

Review Article

Self-Regulated Learning Diary Interventions and the Implications for Health Professions Education

Zahra Zarei Hajiabadi ¹, Roghayeh Gandomkar ^{1,2}, Houra Ashraffard ¹ and John Sandars ³

¹Department of Medical Education, School of Medicine, Tehran University of Medical Sciences, Tehran, Iran

²Health Professions Education Research Center, Tehran University of Medical Sciences, Tehran, Iran

³Edge Hill University Medical School, Edge Hill University, Ormskirk, UK

Correspondence should be addressed to Roghayeh Gandomkar; gandomkarr@gmail.com

Received 8 June 2022; Revised 7 September 2023; Accepted 26 September 2023; Published 18 October 2023

Academic Editor: Zhonggen Yu

Copyright © 2023 Zahra Zarei Hajiabadi et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Background. There is increasing interest in the application of self-regulated learning (SRL) to improve academic and clinical performance in health professions education. SRL-learning diary (SRL-LD) interventions have become popular in non-health professions contexts to develop students' SRL and academic performance. The aim of this systematic review was to identify how SRL-LD interventions have been used in health and non-health professions education, with the intention to provide insights into their use and to inform future implementation and research in health professions education. **Methods.** Electronic search in ERIC, ProQuest, PubMed, Scopus, Embase, and Web of Science was conducted. Two authors independently selected studies based on inclusion criteria and all selected studies were analyzed using a predetermined framework. **Results.** Of the identified 986 studies, 23 were selected for the review. Most studies were conducted in higher education within a domain-specific context, with only one study in health professions education. Most were justification studies. Five types of intervention were identified (Diary + SRL instruction, Diary + feedback, Diary + SRL instruction + feedback, Diary only, and SRL instruction only). Overall, the combination of a diary with explicit SRL instruction and/or feedback improved more SRL processes than diary only or SRL instruction only interventions. In studies reporting academic outcomes, there was also an improvement in 40% of studies. **Conclusion.** This systematic review highlights the potential usefulness of SRL-LD interventions in health professions education. Recommendations for implementation and future research are discussed.

1. Introduction

There is increasing interest in the application of self-regulated learning (SRL) in health professions education, with evidence that interventions based on SRL can improve academic and clinical learning and performance [1–6]. There are several SRL theoretical models [7], with Zimmerman's being widely applied within both health and non-health professions education to understand and design interventions for developing SRL [8]. In Zimmerman's [9] model, SRL is considered to be a cyclical and dynamic process that occurs in three main phases in relation to a learning task: forethought, performance and self-reflection. In each phase there are also several key specific subprocesses related to the cognitive and motivational aspects of learning [9]. In the forethought phase, there is task analysis

with goal setting and the choice of appropriate strategies for achieving successful learning. During the performance phase, the chosen strategies, which may also include time structuring, environmental structuring, and help seeking, are implemented. In addition, the student metacognitively monitors their achievement of learning. During the self-reflection phase, the student evaluates their learning and the extent to which their choice of chosen strategies has been successful in achieving their desired learning, with consideration of the need to adapt their motivational and cognitive strategies in response to both the current learning task and future learning tasks [9].

Interventions for improving SRL in health profession education have been mainly based on courses with explicit or direct SRL instruction on how to apply SRL to their overall

learning [10, 11], but more recently personalized interventions with the focus on identifying SRL subprocesses and providing feedback have been proposed, such as by micro-analysis with a focus around a short specific learning task [12–16]. An important challenge with these interventions in health professions education is that they are time consuming for both educators and learners but also there is limited time over which SRL processes can develop [17–19]. In response to the shortcomings of similar current interventions in non-health professions education, learning diary-based interventions have become increasingly popular to foster learners' SRL as a situated and dynamic processes over time.

A diary is a self-report instrument in which an individual can document an individual student's experiences in a real and authentic setting over multiple time points [20, 21]. Learning diaries can be structured to both capture and develop SRL in the context of a specific learning task [22, 23]. These SRL learning diaries (SRL-LD) can provide an opportunity for the learner to (i) plan their motivational and cognitive aspects of learning within the diary before beginning a learning task. (ii) monitor and reflect upon what aspects of learning went well, and what did not go so well, both during and after finishing the learning task, and (iii) adapt their motivational and cognitive aspects of learning either during the learning task or for a subsequent learning task [23].

There are two general approaches to SRL training: direct and indirect instruction. Direct instruction may be conducted in the form of teaching the SRL process and key subprocesses (explicit instruction) or modeling and scaffolding the main SRL process and key subprocesses by a teacher, a peer or completing a SRL-LD (implicit instruction). Indirect instruction of the SRL process and key subprocesses refers to providing an encouraging learning environment, such as through cooperative learning, situated learning or creating cognitive challenges [24]. ASRL-learning diaries (SRL-LD) have the advantage of having the potential to develop SRL and academic performance over time but also being ecologically valid since they have a focus on improving SRL in real learning settings [25].

SRL-LD have been used in three main different formats as an intervention to develop SRL in non-health professions education [26]; unstructured (containing no questions or prompts), semistructured (with open ended questions and/or prompts related to the main phases of SRL), and structured diaries (with specific open ended and/or closed questions related to specific SRL phases and key subprocesses). These SRL-LD can be completed at different time intervals, such as daily, biweekly or weekly, and also in variety of formats, including paper-and-pencil, brief telephone interview and electronic [21].

Over the last 20 years, educators in non-health professions, especially humanities and engineering, have become increasingly interested in SRL-LD interventions [27–34]. The intention is that regularly recording of SRL during learning may improve both students' SRL and academic performance over time [35, 36] specially diaries those address both learning behavior and content, cognitive, and metacognitive

aspects with external feedback on SRL. Diaries also can be useful for all age groups of learners and all educational contexts [36]. Despite the potential benefits of SRL-LD to improve academic and clinical performance by strengthening SRL, our experience in planning a study in medical students highlighted that there appeared to be few studies in health professions education. However, SRL-LD interventions have been widely used in non-health professions education and we therefore conducted our systematic review with the aim to identify how SRL-LD interventions have been used in health and non-health professions education, with the intention to provide insights into their use and to inform future implementation and research in health professions education.

