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Educational Interventions to Promote Self-Regulated Learning in Vocational Schools - A Systematic Review

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Abstract

Purpose: In the evolving landscape of the 21st century, characterized by dynamic global challenges such as health crises, climate change, and rapid technological advancements, the imperative of lifelong learning has become more pronounced than ever. Self-Regulated Learning (SRL) plays a pivotal role in lifelong learning, involving independent, self-directed behaviors to enhance knowledge and skills. While the significance of SRL is widely acknowledged in the broader context of lifelong learning, its specific role in vocational schools is a critical aspect that requires careful investigation. In these specialized educational settings, effective SRL practices are not only integral to individual academic success but are also crucial for fostering the competencies essential for a thriving professional career.

However, there is a need for a systematic analysis of how SRL is fostered within vocational schools. Despite its importance, the current best practices for promoting successful SRL in vocational schools remain underexplored. Therefore, this study aimed to systematically review intervention studies focused on changing educational practices related to SRL in vocational schools. Specifically, we addressed two key research questions: (1) What are the characteristics of intervention studies aimed at fostering SRL in vocational schools? and (2) What is the quality of these interventions in terms of their impact on promoting SRL?

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Methods: To address these questions, we conducted a systematic review of intervention studies focused on fostering SRL in the context of vocational education. Our review includes 11 studies, with 10 reporting positive effects of interventions promoting SRL.

Findings: The findings highlight that collaborative and problem-solving approaches, along with learning environments emphasizing student autonomy, are effective methods for enhancing SRL. Additionally, the review underscores the importance of distinguishing between direct and indirect interventions to promote SRL in the classroom. The effectiveness of each approach is contingent on the specific context and student population.

Conclusion: However, comparing and drawing conclusions from these studies presented challenges due to the limited similarity in outcome measures and variations in the quality of evidence. Future research should consider methodological adjustments to address the heterogeneity of intervention studies on SRL at the vocational school level, including the development of standardized assessment tools and more rigorous experimental designs to better evaluate the impact of SRL interventions. These adjustments are crucial for ensuring that vocational schools can effectively integrate SRL practices that not only align with academic goals but also prepare students for the demands of their professional careers.

Keywords: Self-Regulated Learning, Vocational Schools, Intervention Studies, VET, Vocational Education and Training, Systematic Review

1 Introduction

Vocational Education and Training (VET) has increasingly been recognized as a critical tool for addressing socio-economic challenges and integrating young individuals into the labor force as skilled professionals (Forster et al., 2016; Oswald-Egg & Renold, 2021; Powell & Solga, 2010). Unlike general education, which broadly cultivates learners' knowledge and skills in preparation for tertiary education (UNESCO, 2012), VET is more complex and varies widely across different forms, such as school-based programs, apprenticeships, and continuing education (Evans, 2020). Among the various approaches, the dual system is recognized as particularly effective, as it integrates general education with hands-on vocational training. This combination not only enhances lifelong learning but also promotes social integration and participation among young people (Aarkrog, 2005; Hoeckel & Schwartz, 2010; Hoffman & Schwartz, 2015; OECD, 2022).

Since 2015, several European Union countries have transitioned their VET systems to the dual model, inspired by the successful examples set by Germany, Austria, and Switzerland (Cedefop, 2021; Deissinger & Gonon, 2021). The dual VET system has been credited with driving economic success, lowering youth unemployment rates, and facilitating smooth

transitions into the labor market through its structured, industry-aligned curriculum (Frey et al., 2012; Gonon, 2013; Hoeckel et al., 2009; Hoeckel & Schwartz, 2010; Hoffman & Schwartz, 2015; OECD, 2010; Strahm, 2014). Although attempts to establish similar systems globally have seen varying degrees of success (Christopoulou & Ryan, 2009; Pilz & Wiemann, 2021), the concept of a "dual apprenticeship"—linking formal education with workplace training—has gained recognition as a key component of effective vocational education (Valiente & Scandurra, 2017). This definition allows for a broader analysis beyond the traditional German-speaking countries, acknowledging significant international developments and policy innovations in many developed countries (Ryan, 2001).

This short overview of the significance of the dual vocational education system demonstrates the importance of general education for a sustainable VET system. This is particularly relevant in light of the rapid pace of technological change and the emergence of megatrends such as automation, digitalization, and green energy, which are having a significant impact on the future of VET systems (Achtenhagen & Oldenbürger, 1996; Boldrini & Wüthrich, 2022; Seifried, 2002; Seufert, 2018). To address these challenges, governments and educational institutions are seeking to develop more flexible, industry-aligned curricula, and foster stronger partnerships between education and industry (Stalder & Clerc, 2019; Wettstein et al., 2014; Winther & Achtenhagen, 2009).

In light of these challenges, VET systems must focus on not only developing specific job-related knowledge but also fostering interdisciplinary competencies like problem-solving, critical thinking, communication, and collaboration—skills that are increasingly crucial in today's rapidly changing world (Frey et al., 2014). Self-Regulated Learning (SRL) is essential for acquiring these competencies and is indispensable for success in both current vocational training and lifelong learning (Forster et al., 2016; Hanushek et al., 2017; Jossberger et al., 2010; Kirschner & Stoyanov, 2020; Rozendaal et al., 2003, 2005). Studies show that workers with strong SRL foundations and a commitment to continuous education are more adaptable to market changes and less prone to long-term unemployment (Dubs, 2018). Thus, the dual VET system not only equips students with necessary professional qualifications but also plays a critical role in fostering SRL (Valiente & Scandurra, 2017). Understanding how vocational students navigate job market challenges requires studying their transition into professional life, with vocational schools playing a key role in this preparation.

With the importance of SRL in VET established, it is crucial to explore how this concept can be effectively implemented in vocational schools. This involves understanding the conditions that facilitate optimal SRL. As preparing young people for the labor market becomes an increasingly urgent goal for VET systems, the challenge lies in determining how SRL can be developed and promoted within vocational education.

2 Self-Regulated Learning in Vocational Schools

SRL serves as a foundation for the development of sustainable knowledge construction and is therefore highly relevant in schools and classrooms as well as for lifelong learning (Anthonysamy et al., 2020; Bolhuis, 2003; Lüftenegger et al., 2012; UNESCO, 2022). SRL is viewed as a hierarchical, dynamic, and adaptive process in which learners analyze a task, set goals, and devise plans to complete the task. The use of various learning strategies and the influence of motivational and emotional factors are crucial for initiating and maintaining progress towards these goals. The learning process and goal attainment are regularly evaluated through metacognitive strategies, and the choice and effectiveness of self-regulatory strategies are contingent on the task and context of the learning environment (Greene et al., 2021).

A crucial task in vocational education is to equip learners not only with specific job-related knowledge but also with interdisciplinary competencies such as critical thinking, collaboration, creative problem-solving, personal responsibility, adaptability, communication skills, and a commitment to lifelong learning (Asplund et al., 2021; Höpfer, 2017; OECD, 2016; Sembill, 2000). This highlights the importance of SRL in VET (Forster et al., 2016; Hanushek et al., 2017; Kirschner & Stoyanov, 2020). Therefore, vocational school instruction should be seen as a crucial component of VET, warranting continual improvement due to its lasting impact on learners' learning and behavior patterns (Höpfer, 2017).

Several empirical studies have specifically focused on SRL within vocational schools. For instance, Sembill et al. (2007) examined the implementation of SRL in various settings at commercial vocational schools, finding that teaching SRL strategies led to increased learning motivation and problem-solving abilities among learners while maintaining technical knowledge. Other studies suggest that strategies like self-control, time management, and the regulation of motivation and concentration are viewed ambivalently by vocational learners during their training (Metzger, 2001; Metzger & Nüesch, 2011). However, it can be assumed that the use of learning strategies positively affects problem-solving abilities and expands learners' strategic repertoires (Metzger, 2014; Sembill, 1999; Wuttke, 1999).

