The effectiveness of self-directed learning in health professions education: a systematic review

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OBJECTIVES Given the continuous advances in the biomedical sciences, health care professionals need to develop the skills necessary for life-long learning. Self-directed learning (SDL) is suggested as the methodology of choice in this context. The purpose of this systematic review is to determine the effectiveness of SDL in improving learning outcomes in health professionals.

METHODS We searched MEDLINE, EMBASE, ERIC and PsycINFO through to August 2009. Eligible studies were comparative and evaluated the effect of SDL interventions on learning outcomes in the domains of knowledge, skills and attitudes. Two reviewers working independently selected studies and extracted data. Standardised mean difference (SMD) and 95% confidence intervals (95% CIs) were estimated from each study and pooled using random-effects meta-analysis.

RESULTS The final analysis included 59 studies that enrolled 8011 learners. Twenty-five studies (42%) were randomised. The overall methodological quality of the studies was moderate. Compared with traditional teaching methods, SDL was associated with a moderate increase in the knowledge domain (SMD 0.45, 95% CI 0.23–0.67), a trivial and non-statistically significant increase in the skills domain (SMD 0.05, 95% CI – 0.05 to 0.22), and a non-significant increase in the attitudes domain (SMD 0.39, 95% CI – 0.03 to 0.81). Heterogeneity was significant in all analyses. When learners were involved in choosing learning resources, SDL was more effective. Advanced learners seemed to benefit more from SDL.

CONCLUSIONS Moderate quality evidence suggests that SDL in health professions education is associated with moderate improvement in the knowledge domain compared with traditional teaching methods and may be as effective in the skills and attitudes domains.

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INTRODUCTION

Given the continuous advances in medicine and the biomedical sciences, health care professionals need to develop the skills that will enable them to be lifelong learners. Self-directed learning (SDL) is considered by many as the most appropriate methodology to allow practitioners to stay up-to-date and knowledgeable of the current literature. Self-directed learning has been advocated for the efficient and effective training of medical students, residents, practising doctors, nurses and other health care professionals.[1–3]

However, the effectiveness of SDL compared with traditional and pedagogic learning methods has not been determined. The main challenges to answering this question involve the difficulty of defining SDL and the heterogeneity of SDL-based curricula. In 1975, Malcolm Knowles provided one of the most commonly cited and comprehensive definitions of SDL: 'SDL is a process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes.'[4] Knowles described several essential components of SDL: the educator should be a facilitator of learning and not a content source; learners should be involved in identifying their learning needs, objectives and resources, and learners should be involved in implementing the learning process, should commit to a learning contract and should evaluate the learning process.[4] Nevertheless, systematic reviews have demonstrated that only 8% of published SDL curricula present an explicit definition of SDL[5] and less than one in five published studies satisfy all the key components of SDL as defined by Knowles.[6] Numerous educational interventions share some elements of SDL and are often labelled as such, including problem-based learning, active learning exercises (class discussions, learning cells, active minute paper techniques, affective response exercises, etc.) and simple educational interventions that consist of merely a computerised educational module or self-study guide. Yet, for learners to be truly self-directed, some of the other components contained in Knowles' definition[4] should be incorporated in the learning process (i.e. learners should be involved in needs assessment, choose their learning resources, assess their learning, etc.).

The uncertainty about the effectiveness of SDL and the heterogeneity in the published literature provided the impetus for this study. To aid educators interested in incorporating SDL methodology into their programmes, we undertook this systematic review and meta-analysis with the primary aim of evaluating the effectiveness of SDL in health professions education.

METHODS

Study eligibility

For studies to be included in this protocol-driven systematic review, they had to describe a curricular or educational intervention that utilised self-directed methodologies delivered to health care professionals (medical students, residents, doctors, nurses, or learners in other health care professions and disciplines). In terms of the definition of SDL, we accepted authors' definitions and included the study if the authors described their intervention as involving SDL. The purpose of being more inclusive was to provide an estimate of the effectiveness of SDL as it is defined and understood by educators in the published literature. Therefore, studies that represent SDL in the literature are broadly included in this review and the activities they describe as SDL are later compared against Knowles' definition.[4]

Studies had to be comparative (i.e. provide data about a comparison cohort that received traditional didactic learning or have a pre-post design). Both randomised and non-randomised studies were considered. We did not include studies that measured the learner's readiness for SDL. Included studies had to provide quantitative data about the effectiveness of SDL (i.e. they had to report a mean change in knowledge, skills or attitudes that occurred in response to an SDL intervention and was measured using a numeric scale such as an examination or test score).