2. Materials and Methods

This systematic review was conducted according to the PRISMA (preferred reporting items for systematic reviews and meta-analyses) statement criteria [37]. The authors have previous experience in SRL research and conducting review studies, which guided the overall conduct of the review and the interpretation of the results. The review protocol has not been published before conducting the research. However, all data generated or analyzed during this study are shared in this paper and its supplementary data. We followed a step-wise process in conducting the review.

2.1. Identifying Research Questions. We formulated four research questions:

- (i) In what contexts have SRL-LD interventions been used?
- (ii) What are the key components of SRL-LD interventions?
- (iii) What are the outcomes of SRL-LD interventions?
- (iv) What are the practical implications for future design and research on SRL-LD interventions in health professions education?

2.2. Identifying Relevant Studies. The first author (ZZH) formulated the search strategy (Table S1) following discussion with the research team and in consultation with an experienced librarian using subject keywords and their combinations: self regulate*, learning, regulation of learning—diary, diaries, journal. Search terms were refined iteratively to include the wide-ranging of related papers (e.g., learning journals) while excluding unrelated articles (e.g., regulation of depression). We included all primary research indexed in ERIC, ProQuest, PubMed, Scopus, EMBASE, and Web of Science, including conference presentations and dissertations. Additional references were identified through hand searching. The literature search was conducted in English on July 7, 2021. Studies were considered eligible for inclusion if they adhered to the following criteria: described the use of diary interventions for developing and improving SRL; reported at least one SRL outcome; conducted in all higher education contexts, including health professions education and papers were published in English. Time frame were not considered for eligibility. We excluded studies that

described diaries as only a data collection tool, noninterventional studies, or interventions to foster SRL without using a diary as part of training, and those performed in k-12 context. We also excluded non-English papers, books or book sections, secondary studies, letters, reports, editorials, and perspectives.

2.3. Study Selection. All identified papers were entered into a reference management software and duplicates were removed. Two authors (ZZH and HA) independently screened the titles and abstracts in terms of inclusion criteria relevance and then discussed any differences until consensus was reached. The full text of selected articles was reviewed against the eligibility criteria and uncertainty about inclusion was discussed between the two authors (ZZH and RG).

2.4. Charting the Data. The data extraction form was developed iteratively through discussions between all authors. The form was initially piloted with a small number of studies by ZZH and then was discussed, reexamined, and revised by ZZH, RG, and JS.

2.5. Collating, Summarizing, and Reporting the Results. We calculated frequencies to describe study characteristics and conducted content analysis [38] using several analytic frameworks for abstraction of findings. For the educational domain, we considered whether interventions were conducted in specific circumstances such as a lesson, an educational subject or an educational objective and identified them as domain-specific through the continuum of domain specificity (Figure S1). Outcomes of the intervention were classified based on the Kirkpatrick and Kirkpatrick [39] levels. Perceptions of the participants were categorized thematically as positive or negative reactions to the “diary,” “instruction,” or “SRL intervention as whole” based on the studies’ findings. Response rate of studies were classified as high, moderate, or low. Additionally, we classified SRL targeted in SRL-LD interventions based on the three phases of Zimmerman’s [9] model (forethought, performance and self-reflection). Study recommendations also were coded in order to gain a comprehensive view about practical considerations to design and implementation of such interventions and further research. The Medical Education Research Study Quality Instrument (MERSQI) tool was used to assess the methodological quality studies [40]. The MERSQI includes ten items for investigating the quality of six dimensions: study design, sampling, data type, validity of assessments, data analysis, and outcomes (possible total scores: 5–18). The framework used by Gordon et al. [41] was applied to assess the quality of the reporting of the training intervention for each study and the results were presented as green for high quality, yellow for unclear quality, and red for low-quality intervention across five categories: *U*=underpinning theory described, *R*=resources described, *S*=settings described, *E*=educational methods described, and *C*=content described. Clear and detailed description of underpinning theory or model (*U*), resources such as time and costs (*R*), educational context and participants’ characteristics (*S*), educational methods (*E*), and materials or access to the materials (*C*) got green. If the descriptions were not complete or detailed in each category got yellow and if no information was exist got red [41].

One author (ZZH) undertook initial data extraction and summarizing for each paper, which was subsequently independently checked and verified by RG. The authors iteratively moved through the papers to ensure all extraction topics were comprehensively examined for each paper. The process of quality assessment of the studies was performed by HA and ZZH independently. Any differences were discussed until agreement was reached.

3. Results

A total of 986 papers were retrieved from selected databases via electronic and hand searching. After removing duplicates, 734 records remained. Following the inclusion–exclusion process, finally 23 papers were selected for the review. Details of the article selection process are shown in Figure 1.

The quality scores of the studies ranged from 9.5 to 15.5 (mean MERSQI = 11.91) showing acceptable quality of the studies’ methodology. However, the reporting of the training interventions was often unclear (Table S2).

3.1. In What Contexts Have SRL-LD Interventions Been Used? Table 1 shows a summary of the study characteristics. All studies were published between 2006 and 2020. Most interventions were conducted in Germany ($N=8$) and the USA ($N=4$ most studies ($n=17$) implemented SRL-LD interventions related to a specific domain such as Math lessons. There was one study in health professions education, with a focus on anesthesiology residents.

3.2. What Are the Key Components of SRL-LD Interventions? Please see Table 2.

3.3. Types of SRL-LD Interventions. We identified five types of interventions: diary + SRL instruction ($n=10$), diary + feedback ($n=4$), diary + SRL instruction + feedback ($n=1$), diary only ($n=16$), and SRL instruction only ($n=4$). Thirteen studies had explicit SRL instruction at least for one of their intervention groups including didactic teaching of SRL key subprocesses; and five studies presented an individualized SRL feedback on participants’ learning diaries. In two studies, researchers [42] or instructors [43] collected the participants’ daily diary at the end of each week and provided personalized qualitative feedback to each participant. In two studies, participants were provided with an online daily personalized feedback in tabular [44] or graphical [45] format. In one study, highly elaborated online feedback was provided by the trained teaching assistants. Interventions lasted between 3 weeks to two academic semesters.

Eleven studies employed a structured diary, 11 studies also reported a semistructured and one study presented an unstructured diary. In 20 studies, diaries were implemented in a time-based manner, with administration at fixed time intervals, such as weekly or daily. Two studies employed an event-based learning diary, which was delivered after each lesson of students’ regular course. An electronic learning diary was used in 14 studies and 9 used a paper-based diary.