Hiltmann (2015) demonstrated that the ability to learn in a self-regulated manner positively influences learning time, with vocational learners using "if-then plans" performing more learning actions and investing more time in their studies. Effective use of learning strategies encourages vocational learners to take active initiative in their own learning, which is closely related to learning performance, motivation, and emotional dispositions (Tenberg, 2008). Furthermore, a strong sense of ownership of the learning process enables deeper information processing (Boekaerts & Minnaert, 2003; Rozendaal et al., 2005; Witteman, 1997).

Motivation, as a key component of SRL, plays a critical role in both learning success in vocational education (Beck, 2000; Hardt et al., 1996; Nenniger & Wosnitza, 2000; Rosendahl & Straka, 2011) and job retention (Bergmann, 1992; Coomber & Barriball, 2007; Duraisingam et al., 2009; Rosser, 2004; Sembill, 1992). Rozendaal (2002) showed that the quality of

the learning environment influences the affective variables of SRL, with direct interventions increasing the motivation of vocational learners, leading to deeper information processing and reduced anxiety.

However, feedback and assessment of learning processes, fundamental to SRL (Butler & Winne, 1995), are not fully implemented in basic vocational education (Rozendaal, 2002). For example, self-reflection elements are not frequently used, resulting in limited use of metacognitive regulation strategies (van Velzen, 2004; van Velzen & Tillema, 2004). The different objectives of vocational learners and teachers further illustrate this gap (Rozendaal et al., 2005). Nevertheless, when teachers encourage self-reflection, it can significantly influence learners' reflective thinking, with the learners' perception of the teacher being particularly relevant (van Velzen & Tillema, 2004).

After reviewing the literature to date, several important aspects emerge that require further investigation. First, all of the cited studies above have been conducted exclusively in the Netherlands, Germany, or Switzerland. Consequently, it is crucial to explore the representation of SRL beyond these borders.

Secondly, there is currently limited knowledge about the learning regulation of vocational students (Jossberger et al., 2015, 2018; Khaled et al., 2015). This is particularly concerning, as the self-regulation of cognitive, motivational, and emotional processes during practical and academic task performance in vocational education is critical to helping learners achieve effective learning outcomes (Boekaerts & Cascallar, 2006; de Bruijn & Leeman, 2011; Jossberger et al., 2010; van Grinsven & Tillema, 2006). External factors, such as the influence of teachers or the design of the learning environment, can significantly impact learners' SRL (Dignath & Veenman, 2021). This underscores the importance of a well-designed learning environment in fostering SRL among vocational learners.

Thirdly, to accurately demonstrate the effects on the development of SRL in vocational schools, it is essential to identify studies where relevant interventions have been implemented (Gottfredson et al., 2015). Reviews on how SRL can be promoted through educational interventions already exist for different levels of education (e.g., Clark, 2012; Dent & Koenka, 2016; Dignath et al., 2008; Dignath & Büttner, 2008; Dignath & Veenman, 2021; Loyens et al., 2008; Richardson et al., 2012; Sitzmann & Ely, 2011). However, reviews focusing specifically on how SRL can be promoted through educational interventions in vocational schools have been lacking.

3 Aims and Research Questions

Based on the aforementioned points, the goal of this study is to use previous intervention studies to identify and characterize effective methods for promoting SRL in vocational schools. This study is important because SRL is crucial for lifelong learning. By examining existing

evidence on the self-regulation of learning processes among vocational students, this study seeks to fill a critical gap in the literature. Intervention research plays a vital role in identifying the most effective teaching methods for promoting SRL in vocational schools. However, to the best of our knowledge, no systematic review has yet been conducted on intervention studies aimed at enhancing SRL in this specific context.

To summarize, the current best practices for promoting successful SRL in vocational schools are not well understood. Therefore, the first step is to identify intervention studies that focus on changing educational practices related to SRL in vocational schools. The second step involves analyzing the characteristics of these studies. To achieve this, an exploratory systematic review of intervention research on SRL in the context of vocational education was conducted. The research questions for this review are as follows:

1. What are the characteristics of intervention studies aimed at fostering self-regulated learning in vocational schools (RQ1)?

2. What is the quality of intervention studies on the promotion of self-regulated learning in vocational schools (RQ2)?

The second question is further divided into two sub-questions:

a) What is the quality of the research designs?

b) What is the quality of evidence provided by the studies found regarding the promotion of self-regulated learning in vocational schools?

These research questions enable an analysis of which interventions effectively foster SRL, as well as the identification of limitations in these approaches. After reviewing the literature on SRL, vocational education and training, vocational schools, and interventions, the research questions were formulated according to the guidelines of the PICo system for qualitative studies (Miller & Forrest, 2001; Murdoch University, 2024). By evaluating the effectiveness of the interventions, it will be possible to draw conclusions about which interventions are most optimal for promoting SRL among vocational students. A broad scope ensures that all studies relevant to the research questions are included, with none excluded a priori (Muka et al., 2020).

4 Methodology

The review was conducted following the method outlined by Boland et al. (2017). This method involves two different but related modes of searching: A scoping search and a main search for evidence. First, a preliminary literature search, known as a scoping search, was

conducted. The purpose of the scoping search was to provide an overview of the published literature and available information on the topic. Based on the findings of the scoping search, a clear search strategy was then developed. This strategy included setting inclusion and exclusion criteria, as well as establishing a screening and selection process to identify potential intervention studies for this review, which is referred to as the main search.

4.1 Search Strategy and Screening Process

The search strategy began with the creation of a comprehensive keyword list, encompassing synonyms for the terms "self-regulated learning", "vocational education", and "intervention". Using this list, a database-agnostic search string was developed which served as the foundation for database-specific queries. This search string was refined through collaborative revisions by the two authors. Subsequently, tailored search queries were constructed for each database to account for differences in syntax and indexing.[1]

The search was executed across several databases, including ERIC (OvidSP), APA PsycInfo (OvidSP), PSYNDEXplus Literature and Audiovisual Media (OvidSP), Web of Science (All Databases), Scopus, SocINDEX (EBSCOhost), International Bibliography of the Social Sciences (ProQuest), and Sociological Abstracts (ProQuest). These databases were selected due to their extensive coverage of literature in the fields of education, psychology, and social sciences, and their relevance to our research focus.

The literature search was conducted in July 2024, with all records available up to the search date included. We applied no restrictions regarding the publication date, but only articles published in English were considered. The search yielded a total of 224 research articles published between 1988 and 2022[2]. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart in Figure 1 outlines the screening and selection process. No additional records were identified through other sources, such as grey literature.

1 The search string syntax is available upon request from the authors.

2 Two scoping queries were carried out initially. The first query yielded 1,645 unique hits, but this number was significantly reduced to 222 when we added the search term 'intervention' to our syntax.