Data sources and search strategies

An expert reference librarian (LJP) designed and conducted the search strategy with input from study authors with expertise in systematic reviews. Relevant biomedical sciences and educational databases were searched from inception through August 2009 (Ovid In-Process and Other Non-Indexed Citations, Ovid MEDLINE, Ovid EMBASE, OCLC ERIC and Ovid PsycINFO). Controlled vocabulary supplemented with keywords was used to define the concept areas 'self-directed learning' and 'health professionals', as well as to limit the findings to studies that compared SDL outcomes with those of other educational methods. The detailed search strategy is available in Appendix S1. The bibliographies of included articles were also reviewed to obtain additional references.

Study selection and data extraction

Pairs of independent reviewers selected studies and extracted data using online standardised and piloted forms. They reviewed abstracts and titles, followed by the full text of included studies, and extracted data from vetted references. Disagreements were resolved by consensus. Chance-adjusted agreement amongst reviewers (the kappa statistic) averaged 0.80. Authors of included studies were contacted by e-mail as necessary to provide clarification or missing data.

We extracted data describing:

1. learner discipline, learning level and content;
2. details of the intervention and control learning strategies in terms of resources, methods and duration;
3. study design and methodology, focusing on selection bias introduced when learners were selected from a larger cohort, randomisation procedures and blinding of outcome assessment processes;
4. quantitative data about learning effectiveness in terms of improvements in knowledge, skills or attitudes, and
5. three elements highlighted by Knowles[4] as determinants of self-directedness in learning, including:
   (i) whether the teachers acted as facilitators rather than as sources of content;
   (ii) whether the learners were involved in selecting learning resources and strategies, and
   (iii) whether the learners were involved in self-assessment of learning outcomes.

The rationale for empirically choosing these last three components stemmed from the findings of a previous systematic review[6] that demonstrated these components to be the most explicitly reported elements according to Knowles' definition[4] (in 55%, 50% and 70% of the published SDL studies, respectively). Therefore, we hypothesised that these three components were considered by many educators to be most consistent with their perceptions of what constitutes SDL. Furthermore, and from a methodological standpoint, if we were to find out that one of these three components significantly alters the learning outcome (i.e. confers a statistical interaction with the pooled effect size), this interaction would provide a partial explanation of the anticipated heterogeneity of the meta-analytic estimates. For practical purposes, we would recommend the most effective components to be incorporated in future SDL curricula.

Meta-analysis

We standardised scaled variables from each study and expressed them in standard deviations and estimated the effect size as the standardised mean difference (SMD). Categorical data were transformed to the SMD.[7] We pooled the SMD across studies using the random-effects model[8] and estimated the 95% confidence interval (CI). An SMD value of 0 indicates similar learning outcomes in both study groups, whereas a value > 0 favours SDL. If both limits of CI are > 0, then the results are statistically significant, which is analogous to a two-tailed p-value of < 0.05. Arbitrary cut-off values of SMD of > 0.5, 0.5–0.3, 0.3–0.1 and < 0.1 are typically considered to be consistent with large, moderate, small and trivial effect sizes, respectively. We used the I^2 statistic to estimate the proportion of heterogeneity that is not attributable to chance or random error.[9] Comprehensive Meta-Analysis Version 2 (Biostat, Inc., Englewood Cliffs, NJ, USA) was used to conduct all analyses.

Subgroup, sensitivity and publication bias analyses

We stratified the analysis according to learner type (doctor, medical student, resident, nurse or other health professional), outcome domain (knowledge, skills, attitudes), study quality (randomised or not, outcome assessment blinded or not), SDL intervention interactivity (high or low) and by the three selected components of Knowles' definition[4] of SDL (teacher as facilitator, learner chooses learning resources, learner conducts self-assessment). These factors define a priori established subgroups. We tested whether a statistical interaction exists between the subgroup characteristic and the effect size using the method of analysis of variance (anova).[7] We tested in sensitivity analysis whether the exclusion of any single study would change our conclusions. We conducted meta-regression to determine if the observed effect size differed according to the duration of the SDL intervention or the time between the end of the intervention and the outcome assessment. A correlation found in this model would explain some of the heterogeneity of the dependent variable in the model, which is the effect size.