Qualitative ($n=8$) and/or quantitative methods ($n=12$) were used to analyze the data of the diaries based on its structure as outcome measure. In two of the retrieved

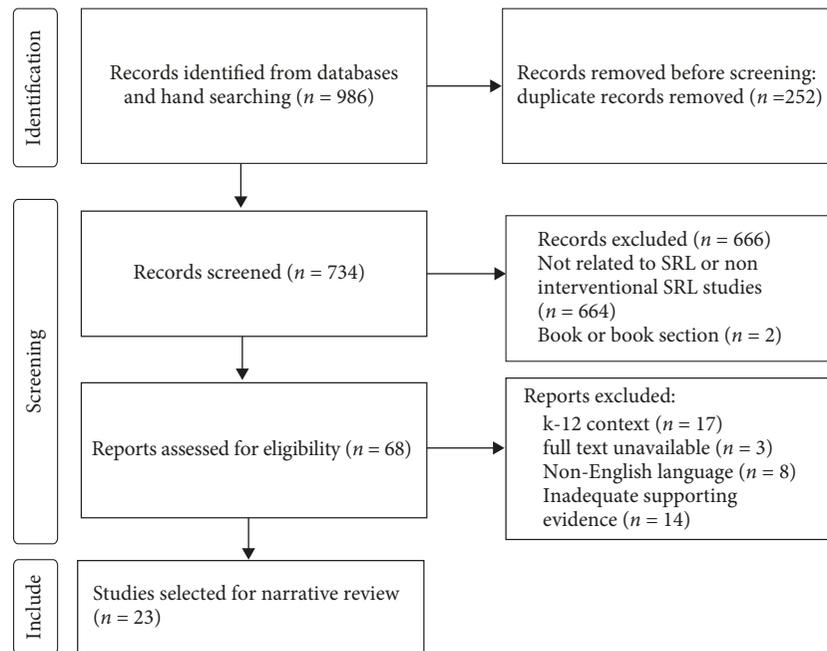


FIGURE 1: PRISMA flowchart showing search process and study selection [37].

studies, the diary was used only as a stimulation for reflection and no analysis was performed for diary data.

3.4. Focus of SRL-LD Interventions on SRL Phases. There were 10 studies that reported explicit instruction in SRL. In six studies instructions contained all three phases of SRL, two studies covered forethought and performance phases and one study presented SRL explicit instruction only in the performance phase of SRL.

In most studies ($n = 17$) diaries contained all SRL phases. There were two studies had diaries that contained both forethought and performance phases. In three studies, the diaries included items related to only one phase of the SRL (forethought $n = 1$ and performance $n = 2$) (Table S2).

3.5. What Are the Outcomes of SRL- LD Interventions? Studies reported several different outcomes. At Kirkpatrick Level 1, the response rate and participants' perceptions to the intervention were analyzed. The response rate was identified in 20 studies and almost all ($n = 18$) reported a moderate to high-response rate. Participants' perceptions were explored using questionnaires with closed- and open-ended questions ($n = 5$), and in most studies participants had a positive attitude toward the diary approach, the instructions and the intervention as a whole (Table S3). Participants' perception about the novelty of instructions were investigated in two studies and participants rated it as average [46, 47].

Outcomes were also evaluated at Kirkpatrick Level 2, as (i) SRL outcomes ($n = 23$) and (ii) academic outcomes ($n = 8$). Most studies ($n = 21$) used self-report questionnaires to assess SRL as the pre/post comparison measure (Table S2). In addition, 14 studies used diary data to evaluate SRL quantitative outcomes and 7 studies collected SRL qualitative data.

- (1) The combination of diary with explicit training on SRL improved more SRL key subprocesses than diary only or SRL instructions only interventions. Integrating feedback with the diary did not improve more SRL measures than only diary (Table 3). Overall SRL and performance phase measures demonstrated improvement more than the other SRL measures. In nine studies, worsened SRL outcomes was detected for several subprocesses of the forethought and performance phases (motivation, self-efficacy, mood, goal setting, handling stress, and quality of cognitive strategies of high expertise students). There was one study that compared the effectiveness of a personalized SRL-LD intervention based on the participants' use of SRL. Overall, there was an increased use of appropriate cognitive strategies after receiving personalized feedback for students who used inappropriate strategies prior to feedback and also students that used appropriate cognitive strategies before receiving feedback showed a decrease in their use after receiving feedback [48].
- (2) Academic outcomes were reported in eight studies, with five studies comparing the academic performance of participants and two studies showed statistically significant difference in favor of the intervention group. There was no worsened academic outcome (Table S2).

3.6. What Are the Practical Implications for Educational Design and Research on SRL-LD Interventions? The main recommendations made by the article authors for further design were the combination of the SRL-LD with explicit SRL instruction and adapting the SRL-LD intervention to the student's characteristics and needs. The main recommendations for future

TABLE 1: Descriptive characteristics of retrieved articles.

| Characteristics of article | Number of articles |
|--|--------------------|
| Year of publication | |
| 2006, 2009, 2010, and 2012 (one study for each year) | 4 |
| 2013 | 2 |
| 2014 | 3 |
| 2015 | 2 |
| 2016 | 2 |
| 2017 | 2 |
| 2019 | 5 |
| 2020 | 3 |
| Country | |
| Germany | 8 |
| USA | 4 |
| Turkey | 2 |
| Romania | 2 |
| Brazil, Qatar, Egypt, Malaysia, Estonia, Australia, and Finland (one study for each country) | 7 |
| Type of article | |
| Journal article | 27 |
| Conference abstract | 3 |
| Dissertation | 3 |
| Participants' majors | |
| University students | 14 |
| Mechanical engineering | 2 |
| Civil engineering | 1 |
| Anesthesiology residents | 1 |
| Business | 1 |
| Psychology and education sciences | 1 |
| Various majors | 5 |
| Not mentioned | 3 |
| Teacher training (Preservice teachers) | 6 |
| College students | 2 |
| Technical university students | 1 |

research were a larger sample size and longer term follow-up, the identification of the optimal components of an SRL-LD intervention, and the impact on students' performance.

4. Discussion

The review had the aim to identify how SRL-LD interventions have been used in health and non-health professions education, with the intention to provide insights into their use and to inform future implementation and research in health professions education. There were 23 studies published between 2006 and 2020 that were eligible to be included in the review.