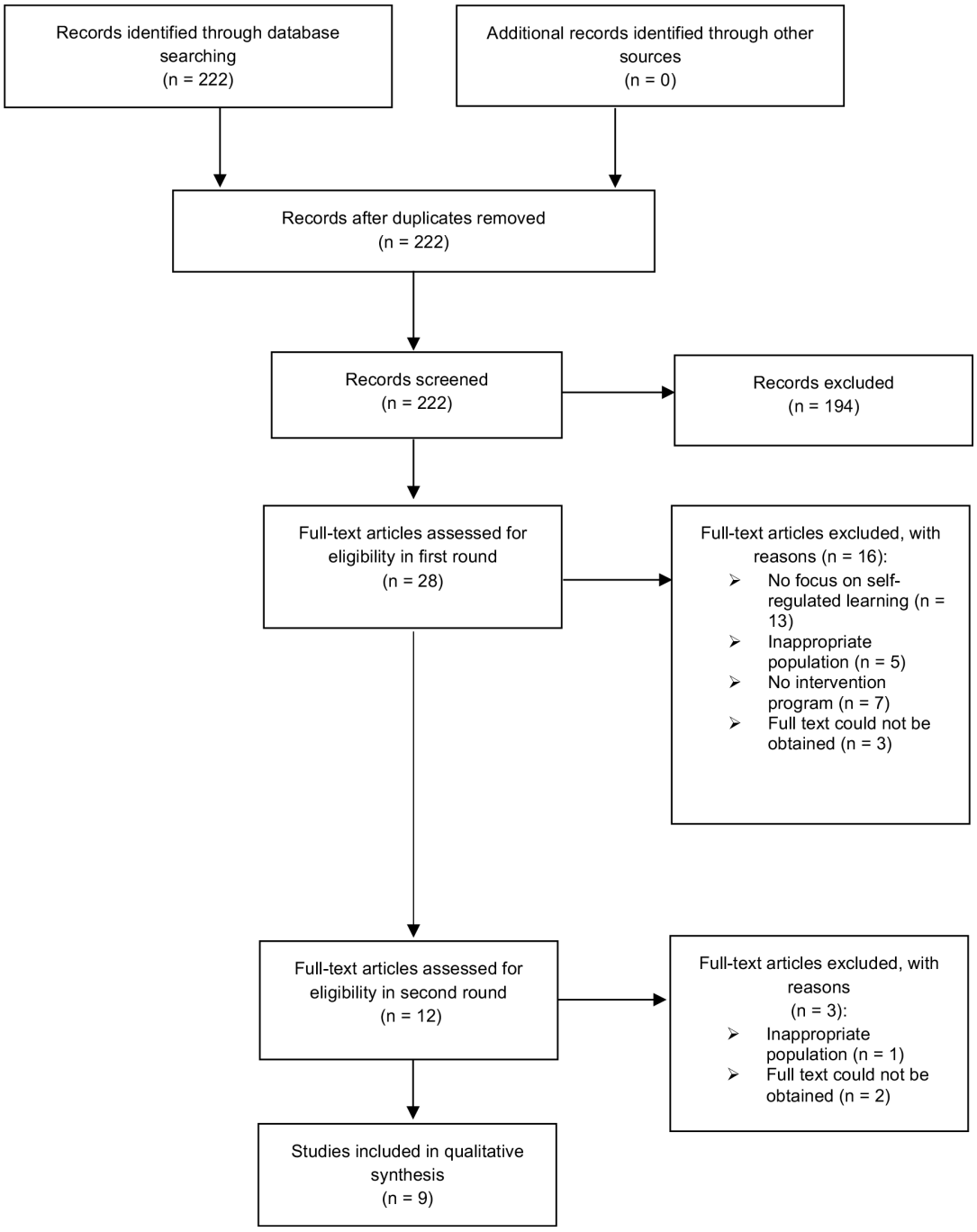

Figure 1: PRISMA Flow Diagram of Included Studies (adapted from Moher et al., 2009)[3]

3 Full-text articles could have multiple reasons for exclusion; therefore, the sum of each reason together is > 16 after the first round for eligibility.

In the first step, the titles and abstracts of the 224 unique hits were screened using a screening and selection tool[4]. During this initial screening round, 30 papers met the inclusion criteria. Studies were included if they encompassed SRL as a comprehensive process or focused on at least one facet of SRL, such as metacognition. 16 papers were excluded, primarily because they did not focus on interventions promoting SRL or involved an inappropriate population (e.g., adult employees rather than vocational school students).

In the second step, full-text papers were reviewed, and 14 studies met the inclusion criteria. However, three additional studies were excluded after this round: Two papers could not be obtained, and one focused on adult staff members instead of vocational school students. Ultimately, 11 publications were included in the systematic review.

4.2 Data Analysis and Grading Evidence

After the scanning and screening process, a multi-step approach was followed for quality assessment, data extraction, synthesis of results, and grading of evidence. To ensure the reliability and usefulness of the conclusions drawn from the data, the quality of the studies was assessed first, followed by data extraction. The design of the included studies was noted at the outset, which allowed for the selection of the appropriate quality assessment tools (Boland et al., 2017). Since there were two different types of study designs, two distinct appraisal tools were applied. For quasi-experiments, which are non-randomized experimental studies, the "Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Quasi-Experimental Studies" was used (Table 1). The "JBI Critical Appraisal Checklist for Randomized Controlled Trials" was utilized for the randomized studies (Table 2) (Tufanaru et al., 2020). These tools were employed to assess the methodological quality and potential biases of the studies.

A multi-step process (Boland et al., 2017) was applied for data extraction to determine which data would be most helpful for answering the research questions. In the first step, each paper was analyzed to distinguish between analytical data and descriptive data. Since these two types of data cannot be directly compared, they were then extracted into separate tables in the second step. The descriptive data was divided into two tables: The study characteristics table (Table 3) and the participant characteristics table (Table 4). The third step involved the actual extraction of the relevant data into the tables. Given that the format of the analytical data varied across the 11 studies, different study result tables, rather than a single table, were created (Tables 5-8). To provide a clear overview despite the varying types of numerical data, the data were extracted manually, and data of the same type were consolidated into the same table.

To evaluate and summarize the quality of the evidence and to draw transparent conclusions for the discussion, the Grading of Recommendations Assessment, Development and

4 The screening and selection tool is available upon request from the authors.

Evaluation (GRADE) approach was used for the randomized studies. The GRADE approach is a standardized method for assessing the quality of evidence from different types of studies, allowing for a transparent and consistent evaluation of the results (Schünemann et al., 2019). However, because the GRADE approach is not well-suited for non-randomized studies, the Risk Of Bias In Non-Randomized Studies - of Interventions (ROBINS-I) tool was used instead. ROBINS-I is part of the GRADE approach and is used to assess the risk of bias in non-randomized intervention studies (Sterne et al., 2019).

Each outcome of the study was evaluated in the following domains: "Risk of bias", "inconsistency", "indirectness", "imprecision", and "publication bias". Starting with an initial level, outcomes in these five areas were assessed, leading to a final quality level of evidence (Table 9).

5 Results

The findings of the study are organized and presented to address the research questions posed. In the first section, the main characteristics of the studies (RQ1) are presented and analyzed. In the second section, the studies are assessed for quality (RQ2), distinguishing between the quality of the research design and the quality of the corresponding evidence.

5.1 Analysis of Study Characteristics and Participant Characteristics

In the subsequent sections, we will utilize the identification numbers (ID) assigned to the studies from tables 1 and 2 to facilitate comprehension. The intervention studies were conducted in different countries between 1988 (ID 4) and 2022 (ID 10). Five studies were conducted in Taiwan, with one each in the Netherlands, Switzerland, Austria, the US, and Turkey. One study did not specify the location of the study (ID 1). All studies examined different intervention programs to analyze how SRL helps vocational students become better, independent learners. The approaches, designs, and outcomes of the studies varied. In addition to the intervention group, five studies had a control group (ID 1, ID 4, ID 6, ID 10, ID 11). The other studies (ID 2, ID 3, ID 5, ID 7, ID 8, ID 9) compared different intervention groups to one another. Regardless of the study design, many of the studies found positive effects of the intervention on the SRL of vocational students. The learners' motivation had a strong influence on their use of SRL strategies, and students could experience more autonomy and self-efficacy if the teaching was less teacher centered. Students had positive perceptions towards web-mediated SRL and collaborative learning, or they improved their skills, grades, and test results in SRL online courses or problem-based learning settings.