We conducted Egger's regression test to statistically test for publication bias. Egger suggests that we assess bias by using precision (the inverse of the standard error) to predict the standardised effect (effect size divided by the standard error). In this regression model, the size of the treatment effect is captured by the slope of the regression line and bias is captured by the intercept.[7]

RESULTS

The study selection process is depicted in Fig. 1. Fifty-nine studies were included in the final analysis (medical students, 30 studies; residents, six studies; doctors, eight studies; nurses, six studies; other health professionals, nine studies).[10–68] Study subjects included 8011 learners who studied a variety of topics. A detailed description of included studies is presented in Table S1. Forty studies reported outcomes in the knowledge domain, nine studies reported outcomes in the skills domain, and five reported outcomes in the attitudes domain. For example, Bradley *et al.*[63] compared an SDL computer-based educational intervention with a non-SDL intervention and reported a knowledge-based outcome (knowledge of evidence-based medicine principles) and a skills-based outcome (ability to critically appraise evidence). Arroyo-Jimenez *et al.*[68] measured the effect of SDL on the number of successful dissections performed in anatomy classes in a medical school, thereby demonstrating a skills-based outcome. Hatem *et al.*[45] reported an SDL-based faculty development course on teaching the medical interview and assessed attitudinal outcomes that included faculty staff's self-assessed confidence in their ability to teach medical interviewing as measured on a 7-point Likert scale.

Learners were randomly allocated to SDL in 25 studies (42%); however, details about randomisation and other study characteristics needed for quality assessment were poorly reported. Blinded outcome assessment, a desirable and critical measure to protect against bias in both randomised and non-randomised educational studies, was applied in only nine of 59 studies (15%) and was unreported or clearly not applied in the remaining studies. An example of a study that adopted adequate bias protection measures is that by Bradley *et al.*,[63] in which a randomisation procedure was clearly described, allocation was concealed using opaque envelopes, and outcome assessors and data collectors were blinded to subjects' assignments.

Learning resources included interactive computerised modules in 13 studies (22%) and non-interactive (reading materials, audiovisual resources) in the remaining studies. Studies were more likely to report