Only one study in health professions education was identified, with a focus on anesthesiology residents. In this study the diaries were used only for documenting their study time schedule and assessed the amount of time that residents invested on studying related materials before and after two

TABLE 2: Descriptive characteristics of interventions.

| Characteristics of interventions | Number of articles |
|--|--------------------|
| Domain specificity | |
| Domai-general | 6 |
| Domain specific | 17 |
| ICU rotation | 1 |
| Online child growth course | 1 |
| Tourism English course | 1 |
| Educational psychology course | 4 |
| Math lesson | 2 |
| Online computer application course | 1 |
| English grammar and SRL courses | 1 |
| Curriculum development course | 1 |
| Teaching principles and methods course, and collaborative learning | 1 |
| Online research methodology course | 1 |
| Psychology of learning course | 1 |
| Computer programing course | 1 |
| A not mentioned virtual course | 1 |
| Types of intervention groups | |
| Diary + SRL instruction | 10 |
| Diary + feedback | 4 |
| Diary + SRL instruction + feedback | 1 |
| Diary only | 16 |
| SRL instruction only | 4 |
| Types of diaries | |
| Structured | 11 |
| Semistructured | 11 |
| Unstructured | 1 |
| Electronic | 14 |
| Paper-and-pencil | 9 |
| Time based | 20 |
| Event based | 2 |
| Not mentioned | 1 |
| Analysis methods of diary data | |
| Qualitative methods | 8 |
| Thematic analysis | 1 |
| Content analysis | 4 |
| Qualitative analysis (not specified) | 3 |
| Quantitative methods | 12 |
| Descriptive analysis | 2 |
| Hierarchical linear modeling | 2 |
| Time series and trend analysis | 4 |
| Time series analysis | 1 |
| Trend analysis | 1 |
| ANOVA | 2 |
| Not performed | 2 |

different short SRL instructions (WOOP: wish-outcome-obstacle-plan and goal setting) [49].

There were five types of SRL-LD interventions identified in the studies; diary + SRL instruction, diary + feedback, diary + SRL instruction + feedback, diary only, and SRL instruction only. Our review found that in almost half of diary interventions,

TABLE 3: SRL outcomes of studies based on overall and three phases of SRL.

| | Intervention groups | | | | |
|-----------------|--------------------------------------|------------------------------|--|-------------------------|----------------------------------|
| | Diary + SRL instruction ($n = 10$) | Diary + feedback ($n = 4$) | Diary + SRL instruction + feedback ($n = 1$) | Diary only ($n = 16$) | SRL instruction only ($n = 4$) |
| Overall SRL | 3/3 (100%) | 1/1 (100%) | 0/0 (0%) | 2/4 (50%) | 0/4 (0%) |
| SRL outcomes | | | | | |
| Forethought | 3/9 (33%) | 2/3 (66%) | 0/0 (0%) | 8/15 (53%) | 2/4 (50%) |
| Performance | 7/9 (77%) | 3/3 (100%) | 1/1 (100%) | 9/16 (56%) | 3/4 (75%) |
| Self-reflection | 6/9 (66%) | 0/3 (0%) | 1/1 (100%) | 7/15 (46%) | 0/4 (0%) |

Note: n/n : number of intervention groups that reported improvement in the domain/total number of studies that reported the outcome in the domain.

SRL in all three phases were improved. In diaries with explicit SRL instruction, improvements in SRL were found in the student's use of SRL in the forethought phase (50%) and performance phase (75%). All diary + feedback interventions achieved improvements in the performance phase, and forethought improvements were obtained in more than half of these groups. In diary + feedback interventions no improvement was found for the self-reflection phase. Diary with explicit SRL instruction groups had enhancement in all SRL phases; more than half of these studies showed improvement in performance and self-reflection phases and less than half of studies reported improvement in forethought phase. Overall, SRL-LD interventions mostly improved participants' SRL in the performance phase and when used in a combination of SRL explicit instruction and/or feedback, there was additional effectiveness of the intervention in the performance phase. Similar to Theobald's [35] meta-analysis of SRL training programs with explicit instruction for university students (2021), there was also an overall improvement in SRL, especially for interventions that included instruction and feedback.

Studies included in this review used and compared different formats of SRL-LD interventions, but none of them were focused on comparing the format of SRL-LD. Therefore, we are limited in making specific inferences from this review about the preferred type of SRL-LD. In addition, most studies also employed structured, time-based and electronic diaries with used different types of quantitative methods to analyze the data. This has implications for future research since the use and design of appropriate SRL-LD are influenced by alignment to the research question [50], feasibility, and educational effect [25]. For instance, if the research aim is to explore a rich understanding of the SRL process and key subprocesses, an unstructured or semistructured SRL-LD in which participants document their learning experiences without limitation can provide qualitative data that leads to a deep understanding of their SRL [51–53]. In contrast, if researchers aim to enhance and/or evaluate specific SRL key subprocesses in participants, a more structured SRL-LD is recommended [25, 47, 54]. A structured SRL-LD may also promote the feasibility by increasing the response rate and by providing quantitative data [25].

Regarding outcomes, in two of the eight studies that investigated the academic outcomes, significant differences were obtained in favor of the intervention group. Interestingly both of these studies had diary + feedback intervention groups.

Theobald's [35] meta-analysis also showed the overall positive effects of SRL on academic performance in higher education.

The reviewed studies showed that low-academic performance students benefited more from the different SRL-LD interventions compared with high-performance students [48]. This finding is similar to the findings from Theobald's [35] meta-analysis of SRL explicit instruction programs.

Although the majority of students considered that the longitudinal use of diary and the instructions were useful, some participants were dissatisfied. Their main reasons for being dissatisfied were the lengthy instruction sessions and the lack of motivation to repeatedly complete the diary over a period of time [55, 56].

Overall, the positive SRL and academic performance outcome findings and favorable students' perceptions suggest that SRL-LD interventions offer an acceptable and effective approach for health professions education.

4.1. Implications for Future Design and Implementation of SRL-LD Interventions in Health Professions Education. The findings of the review, although limited to insights from non-health professions education, suggest that there is potential for using SRL-LD interventions in the health professions education [57]. We provide several recommendations to guide future design and implementation which are based on the review.

4.1.1. Use an Appropriate Theoretical Framework. A theoretical framework can guide future design and implementation and evaluation of SRL-LD interventions. We recommend Zimmerman's model since it has a practical focus on three important cyclical SRL phases and has been effectively used in our reviewed studies of SRL-LD interventions. Furthermore, Zimmerman [9] considers SRL as a situational variable feature that the diary is more fitted to the development and assessment of SRL across several occasions and situations.