Table 1: Results of Quality Assessment for the Non-Randomized Studies

Study	Clear indication of the order of the variables ("cause" and "effect")	Similarity of the groups in regard to the characteristics which may explain the effect of the intervention (selection bias)	Presence of other treatment than the intervention of interest	Existence of control group	(Multiple) measurements of the outcome both pre- and post-intervention	Completed follow up or if not, adequate description and analysis of the differences	Same measurement (instrument, scale) of outcomes for the groups (validity)	Measurement of the outcomes in a reliable way	Use of appropriate statistical analysis
Cattaneo & Boldrini (2017)	yes	yes	no	part[a]	part[b]	NS	yes	part	NS
van Grinsven & Tillema (2006)	yes	part[c]	no	no[d]	NA	NA	yes	yes	yes
Gunduz et al. (2016	yes	yes	no	no[e]	NA	NA	yes	part	no
Mejeh & Held (2022)	yes	yes	no	yes	yes	no	yes	yes	yes
Helm (2014)	yes	yes	no	yes	yes	no	yes	yes	yes
Rush & Milburn (1988)	yes	yes	no	yes	yes	yes	yes	yes	yes
Tsai (2011)	yes	yes	no	no[f]	NA	NA	yes	yes	NS
Tsai et al. (2013)	yes	part[g]	no	yes	NA	NA	yes	part	yes
Yang (2016)	yes	part[h]	no	no[i]	yes	NS	yes	yes	yes

Note. yes (item adequately addressed); no (item not adequately addressed); part (item partially addressed); NS (not stated); NA (not applicable).
[a]not all cases had a control group.
[b]four different cases were analyzed in the study and only the first case had a pre- and post-intervention measurement.
[c]five different types of learning environments, such as traditional education or open learning center.
[d]five different intervention groups.
[e]intervention group only.
[f]intervention groups only.
[g]two intervention groups came from the same class while the control group was from a different class; students were randomly allocated to one of the two intervention groups.
[h]different vocational programs.
[i]different workshop programs.

Table 2 provides an overview of the participants' characteristics. To make it clear that there were different levels of education in the eleven studies, i.e., that the professional learners did not have the same level of education across the included papers, the column "current education level" was added. Not all authors consistently provided details on the age of the participants. Four studies did not provide any information about age at all, while the five others reported the mean age or range but not consistently. The five studies that supplied data on the students' mean age had an average age of 17.7 years. In the final data extraction tables, the study results will be presented (tables 5 – 9).

Table 2: Results of Quality Assessment for Randomized Studies

Study	True randomization	Concealment of allocation	Similarity of groups at the baseline	Blind assignment to intervention	Blind delivering to intervention assignment	Blinding of outcomes assessors	Identical treatment of groups	Completed follow up or if not, adequately description and analysis of the differences	Analysis of the groups to which they were randomized	Same measurement (instrument, scale) of outcomes for the groups (validity)	Measurement of the outcomes in a reliable way	Use of appropriate statistical analysis	Appropriate design for the topic
Tsai et al. (2011)	yes	NS	yes	NS	NA	NA	yes	NA	yes	yes	yes	yes	yes
Lee et al. (2010)	yes	NS	yes	NS	NA	NA	yes	NA	yes	yes	yes	no	yes

Note. yes (item adequately addressed); no (item not adequately addressed); NS (not stated); NA (not applicable).

5.2 Results of Quality Assessment

All non-randomized studies (table 3) clearly indicated the order of the independent and dependent variables, and the same applied to the measurement of outcomes for the groups studied. In addition, none of the studies examined other treatments or interventions, other than the one being studied. Six studies had similar groups in terms of their characteristics for the comparison, four did not have control groups and compared groups across different learning conditions, and one study did not report clearly if there was a control group or not. Four studies did not have a pre- and post-intervention measurement design, two studies did not describe the characteristics of the follow-up measures even though they fully or partially had a pre- and post-intervention measurement design, it remained unclear if there was a loss in participants. Six of the quasi-experimental studies reported reliable measurement of the outcomes while three were only partially reliable. Six studies had appropriate statistical analysis, two did not state how they analyzed their data, and one study did not adequately describe their statistical analysis.

In three non-randomized studies, the participant characteristics in the compared groups were uncertain, leading to a high risk of selection bias (Tufanaru et al., 2020). For example, study ID 2, wanted to investigate if there is a functional relationship between different learning environments, students' motivation and SRL strategies. Their design consisted of post-intervention measurement only, and they analyzed the outcomes of five different intervention groups. Not including students' baseline measurements leads to a possibility of uncontrolled confounding and increases the uncertainty of the final results.

Table 3: Study Characteristics

Study	Study ID	Country	Study focus	Study design	Study sample	Intervention and comparator	Means of data collection	Study findings
Cattaneo & Boldrini (2017)	1	not stated	Effectiveness and feasibility of video-enhanced instructional strategies for learning from errors	Case 1: Quasi-experiment (pre- and post-intervention measurement) Case 2 and 4: Pilot studies Case 3: Quasi-experiment	case 1: $N = 38$ case 2: $N = 6$ case 3: $N = 136$ case 4: $N = 3$	Case 1: One intervention group received a video of a concrete work situation as demonstration material to help analyze errors; one control group with no video support Case 2: One intervention group received a video of a concrete work situation as demonstration material, which included deliberate errors; the intervention group wrote annotations while analyzing the errors in the video; no control group Case 3: One intervention group analyzed errors; one control group analyzed correct behavior, viewing a video with a simulated interview of an apprentice office clerk with a mock customer Case 4: One nursing student analyzed her practice during debriefing with her tutors and the previously made video annotation	Case 1: Test scores Case 2: Written and oral qualitative data from spontaneous conversations between teachers and students Case 3: Listing correct elements of procedure and potential errors Case 4: Content analysis	Case 1: The intervention group performed significantly better than the control group. Case 2: The pilot study showed that the analysis of a work-based, video-recorded practice with errors is a beneficial instructional strategy. Case 3: Error analysis was more effective; the intervention group developed anticipatory knowledge on how to avoid possible errors. Case 4: The nursing student and her tutors both stated that the video helped identify errors that would not have been recognized in real practice. The tutors changed their feedback style from nonspecific, corrective feedback to supportive feedback. The nursing student became more receptive to feedback and more accepting of the errors she made.

Study	Study ID	Country	Study focus	Study design	Study sample	Intervention and comparator	Means of data collection	Study findings
van Grinsven & Tillema (2006)	2	The Nether-lands	Analysis of student perceptions of their learning environment in relation to their motivation and learning strategies	Quasi experiment with five different intervention groups: Traditional format group, open learning center group, independent group work group, project-oriented learning group, project-based learning group	Traditional education group: *n* = 72 Open learning center group: *n* = 69 Independent group work group: *n* = 344 Project-oriented learning group: *n* = 72 Project-based learning group: *n* = 66	Five differently arranged learning programs, no control group(s)	Questionnaires and a categorization scheme to analyze learning environments	Student motivation had the greatest influence on the use of self-regulated learning strategies. Teachers' behavior in the independent group work group, project-oriented learning group, and project-based learning group was seen as more conducive to learning compared to the other groups. The students in those groups experienced more autonomy, self-efficacy, and motivation than in the other groups, as the teachers were less focused on control and more on supporting student autonomy.
Gunduz et al. (2016)	3	Turkey	Evaluation of effectiveness of a problem-based online learning environment	Quasi-experiment with one intervention group, no control group (post-intervention measurement only)	Performance task: *n* = 187 Self-evaluation form: question 1: *n* = 70 question 2: *n* = 59 question 3: *n* = 230	The intervention group participated in an online problem-based learning environment	Performance task and self-evaluation form from students	A positive influence on how to write a petition was a positive effect of the designed online problem-based environment; less interaction with each other and less participation from the students were negative effects.