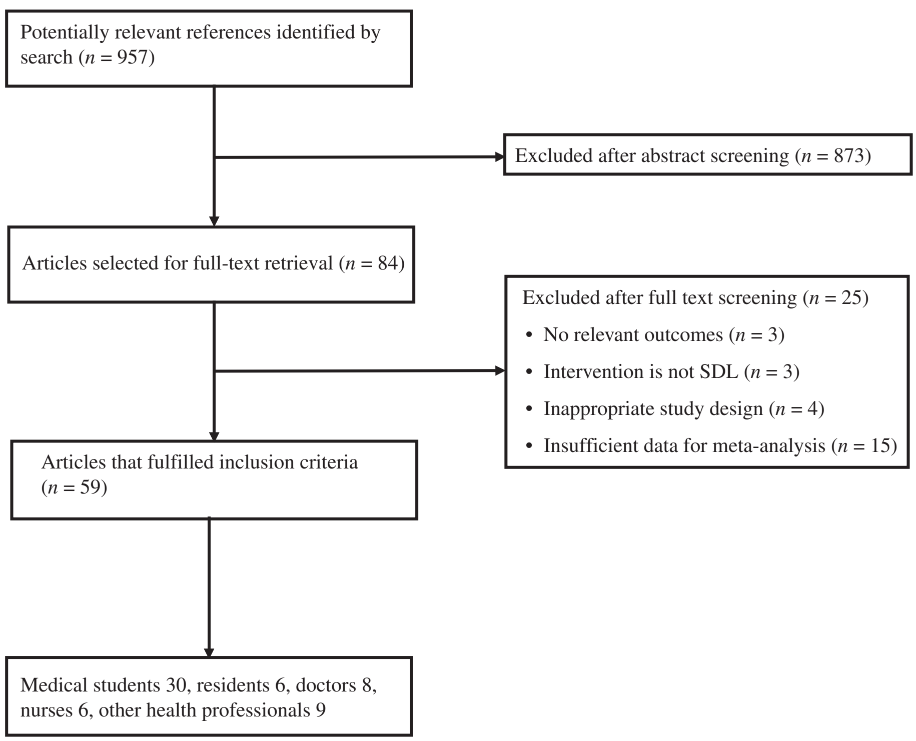

Figure 1 Study selection process. SDL = self-directed learning

outcomes in the knowledge domain than in the skills and attitudes domains.

The three elements of SDL we considered to be congruent with Knowles' definition[4] of SDL were reported in only 24 studies (41%) for 'teacher as a facilitator and not a content source', in seven studies (12%) for 'learners involved in identifying learning resources', and in five studies (8%) for 'learners involved in assessment of learning outcomes'.

Meta-analysis

When data were pooled in meta-analysis and outcomes compared with those of traditional teaching methods, SDL was associated with a moderate increase in the knowledge domain (SMD 0.45, 95% CI 0.23–0.67; I^2 = 92%) (Fig. 2), a trivial and non-statistically significant increase in the skills domain (SMD 0.05, 95% CI − 0.05 to 0.22; I^2 = 2%) (Fig. 3), and a non-significant increase in the attitudes domain (SMD 0.39, 95% CI − 0.03 to 0.81; I^2 = 91%) (Fig. 4).

Subgroup, sensitivity and publication bias analyses

We explored causes for the marked heterogeneity observed by conducting stratified analyses in subgroups defined a priori. There was a trend showing that nurses had better learning outcomes compared with other health care professionals in the domains of knowledge and attitudes (p-values for interaction 0.11 and 0.13, respectively; insufficient data for subgroup analysis in the skills domain). There was a statistically

Knowledge

	SMD	95% CI LL	95% CI UL
Abraham *et al.*[11]	−1.07	−1.78	−0.36
Bhat *et al.*[33]	0.66	−0.10	1.42
Borduas *et al.*[62]	1.83	0.69	2.97
Bradley *et al.*[63]	0.28	−0.03	0.59
Bridges *et al.*[19]	0.36	−0.07	0.79
Bull *et al.*[37]	0.66	−0.28	1.60
Carvalho *et al.*[14]	0.28	−0.23	0.79
Cavaleiro *et al.*[35]	0.12	−0.17	0.41
Clarke[12]	0.81	−0.01	1.63
Considine *et al.*[65]	1.31	0.84	1.78
DaRosa *et al.*[17]	−0.29	−0.56	−0.02
Finley *et al.*[22]	0.08	−0.59	0.75
Fukuchi *et al.*[26]	1.22	0.30	2.14
Gega *et al.*[57]	−0.20	−0.61	0.21
Graham *et al.*[24]	0.04	−0.23	0.31
Grieve[18]	−0.25	−0.66	0.16
Holla *et al.*[25]	−1.01	−1.56	−0.46
Kao *et al.*[15]	0.91	0.52	1.30
Kulier *et al.*[42]	−0.78	−2.00	0.44
Lamperti & Sodicoff[21]	0.10	−0.10	0.30
Lee *et al.*[53]	0.17	−0.26	0.60
Mahmoud *et al.*[40]	0.05	−0.52	0.62
Ogrinc *et al.*[32]	0.64	0.19	1.09
Parker & Mazmanian[66]	0.53	0.12	0.94
Peng[64]	0.03	−0.24	0.30
Robinson *et al.*[13]	3.76	3.19	4.33
Rosenberg *et al.*[60]	0.62	0.27	0.97
Sachs *et al.*[10]	0.00	−0.10	0.10
Sanford *et al.*[54]	0.15	−0.22	0.52
Schell & Flynn[38]	1.99	0.97	3.01
Schneeweiss & Ratnapalan[46]	−1.57	−2.22	−0.92
Short *et al.*[43]	−0.33	−1.58	0.92
Slothus[55]	0.25	−0.73	1.23
Swank *et al.*[50]	1.89	1.48	2.30
Upton[61]	0.12	−0.29	0.53
Vasan *et al.*[34]	0.73	0.36	1.10
Vichitvejpaisal *et al.*[27]	1.77	1.42	2.12
Wehrs *et al.*[47]	2.44	1.58	3.30
Wiecha *et al.*[30]	0.38	0.07	0.69
Zitzmann[56]	0.03	−0.34	0.40
	0.45	**0.23**	**0.67**

