clear and very likely to be true. 5 = results are unequivocal)
Table 4 Baseline characteristics of included studies and significant outcomes respecting researched co-variables that are potentially predictive for Kolb’s learning styles

<table>
<thead>
<tr>
<th>Author and year</th>
<th>Medical specialty, total number of physicians (n), percentage of residents of total physicians (%)</th>
<th>Country</th>
<th>Study design*</th>
<th>LSI version</th>
<th>LSI outcomes of total study population†</th>
<th>Investigated associations between physicians’ learning styles and physicians’ preference in learning activities, significant findings, strength of findings</th>
<th>Investigated learning activities tailored to the physicians’ learning style associated with learning effect, significant findings, strength of findings, Outcome level of Kirkpatrick’s Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Study design uses terminology defined by BEME collaboration.
† Total group of physicians represented in study. Ass = assimilator, Con = converger, Acc = accommodator, Div = diverger
Table 5 Pooled data analyses on the distribution of Kolb’s learning styles among reviewed medical specialties

<table>
<thead>
<tr>
<th>Medical specialty</th>
<th>Total*</th>
<th>Fac</th>
<th>Res</th>
<th>Res vs Fac</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medical specialty total no. of physicians</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accommodator</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diverger</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assimilator</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Converger</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p-value†</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accommodator</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diverger</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assimilator</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Converger</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p-value†</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accommodator</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diverger</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assimilator</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Converger</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p-value†</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accommodator</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diverger</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assimilator</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Converger</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p-value‡</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Legend:**
Res = resident; Fac = faculty members
Bold cells represent the significantly predominant learning style of medical specialties. *p<0.05

*if studies do not differentiate between residence and faculty members the “total” group represents the results of all physicians irrespective of their level of education.
†p-value of Chi-square goodness-of-fit test with expected even distribution of learning styles
‡p-value of Chi-square goodness-of-fit test with resident’s learning style distribution compared to faculty members’ learning style distribution as reference
References