Study	Study ID	Country	Study focus	Study design	Study sample	Intervention and comparator	Means of data collection	Study findings
Rush & Milburn (1988)	4	USA	Evaluation of effectiveness of a reciprocal teachinga procedure of the metacognitive comprehension method	Quasi-experiment with two intervention groups and two control groups (pre- and post-intervention measurement and follow-up measure after five weeks)	$n = 150$	Intervention group one learned the metacognitive comprehension method through reciprocal teaching; intervention group two learned the metacognitive comprehension method through conventional teacher-centered whole-class instruction; control group one engaged in course-related reading activities; control group two engaged in non-reading course activities	Reading comprehension task (The Cooperative English Test)	Measurement immediately after the intervention showed the effectiveness of the intervention but did not favor either instructional format. Students in the reciprocal teaching group were more enthusiastic and involved, but the metacognitive comprehension method was not more effective compared to conventional teacher-centered whole-class instruction. Intervention group two significantly outperformed both control groups on the Cooperative English Test.
Tsai (2011)	5	Taiwan	Effectiveness of a web-mediated self-regulated learning and collaborative learning course on students' thoughts in regard to this course	Quasi experiment with one intervention group (post-intervention measurement only)	$n = 64$	The intervention group got exposed to a web-mediated self-regulated learning and collaborative learning course	Questionnaire	There was a positive effect on students' thoughts, which were improved in regard to the web-meditated self-regulated learning and collaborative learning course.
Tsai et al. (2013)	6	Taiwan	Investigation of effects of web-enabled problem-based learning and self-regulated learning on low achieving vocational students' computing skills	Quasi experiment with two intervention groups and one control group (pre- and post-intervention measurement)	intervention group one: $n = 23$ intervention group two: $n = 22$ control group: $n = 31$	Intervention group one received problem-based and self-regulated learning online course; intervention group two received problem-based online course; the control group received face to face teaching in classroom	Certificate examinations, which measured students' computing skills in grades; grade-point average (GPA) to measure the students' learning progress	Intervention group one had significantly better computing skills than intervention group two and control group.

Yang (2016)	7	Taiwan	Analysis if self-regulated learning in on-site workshops and with an online learning community makes low foreign language achiever to become more autonomous learners	Quasi-experiment with one intervention group, no control group (pre- and post-intervention measurement)	$n = 104$	The intervention group signed up for a series of 18 ESP (English for specific purposes) workshops	Test of English for International Communication (TOEIC); questionnaire about students' beliefs in learner autonomy, self-regulated learning and ESP	The intervention group had significant better post-intervention results than pre-intervention and developed learner autonomy.
Tsai et al. (2011)	8	Taiwan	Effect of a course with web-enabled self-regulated learning on vocational students' skills of applying functions of database management system	Quasi-experiments with randomization; three intervention groups, no control group (pre- and post-intervention)	intervention group one: $n = 39$ intervention group two: $n = 36$ intervention group three: $n = 37$	Intervention group one received ten arranged blended learning sessions with self-regulated learning aspects; group two received five arranged blended learning sessions with self-regulated learning aspects; intervention group three received five arranged blended learning sessions without self-regulated learning aspects	Computer skills test (graded) before the intervention; questionnaire about student's thoughts towards blended course and interventions concerning self-regulated learning	Intervention group two had the highest grades in the database management system exams and most positive thoughts towards the intervention.
Lee et al. (2010)	9	Taiwan	Effect of four different learning settings on students' involvement in learning	2 x 2 factorial pre- and post-intervention measurement	intervention group one: $n = 28$ intervention group two: $n = 25$ intervention group three: $n = 24$ control group: $n = 25$	Intervention group one received self-regulated learning and problem-based learning approach; intervention group two received problem-based and no self-regulated learning approach; intervention group three received self-regulated and no problem-based approach; the control group received no self-regulated learning and no problem-based learning approach	Personal Involvement Inventory (PII)	Significant increase in scores of involvement for the problem-based groups post-intervention measurement; significant increase in scores of involvement of the self-regulated learning post-intervention measurement.

Mejeh & Held (2022)	10	Switzerland	Investigate the development of SRL components over time and analyze the impact of an SRL-promoting learning environment compared to regular instruction	Quasi experiment with tree intervention groups and four control groups (pre- and post-intervention measurement)	intervention group *n* = 68 control group *n* = 91	Intervention group: - received a learning job (document that included all tasks to be completed) every 4 weeks - 4 to 5 20 min. input sessions with technical content of subjects - students created their learning process largely on their own - each student was supported by a personal coach and had a coaching meeting every 4 weeks control group: - attended regular classes with lessons in all subjects for 45 min.	Long questionnaires (14 scales addressing the different components of SRL) at the beginning and end of the school year, and weekly short questionnaires (consisted of one item of the scales)	Differences in dispositional changes in (meta)cognitive strategies like planning and elaboration within and between intervention and control group; the students' disposition regarding planning increased significantly in the intervention group. Momentary metacognitive activity (e.g., repetition planning or monitoring) increases over time in the intervention group.
Helm (2014)	11	Austria	Examine the competence development of students in grade 9	Quasi experiment with 13 intervention groups and 14 control group (pre- and post-intervention measurement)	Intervention group *n* = 285 Control group *n* = 317	Intervention group received the treatment while the traditional classes attended normal school lessons	Students' competence in Accountancy were measured with the standardized instrument "Knowledge Testing of Basic Knowledge of Bookkeeping"	Differentiation, scaffolding, the use of "constructivist" tasks and metacognition were negatively related to Accountancy scores.

Note. a "Reciprocal teaching is an instructional procedure designed to teach students cognitive strategies that might lead to improved reading comprehension" (Rosenshine & Meister, 1994, p. 479).

The two randomized studies did not report information about the concealment of allocation, and it was unclear if the students were blind to the intervention. Since there was no follow-up in either of the studies, this point was not applicable for the quality assessment. Apart from that, both studies fulfilled all quality criteria for randomized studies (Tufanaru et al., 2020). The methodological quality in terms of statistical analysis in the study with ID 9 could have been improved. They only performed independent t-tests, while their study design would have been improved if they added paired sample t-tests.

Further, studies with ID 3 and ID 6 were missing statistical analysis and the description of the case studies in study with ID 1were almost completely absent.

Table 4: Participant Characteristics

Study	Study ID	Sample size	Age (years)		Female sex N	Current education level
			M (SD)	range		
Cattaneo & Boldrini (2017)	1	case 1: *N* = 38 case 2: *N* = 6 case 3: *N* = 136 case 4: *N* = 3	NS (NS)	NS	NS	Case 1: First-year vocational students in a three-year long clothing design apprenticeship Case 2: Second-year vocational students, not stated how long the butcher apprenticeship takes Case 3: Second-year vocational students in three-year long office clerk apprenticeship Case 4: Nurse student, not stated in which year of her apprenticeship she is in and how long the apprenticeship takes
van Grinsven & Tillema (2006)	2	*N* = 623	NS (NS)	16 – 18	NS	Second-year vocational education students, in their three- to four-year long vocational education
Gunduz et al. (2016)	3	*N* = 623	NS (NS)	16 – 18	NS	Second-year vocational education students, in their three- to four-year long vocational education
Rush & Milburn (1988)	4	*N* = 150	NS (NS)	NS	0	Students who were enrolled in a post-secondary technical diesel automotive training program; it is not stated how long their vocational education takes
Tsai (2011)	5	*N* = 64	20 (NS)	NS	NS	Second-year university students from the department of Security Management; it is not stated how long their vocational education takes
Tsai et al. (2013)	6	*N* = 76	18.17 (NS)	NS	48	First-year students from the department of business administration of a private vocational school; it is not stated how long their vocational education takes
Yang (2016)	7	*N* = 104	NS (NS)	20 – 26	52	Students from technical or vocational universities; it is not stated how long their vocational education takes second-year vocational students, enrolled in a course titled
Tsai et al. (2011)	8	*N* = 112	19 (NS)	NS	79	"Database management system"; it is not stated how long their vocational education takes
Lee et al. (2010)	9	*N* = 102	NS (NS)	NS	71	First-year students at a university of science and technology, enrolled in a course titled "packaged software and application; it is not stated how long their vocational education takes
Mejeh & Held (2022)	10	*N* = 159	16.64 (2.23)	NS	83	First school year at vocational school
Helm (2014)	11	*N* = 602	14.5 (.76)	NS	430	9th grade at vocational school

Note. NS (not stated).

The quality assessment revealed that the included papers did not have the same design or the same type of numerical data for extracting and analyzing the results. Two studies used randomization of participants to the intervention or control group, while seven studies were quasi-experimental studies without randomization. Some of these were pre- and post-intervention measurements, while others were only post-intervention. Overall, there were limitations in the quality assessment regarding how the 11 studies were designed and conducted. They were partially reliable, particularly in regard to how they provided support in answering the research question.