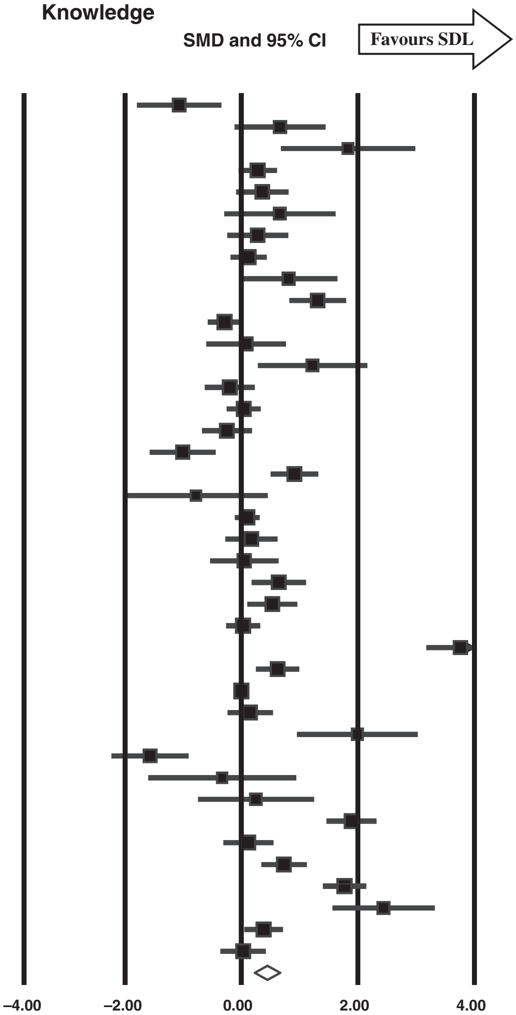

Figure 2 Random-effects meta-analysis of knowledge outcomes in studies that compared self-directed interventions with traditional teaching methods. SMD = standardised mean difference; 95% CI = 95% confidence interval; LL = lower limit; UL = upper limit; SDL = self-directed learning

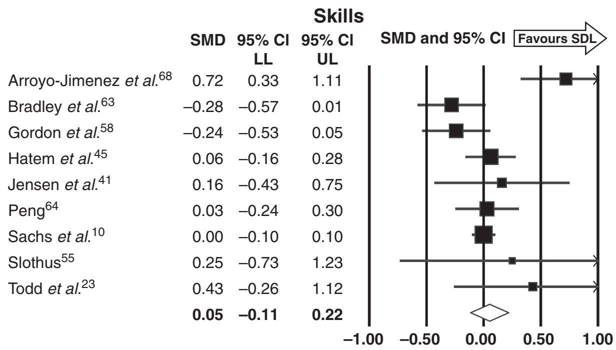

Figure 3 Random-effects meta-analysis of skills outcomes in studies that compared self-directed interventions with traditional teaching methods. SMD = standardised mean difference; 95% CI = 95% confidence interval; LL = lower limit; UL = upper limit; SDL = self-directed learning

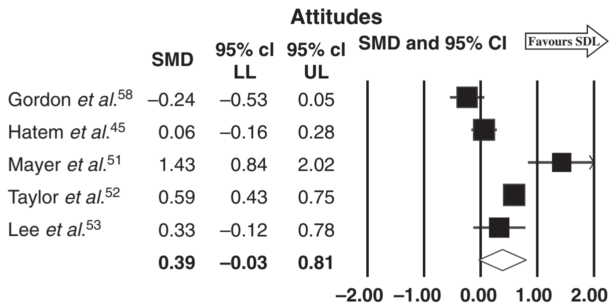

Figure 4 Random-effects meta-analysis of attitudes outcomes in studies that compared self-directed interventions with traditional teaching methods. SMD = standardised mean difference; 95% CI = 95% confidence interval; LL = lower limit; UL = upper limit; SDL = self-directed learning

significant interaction suggesting that when learners were involved in choosing learning resources, they made larger improvements in the knowledge domain. We found no other statistically significant interactions to suggest that the effectiveness of SDL differed according to the other two a priori selected components of Knowles' definition[4] of SDL (teacher as facilitator and learner conducts self-assessment). The interactivity of learning modules did not affect the effect size and neither did study blinding or randomisation. The results of subgroup analyses are summarised in Table 1.