4.1.2. Include All Important Components of SRL in the Diary. Results of this review showed that the interventions that covered all three SRL phases according to Zimmerman's model had effects on improving most SRL phases; forethought [25, 58, 59], performance [25, 51, 56, 58, 59], and also self-reflection phases [25, 58, 59]. In line with the Zimmerman's theoretical model, we suggest including all three phases of SRL in designing the diary since theoretically there is cyclical feedback loop in which the phases are influenced

by each other [60] and it is necessary to consider all components together to have a holistic approach to develop and/or assess the SRL. Diaries provide an opportunity for students to self-monitor how each SRL phase and its key subprocesses can have an impact on their performance, allowing them to make adaptive changes for the future performances [23]. Frequent completion of a diary over time can lead to these processes becoming more automatic [61].

4.1.3. Use an SRL-LD Intervention that Combines Explicit SRL Instruction and/or Feedback with Diary. As the results of this review indicate, combining feedback on participants' SRL or SRL explicit instruction + feedback with diaries may increase the effectiveness of SR-LD interventions. This does not necessarily mean providing longer training and the use of more resources since explicit training can be limited to initially providing information on the importance of SRL for academic success as well as including short practical tips related to applying several different SRL/subprocesses. Furthermore, as feedback improves the SRL-LD intervention effectiveness [36, 62], the automated online feedback can be a cost-effective approach for this aim [28].

4.1.4. Consider the Feasibility of Implementing an SRL-LD Intervention. The main challenges that retrieved studies had been mentioned were the issues with diary completion rate and also continuation of student participation in longitudinal SRL-LD interventions. SRL-LD interventions are also a major consideration for health profession students due to their high academic and clinical workload. To resolve this problem in some studies, incentives are considered for the participants while this approach may affect the results of the study. We suggest several potential solutions: (i) emphasizing the importance of the diary in improving their performance. We could introduce the diary and its benefits to provide documentation about ones' planning and reflecting in own learning. In addition, we should train participants how to work with their diary; (ii) using short structured weekly diaries instead of long daily diaries. There is no preferred type of SRL-LD, but it seems to be more efficient if we consider a structured SRL-LD covering key SRL subprocesses. Furthermore, to avoid increasing health professions students' workload, we recommended designing the diary and intervention to ensure that it meets the participants' needs.; (iii) designing short practical SRL training sessions since research suggests that health profession students have less need for extensive training related to SRL because they usually have greater awareness (reached by self-experience or prior training) and they need more emphasis on practicing the application of SRL [63]; and (iv) placing the intervention close to an important assessment to maximize student participation, for example as a test preparation course.

4.1.5. Consider the Characteristics of the Students. The reviewed studies highlighted the importance of adapting the SRL-LD intervention to the students' prior academic performance and their differences in the use of SRL. For instance, low-achieving medical students show less use of SRL and its key sub-processes compared with high-achieving

students [16, 64–67]. On the other hand, research has showed that low performance adult learners benefited more from the training on time and resource management strategies [63]. Considering students' needs can lead to improve participants' motivation and the outcomes of the intervention in addition to avoiding waste of resources. In preclinical phase of HPE, SRL-LD interventions can be conducted same as other higher education context. HP students in their clinical practice, experience dynamic and complex environments, with time-pressures and stressors. Research in health professions education highlights the need to have a dynamic approach to develop and assess the students' SRL in such complex and work-place context [68]. The most prominent features of the SRL-LD are its authenticity and ecological validity [25] so that it has the capacity to capture SRL in various situations in real time and place of occurrence, congruent with the situated nature of SRL.

4.1.6. Familiarize Faculty with the Diary. A significant number of retrieved studies had been conducted in the field of teacher training. As the SRL is an important competency for life-long learners both faculties and health professions students can benefit from instruments that stimulate and develop their SRL in a more thriftilly way in terms of its implicit training effects. Furthermore, faculty development is essential for implementing any new intervention to ensure that faculty can support students [69, 70]. Faculty development courses can introduce the diary as a SRL enhanced tool and encourage health profession teachers to use it for self-awareness and self-improvement in the SRL. Also, teachers can move to a more student-centered learning environment by applying the diary to help students promoting their SRL.

5. Suggestions

There are several future areas of research to fill the existing knowledge gaps for the use of SRL-D interventions in health professions education. Since the most effective interventions in other disciplines were those that combined explicit SRL training and diary methods [47, 59], we recommend replication studies of combined SRL instruction and diaries, as well as studies that compare the combined intervention with diary only in health professions education. Future research can also provide more evidence for validity of the learning diary [71], especially the important question of whether changes in SRL and its key subprocesses are associated with academic outcomes. Other important areas for research are the generalizability of the effectiveness of the diary across different tasks [21, 71, 72], and the identification of how many diary completions are appropriate for the maximum effectiveness of the intervention [73].

6. Conclusion

This systematic review investigated SRL-LD interventions and found that there were several types of diary interventions. Overall, there was an improvement in SRL and academic performance, especially for students with low performance. The most effective intervention was a diary in combination

with explicit SRL training and/or feedback that covers all SRL phases.

Data Availability

We did not publish the review protocol including the research objectives and methods. However, all data generated or analyzed during this study are included in this published article and its supplementary information files.

Additional Points

Limitations. This review has several potential limitations. A potential limitation of the review, similar to all systematic reviews, is that we may have missed important articles, including the exclusion of non-English articles and inclusion criteria limited to empirical research and excluded information from perspective articles, opinion pieces and innovations. However, we adopted a systematic process throughout all the stages of the review. The overall quality of the included studies was low but we consider that useful information about the effectiveness of SRL-LD interventions can be obtained to inform future application for health professions education.

Ethical Approval

This study was approved by the Research Ethics Committee of the Tehran University of Medical Sciences, Tehran, Iran. Approval ID: IR.TUMS.VCR.REC.1396.4673.

Disclosure

We, authors confirm that all methods were carried out in accordance with declaration of Helsinki guidelines and regulations. The role of the funding body was in the design of the study and collection, analysis, and interpretation of data.

Conflicts of Interest

The authors declare that they have no conflicts of interests.

Authors' Contributions

ZZ, RG, and JS designed the study. ZZ conducted the data curation. All authors (ZZ, RG, HA, and JS) contributed on data analysis and validation, and writing and editing the manuscript.