5.3 Description of the Studies

The authors of study ID 1 (Table 5) designed instructional scenarios with interventions based on student errors. The study primarily focused on whether the precise depiction of possible errors could assist vocational students in avoiding those mistakes. This led to four different study designs, each of which investigated a separate intervention. Case one found that the intervention group had higher test scores for analyzing errors compared to the control group in practical exercises. Case two was conducted as a pilot study and found that the analysis of a work-based video-recorded practice with a description of possible errors is a beneficial instructional strategy. Case three showed that the intervention group, which focused on the analysis of errors, had better average scores in listening to correct elements of consultation process and potential errors than the control group. Case four found that a nursing student and her tutors agreed that the video helped them identify errors that they would not have recognized in real practice. This led the tutors to change their way of giving feedback from a nonspecific, corrective to supportive feedback while the student became more accepting of feedback and increased her self-regulated reflection.

Table 5: Study Results From Cattaneo and Boldrini (2017)

Study ID	Study focus	Outcomes	
1	Case 1	test-score	
	Test score for practical exercise	IG (M/SD) 13.8 (4.0)	CG (M/SD) 8.8 (5.0)
	Case 2	qualitative data	
	Written and oral qualitative data from conversations between teachers and students	The analysis of a work-based video-recorded practice with errors is a beneficial instructional strategy. The errors, which have been put on purpose into the video, can be an initial step for the students to rate their own errors	
	Case 3	test-score[a]	
	Listing correct elements of procedure and potential errors	$t(134) = 5.1^{**}$	
	Case 4	qualitative data	
	Content analysis	The tutors changed their way of giving feedback from a nonspecific, corrective to supportive feedback. The nurse student became more accepting for feedback and for the errors she made; student and tutors said that the video helped them to see errors which in real practice would not have been recognized	

Note. $^{*}p < .05$, $^{**}p < .01$
[a]The authors only reported this t-test result; it remains unclear, where the data of the intervention and control group was.

The study with ID 2 (Table 6) showed that the way an instructional design is planned matters. The focus was on vocational students' perception of their learning environment in relation to their motivation and learning strategies. Different learning environments had different impacts on students' use of SRL strategies. Students' motivation, which is influenced by the learning environment and vice versa, affected the use of SRL strategies the most, more than teachers' behavior and autonomy feeling of students.

Table 6: Study Results From van Grinsven and Tilemma (2006)

Study ID	Study focus	Students in different learning environment	Autonomy	Task value	Supportive teacher behaviour
2	effects of learning environment variables on students experience for self-regulated learning	traditional education	-1.4	1.5	-1.2
		open learning center	-1.5	-1.3	-.7
		independent group work	.8	.3	1
		project-oriented learning	.2	-1.5	.1
		project-based learning	.7	.8	1.3

Note. Transformed beta weights of learning environments on the three aspects of students experience for self-regulated learning.

The next study focused on the effectiveness of a problem-based online learning environment. This study, with ID 3 (Table 7), showed that a problem-based online learning environment

can be beneficial for students when they are provided with necessary informational resources, guidelines, a tool to collaborate with their colleagues, and when they are getting support from their teacher. The students got higher grades for a petition-writing task after they experienced the problem-based online learning approach and said in the questionnaire that this approach helped them become more confident in writing a petition.

The study with ID 4 (table 7) primarily focused on whether a web mediated SRL and collaborative learning course had an effect on vocational students' thoughts regarding SRL and collaborative learning. This study showed that the intervention, a web-mediated self-regulated and collaborative learning course, was beneficial for the students. All 64 students said that the learning collaboration with other students was helpful or very helpful for developing their computing skills. Almost 90% thought that the SRL approach helped them develop a regular learning behavior, and almost all students concluded that the web-mediated self-regulated and collaborative learning course was a better or much better learning experience compared to traditional courses they took.

Table 7: Study Results From Gunduz et al. (2016) and Tsai (2011)

Study ID	Study focus	Scores given by the teacher	Individual degree how much students learned	Individual degree how confident the students felt writing a petition
3	effectiveness of a problem-based online learning environment	high: 78.1% intermediate: 19.8% low: 2.1%	very well: 35.7% enough: 58.6% poor: 5.7%	yes: 91.5% weak: 5.1% no: 3.4%
4	effectiveness of a web-mediated self-regulated learning and collaborative learning course	very helpful: 56.3% helpful: 43.8% not very helpful: 0.0% did not use them: 0.0%	very helpful: 48.4% helpful: 40.6% not very helpful: 9.4% did not use them: 1.6%	much better: 35.9% better: 60.9% worse: 3.1% much worse: 0.0%

Note. Distribution of students' responses in percent

The primary focus of the next study was whether a reciprocal teaching procedure of a metacognitive comprehension method was effective. This study, with ID 5 (table 8), showed that two intervention groups, the reciprocal teaching group, and the whole-class instruction group, performed significantly better in the maintenance phase than the control group, which participated in normal course-related activities. However, five weeks after the intervention, no significant differences in the comprehension measure were found between the different groups. The reciprocal teaching group could not be favored compared to the conventional whole-class instruction group. In the post-intervention measurement, the conventional whole-class instruction group showed even statistically significant better results in the Cooperative English Test than the control group.

Another study focused on the effects of web-enabled problem-based learning and SRL on low-achieving vocational students' computing skills. This study, with ID 6 (table 8), showed increased computing test scores for the intervention group in the long-term (measure was 36 months post-intervention). The intervention involved a web-based problem-based learning

and SRL environment. The results were statistically insignificant. Compared to the intervention group two, which only received the problem-based learning approach, the intervention group performed worse in the long-term and had a similar computing skill test score four months post-intervention as the control group. The control group in particular was seen to be quite ineffective, a significant reduction in test scores was found at 36 months in comparison to four months post-intervention.

The study with ID 7 (table 8) had its focus on whether SRL in on-site workshops and with an online learning community makes low foreign language achievers become more autonomous learners. This study demonstrated that the students, who undertook the workshop in SRL of English for specific purposes with an online learning community, developed autonomy and improved their English reading and listening skills. The results were all statistically significant. There was no control group, however, which would have been a good comparator for the effect of the intervention.

The next study primarily focused on whether a course with web enabled SRL had an effect on vocational students' skills of applying functions of database management system. This study, with ID 8 (table 8), found that a course with web enabled SRL had a positive effect on vocational students' skills of applying functions of a database management system. The students in the intervention group with five lessons of SRL and blended learning had higher average database test scores than those in the group with ten lessons of SRL or blended learning only. The study's results supported the hypothesis that a blended learning course with fewer online classes results in better learning effects and that SRL has a higher effect in a web-based learning environment than without this instructional method. The study also found that the intervention group with zero lessons of SRL had lower average database test scores than the intervention group with five lessons of SRL.

The next study primarily focused on which of four different learning settings were effective on students' involvement in learning. This study, with ID 9 (table 8), showed that the group which received an intervention of problem-based learning and SRL had a statistically significant increase of their post-intervention involvement level compared to their pre-intervention involvement level.

The study with ID 10 focused on whether a classroom structure intervention with "SRL-supportive structures" would foster SRL. The results showed that students' dispositions toward planning, elaboration, and learning with fellow students significantly improved in the intervention group, reflecting dispositional change. Additionally, planning, repetition, monitoring, regulation, and structuring an appropriate learning environment demonstrated situational development, revealing a significant interaction effect between time and the treatment.

The study with ID 11 was the first to provide deeper insights into the effects of cooperative open learning (COOL). Students in the COOL intervention demonstrated higher competencies in Accountancy compared to the control group, which attended regular school lessons.