In three studies, we observed a within-study subgroup effect suggesting that students who are more advanced in learning may benefit more from SDL. Abraham *et al.*[11] and Bhat *et al.*[33] demonstrated that SDL may only be superior to didactics in medical students who belong to the upper group when ranked in terms of merit (past performance and grades) in pharmacology and biochemistry. Arroyo-Jimenez *et al.*[68] evaluated the use of SDL in anatomy classes in a medical school in Spain. Second-year medical students significantly increased the number of items they successfully dissected after using SDL, whereas first-year students did not.[68]

In meta-regression, there was no correlation between the observed effect size and the length of SDL intervention (p = 0.64) or the time interval between the completion of the intervention and outcome assessment (p = 0.14). Given that some studies showed extreme effects and introduced marked heterogeneity to the analysis,[11,13,46,51,68] we repeated the sensitivity analysis excluding these studies as well as all other studies, one at a time. We found that no one study exclusion would change the conclusions of this report.

We found statistical evidence of publication bias in the analysis of the knowledge outcome, but not for the skills or attitudes outcomes (Egger's regression test, p-values of 0.03, 0.44 and 0.98, respectively).

Studies with insufficient data for meta-analysis

Eleven studies fulfilled the eligibility criteria for this review but did not contain sufficient data to contribute to the meta-analysis. These studies are included in Table S1 and described here qualitatively. Learners in these studies were medical students (six studies), residents (one study), doctors (two studies) and nurses (two studies).

In interventions targeting medical students, SDL was found to be superior to didactics in teaching echocardiography,[16] management of hypertension,[20] pathology,[28] emergency psychiatry,[29] urology[36] and various topics in medicine.[31] In interventions targeting residents, learning contracts coupled with independent study led to modest improvements in the care of diabetes patients and meaningful changes in self-reported practice behaviours.[39] In interventions targeting doctors, SDL applied using learning contracts significantly improved knowledge about geriatric topics[67] and was as effective as traditional learning methods in topics relating to neonatal care.[44] In interventions targeting nurses, SDL interventions seemed as effective as control methods in teaching pharmacology topics.[48,49]

DISCUSSION

We conducted a systematic review and meta-analysis of the literature to evaluate the effectiveness of SDL on

*Table 1 Subgroup analyses**

Subgroup/domain	Studies, *n*	SMD	95% CI LL	95% CI UL	I^2[†]	p-value[‡]
Learner type						
Knowledge						
Doctors	5	0.50	– 0.16	1.17	94	0.11
Medical students	22	0.42	0.14	0.70	94	
Other health professionals	7	0.16	– 0.34	0.66	40	
Residents	4	0.49	– 0.28	1.25	80	
Nurses	2	1.60	0.69	2.52	N/A	
Skills						
Doctors	1	0.06	– 0.47	0.59	N/A	0.84
Medical students	5	0.12	– 0.15	0.38	78	
Other health professionals	2	– 0.14	– 0.64	0.37	N/A	
Residents	1	0.16	– 0.60	0.92	N/A	
Attitudes						
Doctors	1	0.06	– 0.85	0.97	N/A	0.13
Other health professionals	2	0.03	– 0.65	0.71	N/A	
Nurses	2	0.94	0.25	1.63	N/A	
Interactivity of learning methods						
Knowledge						
High	13	0.47	0.07	0.87	88	0.92
Low	27	0.44	0.16	0.72	94	
Teacher role						
Knowledge						
Content source	6	0.37	– 0.31	1.05	93	0.63
Facilitator	21	0.56	0.21	0.90	93	
Skills						
Content source	1	– 0.28	– 0.84	0.28	N/A	0.12
Facilitator	4	0.22	– 0.08	0.52	69	
Learner involved in choosing learning resources?						
Knowledge						
No	31	0.32	0.04	0.60	90	0.01
Yes	5	1.31	0.59	2.03	97	
Skills						
No	5	– 0.06	– 0.36	0.24	28	0.20
Yes	3	0.23	– 0.08	0.54	79	
Attitudes						
No	4	0.49	– 0.07	1.05	91	0.48
Yes	1	0.06	– 1.00	1.12	N/A	
Learner involved in assessment?						
Knowledge						
Yes	3	0.23	– 0.62	1.07	79	0.59
No	37	0.47	0.23	0.70	93	
Skills						
Yes	1	0.06	– 0.41	0.53	N/A	0.99
No	8	0.06	– 0.14	0.27	67	