Acknowledgments

This study was funded by the Tehran University of Medical Sciences, Tehran, Iran (Grant No: 96-04-214-36501).

Supplementary Materials

Table S1: contains search strategies that performed in each database and also their numbers of retrieved papers. Figure S1: shows the continuum of domain specificity of the SRL. Table S2: includes the details of SRL-LD retrieved interventions and their reported outcomes. Table S3: presents the study

response rates and participants' reactions. (*Supplementary Materials*)

References

- [1] R. A. Kuiper and D. J. Pesut, "Promoting cognitive and metacognitive reflective reasoning skills in nursing practice: self-regulated learning theory," *Journal of Advanced Nursing*, vol. 45, no. 4, pp. 381–391, 2004.
- [2] H. Leggett, J. Sandars, and T. Roberts, "Twelve tips on how to provide self-regulated learning (SRL) enhanced feedback on clinical performance," *Medical Teacher*, vol. 41, no. 2, pp. 147–151, 2019.
- [3] K. A. Winston, C. P. M. van der Vleuten, and A. J. J. A. Scherpbier, "Prediction and prevention of failure: an early intervention to assist at-risk medical students," *Medical Teacher*, vol. 36, no. 1, pp. 25–31, 2014.
- [4] Y. Salamonson, L. M. Ramjan, S. van den Nieuwenhuizen, L. Metcalfe, S. Chang, and B. Everett, "Sense of coherence, self-regulated learning and academic performance in first year nursing students: a cluster analysis approach," *Nurse Education in Practice*, vol. 17, pp. 208–213, 2016.
- [5] A. R. Artino, T. J. Cleary, T. Dong, P. A. Hemmer, and S. J. Durning, "Exploring clinical reasoning in novices: a self-regulated learning microanalytic assessment approach," *Medical Education*, vol. 48, no. 3, pp. 280–291, 2014.
- [6] S. M. Lucieer, L. Jonker, C. Visscher, R. M. J. P. Rikers, and A. P. N. Themmen, "Self-regulated learning and academic performance in medical education," *Medical Teacher*, vol. 38, no. 6, pp. 585–593, 2016.
- [7] E. Panadero, "A review of self-regulated learning: six models and four directions for research," *Frontiers in Psychology*, vol. 8, Article ID 422, 2017.
- [8] J. Sandars, "The use of reflection in medical education: AMEE guide no. 44," *Medical Teacher*, vol. 31, no. 8, pp. 685–695, 2009.
- [9] B. J. Zimmerman, "Becoming a self-regulated learner: an overview," *Theory Into Practice*, vol. 41, no. 2, pp. 64–70, 2002.
- [10] J. Sandars and M. Homer, "Pause 2 learn: a learning to learn course to help undergraduate medical students to become more effective self-regulated learners," *Education for Primary Care*, vol. 23, no. 6, pp. 437–439, 2012.
- [11] T. Papinczak, L. Young, M. Groves, and M. Haynes, "Effects of a metacognitive intervention on students' approaches to learning and self-efficacy in a first year medical course," *Advances in Health Sciences Education*, vol. 13, pp. 213–232, 2008.
- [12] T. J. Cleary, S. J. Durning, and A. R. Artino, "Microanalytic assessment of self-regulated learning during clinical reasoning tasks: recent developments and next steps," *Academic Medicine*, vol. 91, no. 11, pp. 1516–1521, 2016.
- [13] T. J. Cleary and B. J. Zimmerman, "Self-regulation empowerment program: a school-based program to enhance self-regulated and self-motivated cycles of student learning," *Psychology in the Schools*, vol. 41, no. 5, pp. 537–550, 2004.
- [14] S. J. Durning, T. J. Cleary, J. Sandars, P. Hemmer, P. Kokotailo, and A. R. Artino, "Perspective: viewing "strugglers" through a different lens: how a self-regulated learning perspective can help medical educators with assessment and remediation," *Academic Medicine*, vol. 86, no. 4, pp. 488–495, 2011.
- [15] R. Patel, W. Green, M. W. Shahzad, H. Church, and J. Sandars, "Using a self-regulated learning-enhanced video feedback