Table 8: Study Results From Helm (2014), Lee et al. (2010), Mejeh and Held (2022), Rush and Milburn (1988), Tsai et al. (2011), Tsai et al. (2013) and Yang (2016)

Study ID	Study focus	Groups	Cooperative English Test		Comprehension Measures			
			Pre-intervention	Post-intervention	Baseline	Intervention	Maintenance	Follow-up
5	effectiveness of a four-part comprehension strategy	IG 1: Reciprocal teaching	28	25.3	16.7	19.2*	18.8*	14.0
		IG 2: Conventional, whole-class instruction	28	30.8*	18.1*	18.1	20.6*	17.0
		CG 1: Course-related reading activities	28	23.1°	15.1°	15.4°	15.3°	14.3
		CG 2: Non-reading course activities	28	26.8	–[a]	–	–	–
			pre-intervention computing test score		post-intervention computing test score (four months)		post-intervention computing test score (36 months)	
6	effect of problem-based and self-regulated learning intervention in a web-based learning environment on students computing skills	IG 1: Problem-based learning and self-regulated learning instructions	$M = 11.3$		$M = 81.6$		$M = 83.9$	
		IG 2: Problem-based learning instruction	$M = 10.8$		$M = 75.1$		$M = 70.1$	
		CG: No problem-based or self-regulated learning instruction	$M = 8.2$		$M = 75.3$		$M = 38.6$*	
			pre-intervention TOEIC score		post-intervention TOEIC score		correlation of students' beliefs and behaviors in autonomy	
7	analysis if self-regulated learning in on-site workshops and with an online learning community makes low foreign language achiever to become more autonomous learners and make progress in the on-site workshop	IG: On-site workshop with online learning community CG: none	$M_{listening} = 249.9$ (47.6) [b] $M_{reading} = 232.3$ (41.3)		$M_{listening} = 295.3$ (80.4) $M_{reading} = 274.3$ (75.1)		variable 1: Viewed workshop information = .71** variable 2: Downloaded learning materials = .62* variable 3: Joined the discussion = .66** variable 4: Took the assessment = .70**	

Study ID	Study focus	Groups	Average scores for the database management system test	
8	effect of a course with web-enabled self-regulated learning on vocational students' skills of applying functions of database management system	IG 1: Class of self-regulated learning and blended learning with ten online classes	*M* = 89.7 (9.9)° c	
		IG 2: Class of self-regulated learning and blended learning with five online classes:	*M* = 97.5 (5.7)*	
		IG 3: Class with no self-regulated learning with five online classes	*M* = 88.2 (6.1)°	
9	effect of four different learning settings on students' involvement in learning		Involvement pre-intervention	Involvement post-intervention
		IG one: Problem-based learning and self-regulated learning	*M* = 4.9 (.7)°	*M* = 5.3 (.7)*
		IG two: Problem-based learning only	*M* = 5.3 (.7)	*M* = 5.5 (.5)
		IG three: Self-regulated learning only	*M* = 4.9 (.6)	*M* = 4.9 (.6)
			M = 4.9 (.6)	*M* = 4.8 (.7)
10	Investigate the development of SRL components over time and analyze the impact of an SRL-promoting learning environment compared to regular instruction	IG: SRL environment CG: Conventional, whole class instruction	The results revealed a significant interaction effect of time and the treatment in "elaboration", "planning" and "learning with fellow students" (dispositional change) and in "repetition", "planning", "monitoring", "regulation", and "structuring an appropriate learning environment" (situational development).	
11	Examine the competence development of COOL students in grade 9	IG: COOL instruction CG: Conventional, whole class instruction (non-COOL)	M_{IG} = -.69 (1.5) M_{CG} = -.35 (1.39)	

Note. Analysis of variance means. *$p < .05$, **$p < .01$.
[a] No explanation given why control group two only participated in pre- and post-intervention activities.
[b] standard deviation in bracket.
[c] the means marked with * were significantly better compared to the mean with the °.

5.4 Grading Evidence

In summary, the studies above were evaluated for the quality of their evidence (table 9). The two randomized studies began at a high level of quality but were lowered by one level due to the lack of blinding of participants and assessors, as well as the lack of concealment of allocation. No other limitations were identified in the other four domains, resulting in a final level of "moderate" quality evidence for studies ID 6 and ID 7.

The nine non-randomized studies began at a "low" level of evidence due to the lack of randomization. During the evidence assessment, five studies (ID 4, ID 6, ID 7, ID 10, and ID 11) were raised to a "moderate" level due to demonstrations of effects from post-intervention measurements or plausible explanations for the results. The remaining three non-randomized studies had no effect or plausible bias explanations and remained at a "low" level of quality evidence. The last non-randomized study had four outcomes, three of which were "low" quality evidence, and one was "very low" due to a small sample size.

Table 9: Rating of Quality Evidence With the GRADE Approach (adapted from Schünemann et al., 2019)

Study ID	Study design	Outcome	Initial level of quality evidence	Domain one: risk of bias (large effect, plausible bias)	Domain two: inconsistency	Domain three: indirectness	Domain four: imprecision	Domain five: publication bias	Final level of quality evidence
1	NRSI a	outcome 1	low (2)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	low (2)
1	NRSI	outcome 2	low (2)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	low (2)
1	NRSI	outcome 3	low (2)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	low (2)
1	NRSI	outcome 4	low (2)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	serious (-1)	no limitation (+/-0)	very low (1)
2	NRSI	outcome 1	low (2)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	low (2)
3	NRSI	outcome 1	low (2)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	low (2)
4	NRSI	outcome 1	low (2)	raising (+1)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	moderate (3)
5	NRSI	outcome 1	low (2)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	low (2)
6	NRSI	outcome 1	low (2)	raising (+1)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	moderate (3)
7	NRSI	outcome 1	low (2)	raising (+1)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	moderate (3)
8	randomized study	outcome 1	high (4)	serious (-1)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	moderate (3)
9	randomized study	outcome 1	high (4)	serious (-1)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	moderate (3)
10	NRSI	outcome 1	low (2)	raising (+1)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	moderate (3)
11	NRSI	outcome 1	low (2)	raising (+1)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	no limitation (+/-0)	moderate (3)

Note. [a] NRSI is the abbreviation for non-randomized studies of interventions

5.5 Data Synthesis

In previous sections, key data from the studies and participant characteristics were presented in both data tables and text form (Boland et al., 2017). In this data synthesis section, the results from all studies are consolidated and linked together.

10 studies (ID 1, ID 2, ID 3, ID 5, ID 6, ID 7, ID 8, ID 9, ID 10 and ID 11) have reported positive effects of interventions that promote SRL among vocational students. Post-intervention, the students had higher test scores or reported that they benefited from the intervention, such as developing autonomy or practical skills like computational or accountancy skills. The interventions that had positive outcomes can be characterized as follows: Interventions that used video analysis to improve the understanding of error analysis among vocational students; those which fostered cooperative open learning, leading to improved academic achievement; those that observe dispositional and situational attributes of SRL with a specific classroom structure (SRL-supportive structures); those that led vocational students to a self-confident approach to the topic through problem-based learning in collaboration with classmates; those that led to a better learning experience for vocational students in web-based online courses compared to traditional courses; those that resulted in statistically non-significant improvements in computer test results with a web-based and problem-based approach; and finally, those that enabled autonomy with a workshop on English for specific purposes with a SRL approach. Interestingly, in one study (ID 4) the follow-up measurement some months after the intervention showed that the effect was no longer present in the intervention group. While 10 studies claimed positive effects, one study could not report a benefit of their intervention. One study (ID 4) found that different learning environments had varying impacts on vocational students' experiences of SRL, but it did not identify a specific instructional format as superior.

The methodology of the eleven papers was noteworthy, as there were instances of imprecise or incomplete analysis in nearly all papers (e.g., results tables were missing, or the interpretation of the results was minimal). In terms of descriptive statistics, the studies did not have similar sample sizes. Nine studies (ID 1, ID 2, ID 3, ID 4, ID 7, ID8, ID 9, ID 10, ID 11) had over 100 participants, with a maximum of 623, while two studies (ID 5, ID 6) had under 100 participants, with a minimum of 76. Six studies (ID 1, ID 2, ID 3, ID 4, ID 7, ID 9) did not report the average age of participants. The vocational students in the remaining studies (ID 5, ID 6, ID 8, ID 10, and, ID 11) had similar mean age. Eight studies (ID 1, ID 2, ID 5, ID 6, ID 8, ID 9, ID 10, and ID 11) limited their study population to a single vocational school level, either first or second year of vocational training, while three studies (ID 3, ID 4, ID 7) did not report the education level of their students.