Table 1 (Continued)

Subgroup/domain	Studies, n	SMD	95% CI LL	95% CI UL	I^2 †	p-value ‡
Attitudes						
Yes	2	0.68	– 0.18	1.53	N/A	0.42
No	3	0.23	– 0.45	0.91	92	
Outcome assessment blinded						
Knowledge						
Blinded	5	0.04	– 0.56	0.65	71	0.16
Unblinded	35	0.51	0.27	0.76	93	
Skills						
Blinded	2	– 0.09	– 0.49	0.31	N/A	0.44
Unblinded	7	0.09	– 0.10	0.28	62	
Study design						
Knowledge						
Observational	26	0.37	0.09	0.64	90	0.33
RCT	14	0.60	0.22	0.98	94	
Skills						
Observational	3	0.18	– 0.08	0.45	84	0.21
RCT	6	– 0.05	– 0.29	0.19	25	
Attitudes						
Observational	3	0.62	0.09	1.14	92	0.17
RCT	2	0.03	– 0.62	0.67	N/A	

* All analyses were performed using random-effects mode
† I^2 represents the proportion of heterogeneity not attributable to chance and not estimable when the number of studies is < 3
‡ The p-value refers to an interaction test and is two-tailed. $p < 0.05$ indicates that the difference in the effect size across the multiple comparisons is beyond chance or random error
SMD = standardised mean difference; 95% CI = 95% confidence interval; LL = lower limit; UL = upper limit; RCT = randomised controlled trial; N/A = not applicable

learning outcomes. Compared with traditional learning methods, SDL was moderately more effective in the knowledge domain and likely to be as effective in the domains of skills and attitudes. The analyses of the skills- and attitudes-based outcomes were clearly less precise (as a result of smaller numbers of studies and smaller sample sizes) than that of the knowledge-based outcome; hence we cannot rule out a potential superiority of SDL in these two domains. We also found that SDL may be more effective in advanced learners.

In addition, SDL seemed to be more effective when learners were involved in identifying their learning resources. Knowles suggested that learners who are self-directed should consult with educators and determine the methods and resources that best fit their learning style and the curriculum objectives.[4] For example, cognitive objectives can be achieved using written resources or panel discussions; behavioural objectives can be attained using role-play and case-based learning, and psychomotor objectives are best fulfilled by role-play and simulation. Similarly, self-directed learners should have the ability to choose the learning method that suits their individual learning styles (e.g. a visual learner may choose a video-based method, etc.). An example of an SDL study in which learners were involved in choosing learning resources is that by Parker and Mazmanian.[66] In this study, and as recommended by Knowles,[4] practising doctors in community hospitals developed a learning contract (plan) after consultation with content experts. In the learning contract, certain topics in internal medicine were identified as the objective of learning. Learners chose their own learning resources, which included seminars and self-study reading material of their own choice. The programme demonstrated improved post-intervention knowledge and changes that affected the participants' clinical practice and the care they provided to patients.[66]

Marked heterogeneity beyond chance or random error was present in all analyses.