- educational intervention to improve junior doctor prescribing," *Medical Teacher*, vol. 42, no. 8, pp. 886–895, 2020.
- [16] R. Gandomkar, A. Mirzazadeh, M. Jalili, K. Yazdani, L. Fata, and J. Sandars, "Self-regulated learning processes of medical students during an academic learning task," *Medical Education*, vol. 50, no. 10, pp. 1065–1074, 2016.
- [17] R. Gandomkar, J. Sandars, and A. Mirzazadeh, "Many questions remain to be answered about understanding self-regulated learning in the clinical environment," *Medical Education*, vol. 52, no. 9, pp. 882–884, 2018.
- [18] S. F. E. Rovers, G. Clarebout, H. H. C. M. Savelberg, A. B. H. de Bruin, and J. J. G. van Merriënboer, "Granularity matters: comparing different ways of measuring self-regulated learning," *Metacognition and Learning*, vol. 14, pp. 1–19, 2019.
- [19] R. Gandomkar, K. Yazdani, L. Fata et al., "Using multiple self-regulated learning measures to understand medical students' biomedical science learning," *Medical Education*, vol. 54, no. 8, pp. 727–737, 2020.
- [20] M. Csikszentmihalyi, *Handbook of Research Methods for Studying Daily Life*, Guilford Press, 2011.
- [21] M. Iida, P. E. Shrout, J.-P. Laurenceau, and N. Bolger, "Using diary methods in psychological research," in *APA handbook of research methods in psychology*, H. Cooper, P. M. Camic, D. L. Long, A. T. Panter, D. Rindskopf, and K. J. Sher, Eds., vol. 1 of *Foundations, Planning, Measures, and Psychometrics*, pp. 277–305, American Psychological Association, Washington, DC, US, 2012.
- [22] Y. Y. Ciere, D. Jaarsma, A. Visser, R. Sanderman, E. Snippe, and J. Fleer, "Studying learning in the healthcare setting: the potential of quantitative diary methods," *Perspectives on Medical Education*, vol. 4, no. 4, pp. 203–207, 2015.
- [23] E. Panadero, J. Klug, and S. Järvelä, "Third wave of measurement in the self-regulated learning field: when measurement and intervention come hand in hand," *Scandinavian Journal of Educational Research*, vol. 60, no. 6, pp. 723–735, 2016.
- [24] C. Dignath and M. V. J. Veenman, "The role of direct strategy instruction and indirect activation of self-regulated learning—evidence from classroom observation studies," *Educational Psychology Review*, vol. 33, pp. 489–533, 2021.
- [25] B. Schmitz and B. S. Wiese, "New perspectives for the evaluation of training sessions in self-regulated learning: time-series analyses of diary data," *Contemporary Educational Psychology*, vol. 31, no. 1, pp. 64–96, 2006.
- [26] A. Roth, S. Ogrin, and B. Schmitz, "Assessing self-regulated learning in higher education: a systematic literature review of self-report instruments," *Educational Assessment, Evaluation and Accountability*, vol. 28, pp. 225–250, 2016.
- [27] H. Bellhäuser, B. Mattes, and P. Liborius, "Daily fluctuations in motivation," *Zeitschrift für Entwicklungspsychologie und Pädagogische Psychologie*, vol. 51, no. 4, pp. 228–242, 2019.
- [28] H. Bellhäuser, C. Dignath, and M. Theobald, "Daily automated feedback enhances self-regulated learning: a longitudinal randomized field experiment," *Frontiers in Psychology*, vol. 14, Article ID 1125873, 2023.
- [29] A. Joseph-Edwards, *The effect of standardised learning diaries on self-regulated learning, calibration accuracy and academic achievement*, [Doctoral dissertation], Old Dominion University, 2019.
- [30] J. R. Allison, *The impact of online diary topics on self-regulated behavior in online environments*, ProQuest Dissertations and Theses Global, Mississippi State University, 2014.
- [31] A.-M. Cazan, "Enhancing self regulated learning by learning journals," *Procedia—Social and Behavioral Sciences*, vol. 33, pp. 413–417, 2012.
- [32] A.-M. Cazan, "An intervention study for the development of self-regulated learning skills," *Current Psychology*, vol. 41, pp. 6406–6423, 2022.
- [33] C. Y. Fung, M. N. L. Y Abdullah, and S. Hashim, "Improving self-regulated learning through personalized weekly e-learning journals: a time series quasi-experimental study," *e-Journal of Business Education & Scholarship of Teaching*, vol. 13, no. 1, pp. 30–45, 2019.
- [34] M. M. H. Ahmed, C. Silpasuwanchai, N. M. Fares, Z. M. Amin, and A. E.-R. Ahmed Ahmed Salama, "Exploring self-regulation based virtual learning environments using diary," *Neuroscience and Biomedical Engineering*, vol. 3, no. 2, pp. 66–75, 2015.
- [35] M. Theobald, "Self-regulated learning training programs enhance university students' academic performance, self-regulated learning strategies, and motivation: a meta-analysis," *Contemporary Educational Psychology*, vol. 66, Article ID 101976, 2021.
- [36] C. Dignath, R. van Ewijk, F. Perels, and S. Fabriz, "Let learners monitor the learning content and their learning behavior! a meta-analysis on the effectiveness of tools to foster monitoring," *Educational Psychology Review*, vol. 35, Article ID 62, 2023.
- [37] D. Moher, A. Liberati, J. Tetzlaff, and D. G. Altman, "Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement," *PLOS Medicine*, vol. 6, no. 7, Article ID e1000097, 2009.
- [38] H.-F. Hsieh and S. E. Shannon, "Three approaches to qualitative content analysis," *Qualitative Health Research*, vol. 15, no. 9, pp. 1277–1288, 2005.
- [39] J. D. Kirkpatrick and W. K. Kirkpatrick, *Kirkpatrick's Four Levels of Training Evaluation*, Association for Talent Development, 2016.
- [40] D. A. Reed, D. A. Cook, T. J. Beckman, R. B. Levine, D. E. Kern, and S. M. Wright, "Association between funding and quality of published medical education research," *JAMA*, vol. 298, no. 9, pp. 1002–1009, 2007.
- [41] M. Gordon, M. Patricio, L. Horne et al., "Developments in medical education in response to the COVID-19 pandemic: a rapid BEME systematic review: BEME guide no. 63," *Medical Teacher*, vol. 42, no. 11, pp. 1202–1215, 2020.
- [42] Z. Aarsal, "The effects of diaries on self-regulation strategies of preservice science teachers," *International Journal of Environmental and Science Education*, vol. 5, no. 1, pp. 85–103, 2010.
- [43] S. Alhazbi, "Using E-journaling to improve self-regulated learning in introductory computer programming course," in *2014 IEEE Global Engineering Education Conference (EDU-CON)*, pp. 352–356, IEEE, Istanbul, Turkey, April 2014.
- [44] S. N. Loeffler, J. Stumpp, S. Grund, M. F. Limberger, and U. W. Ebner-Priemer, "Fostering self-regulation to overcome academic procrastination using interactive ambulatory assessment," *Learning and Individual Differences*, vol. 75, Article ID 101760, 2019.
- [45] S. N. Loeffler, A. Bohner, J. Stumpp, M. F. Limberger, and G. Gidion, "Investigating and fostering self-regulated learning in higher education using interactive ambulatory assessment," *Learning and Individual Differences*, vol. 71, pp. 43–57, 2019.
- [46] H. Bellhäuser, T. Löscher, C. Winter, and B. Schmitz, "Applying a web-based training to foster self-regulated learning—effects