We were able to partially explain the heterogeneity by finding that: (i) the benefit of SDL increases when learners are involved in choosing their learning methods, strategies and resources, a key component that defines SDL according to Knowles;[4] (ii) advanced learners may benefit more from SDL compared with less advanced learners, and (iii) learner type (discipline) may also affect the anticipated benefits of SDL (nurses had a larger SMD compared with other health professionals). We found that the interactivity of SDL learning methods did not affect learning outcomes, a finding similar to the conclusions of Cook *et al.*[69] in a systematic review that evaluated the effectiveness of Internet-based learning in health professions, a methodology commonly used to deliver SDL. In addition, we hypothesised that learning content is a factor that should intuitively render some topics more suitable for SDL. However, the data available were insufficient for conducting analyses stratified by the different learning contents. An example of such a potential cause of heterogeneity is a study by Sachs *et al.*,[10] in which the authors demonstrated that medical students who learned using independent study methods scored better on certain topics on Part I of the National Board of Medical Examiners (NBME) examinations (behavioural sciences and microbiology) and worse on other topics (pharmacology and anatomy) than students using didactics.

Inference from this review implies that SDL is likely to be as effective as traditional learning methods. Self-directed learning has been suggested in certain settings (e.g. for adult learners and advanced learners, and in contexts in which access to academic institutions or teachers is limited) and as a supplemental method of learning when learning content is large.[6] It is also plausible that SDL is cost-effective. Nevertheless, the type of data required to confirm the appropriate settings, topics or learner characteristics most amenable to SDL, or to determine its cost-effectiveness, are unavailable. We suggest that SDL curricula be evaluated rigorously until future studies provide an evidence-based approach to the selection of learners and topics and implementation of SDL.

This systematic review has several limitations. It demonstrates significant remaining unexplained heterogeneity despite several exploratory subgroup, sensitivity and meta-regression analyses, which weakens our confidence in the meta-analytic estimates. The quality of the included studies was moderate. Poor indexing of SDL articles was apparent and may have led to the omission of relevant studies (i.e. the SDL literature is not always indexed in the bibliographic databases under a keyword or a term that contains the phrase 'self-directed learning'; rather, other terms are used, such as 'self-planned learning', 'learning projects', self-education', 'self-teaching', 'autonomous learning', 'autodidaxy', 'independent study' and 'open learning').[70] Therefore, we may have missed some relevant articles; however, the number of included studies is fairly large, which is likely to limit the effect of this concern. Lastly, publication bias was evident in one of the analyses and may have potentially been present in the other underpowered analyses. Publication bias leads to exaggeration of the observed effect size. Therefore, as a result of these methodological limitations and the unexplained heterogeneity, the overall quality of the evidence (i.e. confidence in the meta-analytic estimates) is considered moderate at best. The strengths of this report stem from our comprehensive literature search and the rigor of our study selection and analysis. To our knowledge, this is the only systematic review to have quantitatively evaluated the complex topic of the effectiveness of SDL in health professions education.

Although several descriptions of SDL exist, that by Knowles[4] is perhaps the most comprehensive and most frequently cited. This definition has not been necessarily validated; thus, educators developing SDL curricula have incorporated some of the elements described by Knowles as they have deemed relevant and feasible in their learning environments. In this study, we tested three empirically chosen elements from Knowles' definition; however, future studies could test whether other components of this definition or of other definitions are associated with more effective learning. For example, it is very plausible that if learners are involved in the process of needs assessment, as Knowles described,[4] they will benefit more from SDL. However, needs assessment was not well described in the SDL literature we reviewed.

At present and according to our findings, we believe that SDL in health professions education is at least as effective as traditional learning in all three domains.

Self-directed learning may preferentially be more effective in the knowledge domain. We recommend that educators embarking on developing SDL curricula for learners in health professions should:

1 involve learners in choosing learning resources and strategies to enable them to find the most appropriate resources to fit their individual learning styles as well as the overall learning objective;
2 consider SDL as an effective strategy for more advanced learners (e.g. those in the later years of medical school or residency and doctors in practice), and
3 consider SDL particularly when the learning outcome falls in the knowledge domain.

Future evidence may strengthen inferences in the skills and attitudes domains.

CONCLUSIONS

Moderate quality evidence suggests that SDL in health professions education is associated with moderate improvement in the knowledge domain compared with traditional didactic teaching and may be as effective in the skills and attitudes domains. Future research is needed to evaluate the type of learner and educational settings that may be most appropriate for SDL.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article.

Table S1. Details of included studies.

Appendix S1. Search strategy.

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