- of an intervention for large numbers of participants,” *The Internet and Higher Education*, vol. 31, pp. 87–100, 2016.
- [47] J. Broadbent, E. Panadero, and M. Fuller-Tyszkiewicz, “Effects of mobile-app learning diaries vs online training on specific self-regulated learning components,” *Educational Technology Research and Development*, vol. 68, pp. 2351–2372, 2020.
- [48] J. Roelle, K. Berthold, and S. Fries, “Effects of feedback on learning strategies in learning journals: learner-expertise matters,” *International Journal of Cyber Behavior, Psychology and Learning*, vol. 1, no. 2, pp. 16–30, 2011.
- [49] D. Saddawi-Konefka, K. Baker, A. Guarino et al., “Changing resident physician studying behaviors: a randomized, comparative effectiveness trial of goal setting versus use of WOOP,” *Journal of Graduate Medical Education*, vol. 9, no. 4, pp. 451–457, 2017.
- [50] A. L. Dent and R. H. Hoyle, “A framework for evaluating and enhancing alignment in self-regulated learning research,” *Metacognition and Learning*, vol. 10, pp. 165–179, 2015.
- [51] E. Boruchovitch and D. R. Ganda, “Fostering self-regulated skills in an educational psychology course for Brazilian preservice teachers,” *Journal of Cognitive Education and Psychology*, vol. 12, no. 2, pp. 157–177, 2013.
- [52] H. Güvenç, “The effects of cooperative learning and learning journals on teacher candidates’ self-regulated learning,” *Educational Sciences: Theory and Practice*, vol. 10, no. 3, pp. 1477–1487, 2010.
- [53] K. Saks and Å. Leijen, “Digital learning diary as a tool for enhancing EFL learners’ metacognitive reflection,” in *2019 IEEE 19th International Conference on Advanced Learning Technologies (ICALT)*, pp. 263–264, IEEE, Maceio, Brazil, July 2019.
- [54] J. A. Pesonen, E. E. Ketonen, V. Kivimaki, and P. Ihanola, “Does using structured learning diaries affect self-regulation or study engagement? An experimental study in engineering education,” in *2020 IEEE Frontiers in Education Conference (FIE)*, pp. 1–9, IEEE, Uppsala, Sweden, October 2020.
- [55] C. D.-V. Ewijk, S. Fabriz, and G. Büttner, “Fostering self-regulated learning among students by means of an electronic learning diary: a training experiment,” *Journal of Cognitive Education and Psychology*, vol. 14, no. 1, pp. 77–97, 2015.
- [56] B. R. Quince, *The effects of self-regulated learning strategy instruction and structured-diary use on students’ self-regulated learning conduct and academic success in online community-college general education courses*, University of San Francisco, 2013.
- [57] Z. Zarei Hajiabadi, R. Gandomkar, A. A. Sohrabpour, and J. Sandars, “Developing low-achieving medical students’ self-regulated learning using a combined learning diary and explicit training intervention,” *Medical Teacher*, vol. 45, no. 5, pp. 475–484, 2023.
- [58] S. Fabriz, C. Dignath-van Ewijk, G. Poarch, and G. Büttner, “Fostering self-monitoring of university students by means of a standardized learning journal—a longitudinal study with process analyses,” *European Journal of Psychology of Education*, vol. 29, pp. 239–255, 2014.
- [59] L. Dörrenbächer and F. Perels, “More is more? Evaluation of interventions to foster self-regulated learning in college,” *International Journal of Educational Research*, vol. 78, pp. 50–65, 2016.
- [60] T. J. Cleary and B. J. Zimmerman, “A cyclical self-regulatory account of student engagement: theoretical foundations and applications,” in *Handbook of research on student engagement*, S. L. Christenson, A. L. Reschly, and C. Wylie, Eds., pp. 237–257, Springer Science + Business Media, 2012.
- [61] B. J. Zimmerman, “Development and adaptation of expertise: the role of self-regulatory processes and beliefs,” in *The Cambridge Handbook of Expertise and Expert Performance*, K. A. Ericsson, N. Charness, P. J. Feltovich, and R. R. Hoffman, Eds., pp. 705–722, Cambridge University Press, New York, NY, US, 2006.
- [62] M. Theobald and H. Bellhäuser, “How am i going and where to next? Elaborated online feedback improves university students’ self-regulated learning and performance,” *The Internet and Higher Education*, vol. 55, Article ID 100872, 2022.
- [63] R. S. Jansen, A. Van Leeuwen, J. Janssen, S. Jak, and L. Kester, “Self-regulated learning partially mediates the effect of self-regulated learning interventions on achievement in higher education: a meta-analysis,” *Educational Research Review*, vol. 28, Article ID 100292, 2019.
- [64] A. R. Artino Jr., P. A. Hemmer, and S. J. Durning, “Using self-regulated learning theory to understand the beliefs, emotions, and behaviors of struggling medical students,” *Academic Medicine*, vol. 86, no. 10, pp. S35–S38, 2011.
- [65] C. Chang, M. Colón-Berlinger, B. Mavis, H. S. Laird-Fick, C. Parker, and D. Solomon, “Medical student progress examination performance and its relationship with metacognition, critical thinking, and self-regulated learning strategies,” *Academic Medicine*, vol. 96, no. 2, pp. 278–284, 2021.
- [66] C. C. Foong, N. L. B. Ghouse, A. J. Lye et al., “A qualitative study on self-regulated learning among high performing medical students,” *BMC Medical Education*, vol. 21, Article ID 320, 2021.
- [67] M. Versteeg, G. Bressers, M. Wijnen-Meijer, B. W. C. Ommering, A. J. de Beaufort, and P. Steendijk, “What were you thinking? Medical students’ metacognition and perceptions of self-regulated learning,” *Teaching and Learning in Medicine*, vol. 33, no. 5, pp. 473–482, 2021.
- [68] A. R. Artino Jr., R. Brydges, and L. D. Gruppen, “Self-regulated learning in healthcare profession education: theoretical perspectives and research methods,” in *Researching Medical Education*, J. Cleland and S. J. Durning, Eds., pp. 155–166, John Wiley & Sons, Ltd., 2015.
- [69] Y. Steinert, K. Mann, A. Centeno et al., “A systematic review of faculty development initiatives designed to improve teaching effectiveness in medical education: BEME guide no. 8,” *Medical Teacher*, vol. 28, no. 6, pp. 497–526, 2006.
- [70] Y. Steinert, K. Mann, B. Anderson et al., “A systematic review of faculty development initiatives designed to enhance teaching effectiveness: a 10-year update: BEME guide no. 40,” *Medical Teacher*, vol. 38, no. 8, pp. 769–786, 2016.
- [71] S. Ohly, S. Sonnentag, C. Niessen, and D. Zapf, “Diary studies in organizational research: an introduction and some practical recommendations,” *Journal of Personnel Psychology*, vol. 9, no. 2, pp. 79–93, 2010.
- [72] T. J. Wilkinson, J. E. Wells, and J. A. Bushnell, “Using a diary to quantify learning activities,” *Medical Education*, vol. 39, no. 7, pp. 657–664, 2005.
- [73] R. Bloch and G. Norman, “Generalizability theory for the perplexed: a practical introduction and guide: AMEE guide no. 68,” *Medical Teacher*, vol. 34, no. 11, pp. 960–992, 2012.