Seven papers were of final moderate quality evidence (ID 4, ID 6, ID 7, ID 8, ID 9, ID 10, and ID 11). Four studies were of a final low quality (study ID 1, 2, 3 and 5). The papers of final low quality were non-randomized studies, which initially started at a low level of evidence

due to the lack of randomization. With the ROBINS-I tool, large effects and plausible bias were assessed in these studies, but none of the studies had large effects or plausible bias and therefore could not be upgraded by one or two levels of quality evidence. The validity of the results and their substantial evaluation will be discussed in detail in the discussion section.

6 Discussion

The goal of this systematic review was to investigate the current state of intervention studies aimed at fostering SRL at the vocational school level. More broadly, this review seeks to enhance our understanding of how vocational students learn, acquire knowledge, and utilize their self-regulatory skills to succeed in their chosen careers and in lifelong learning. To achieve these objectives, various intervention studies were analyzed through a systematic, criteria-based selection process.

6.1 Participant Characteristics

Upon analyzing the characteristics of the intervention studies, it was noted that 10 studies reported positive effects of their interventions based on SRL approaches. The results highlight the need to improve student engagement and increase active learning in the classroom to facilitate the use of SRL strategies (Sembill et al., 2007). It becomes evident that the design of learning environments in vocational schools plays a crucial role, as discussed extensively in previous research (Bacca et al., 2018; Rintala & Nokelainen, 2020; Roos et al., 2021; Schaap et al., 2012). In vocational schools, it is essential to incorporate real-world problems into the learning experience, as this helps students understand how the skills and knowledge they acquire in the classroom can be applied to solve practical challenges in their chosen careers (Baartman & de Bruijn, 2011; Bouw et al., 2019; Monks, 2010; Wesselink et al., 2010). Additionally, learners in problem-based learning environments have demonstrated better test scores and more pronounced skill development.

This review also confirmed findings observed elsewhere: When teaching is less teacher-centered, students experience greater autonomy and self-efficacy (Kim et al., 2022; Schunk, 1990; Usher & Pajares, 2008; Wilson & Narayan, 2016). From this, it can be concluded that to become self-regulated learners, students need to feel invested in their learning, and teachers should foster a sense of autonomy. In this perspective, learners are seen as active agents in their own learning process (Karlen et al., 2023). Simultaneously, there was a strong emphasis on collaborative learning in the interventions. The interventions aimed to create a collaborative learning environment where students could share their learning experiences, a concept explored in numerous studies on socially shared regulated learning (Hadwin et al., 2017;

Hadwin & Oshige, 2011; Järvelä et al., 2016) and socially shared metacognitive regulation (De Backer et al., 2015; Iiskala et al., 2021; Volet et al., 2009).

Another important finding from the summary of results was that promoting SRL skills was more of a means to an end, rather than the central focus of the intervention studies. Although SRL was applied in various forms, in most of the studies the emphasis was placed on measuring outcomes such as improved test scores, rather than promoting SRL strategies. However, the intervention studies did incorporate key elements of SRL promotion, such as prioritizing learners as problem-solvers, granting high levels of student participation and autonomy, utilizing project-based approaches, and encouraging collaborative group work on complex problems (Sembill et al., 2007).

While all studies identified concepts for promoting SRL in vocational schools, the target group of the interventions remained mostly unclear. There was inconsistent reporting of participant ages among the studies, and information on the complete duration of vocational training was often missing. Given the demonstrated importance of participant characteristics in educational intervention studies (Steed & Kranski, 2020; Wong et al., 2015), this lack of detailed reporting could limit the understanding of the interventions' effectiveness.

Consequently, the findings of this study confirm the importance of distinguishing between direct and indirect interventions to foster SRL in the classroom, a concept thoroughly examined in other educational contexts (Dignath & Veenman, 2021). Research has shown that both direct and indirect approaches can be effective in promoting SRL, but the effectiveness of each approach may depend on the specific context and student population. For instance, direct promotion may be more effective for students with limited prior experience with SRL, while indirect promotion may be more effective for students who have already developed some SRL skills and are motivated to use them (Dignath & Büttner, 2018; Perry et al., 2020).

6.2 Study Quality

The quality of evidence in studies investigating the promotion of SRL varies widely, as demonstrated by the analysis. The interventions showed positive effects, including improved test scores and the development of key skills such as autonomy and computational abilities, which are crucial for successful SRL (Zimmerman & Schunk, 2011). However, there were concerns about the variability in outcome measures and the differing effect sizes across the 11 studies, which can be attributed to the diversity of study designs used. For example, the quasi-experimental approach for the non-randomized studies was interpreted differently across the papers. A quasi-experimental design is commonly used in educational research when randomization is not feasible, but it can lead to "numerous interpretation problems"

(Gribbons & Herman, 1996, p. 2). Authors could have provided more clarity on their interpretation of quasi-experiments when describing their methodology.

In this review, various designs were identified, including post-intervention measurement only, pre- and post-intervention measurement, and even follow-up measurement. Notably, six studies did not include a control group, only intervention groups, yet still discussed the effectiveness of the interventions. This is a limitation because a reliable comparison, typically provided by a control group, was missing (Pressley & Harris, 1994).

Another challenge was the generalization of the effectiveness of the interventions. As Gottfredson et al. (2015) describe, assessing effectiveness typically involves comparing the mean difference in the target variable between the intervention and control groups. To conclude that an intervention is effective, the intervention group should exhibit a statistically significant difference in mean values compared to the control group. For instance, rigorous pre- and post-intervention measurements are necessary to accurately assess whether students benefit from the intervention. The target variable should be measured before and after the intervention in such cases to determine whether it produced individual-level differences (Walton & Wilson, 2018).

The quality of evidence in the intervention studies ranged from low to moderate, suggesting that the findings of individual studies should be interpreted with caution. The variation in study design and methodological quality makes it challenging to compare studies and draw definitive conclusions.

7 Implications, Future Research and Limitations

From the analysis of the different intervention studies on the promotion of SRL in vocational schools, several implications can be derived.

Firstly, a combination of direct and indirect approaches to promoting SRL has been found to be most effective in maximizing the potential benefits of interventions (Schuster et al., 2020, 2023). Future interventions in vocational schools should therefore incorporate both direct and indirect promotion of SRL. However, this approach may also present challenges that need to be carefully considered. The key challenge lies in finding the right balance between direct and indirect promotion for a particular student group, as the effectiveness can vary based on context and the characteristics of the student population.

When analyzing the results of intervention studies, it is critical to consider the interaction between student aptitudes and the treatments provided. The effectiveness of an intervention is believed to be influenced by the fit between a student's abilities and the intervention they receive (Cronbach & Snow, 1977; Yeh, 2012). Based on their unique aptitudes, some students may respond more positively to an intervention (Snow, 1992). This suggests that the impact of an intervention may not be uniform across all students. Further research is needed to

explore whether there are consistent differences in students' aptitudes that affect the success of the intervention.

Secondly, both direct and indirect promotion of SRL are resource-demanding and time-consuming, as they require the development of multiple intervention components, such as instructional materials, training programs, and assessment tools. To address this challenge, it may be beneficial to co-create the interventions with stakeholders, such as students and teachers, using design-based research or co-design methods (McKenney & Reeves, 2013; Penuel et al., 2022; Roschelle & Penuel, 2006).

Thirdly, the overall quality of the studies was relatively low. While the outcome measurements were generally assumed to be valid, there may have been room for improvement in the statistical analyses. This issue highlights a broader problem in educational intervention research: A lack of reported information and transparency in the use of statistical methods. As a result, it becomes challenging to generate reliable and generalizable meta-analytic results that can be applied to educational practice, particularly in research on SRL (Cornelius-White, 2007; Dent & Koenka, 2016; Dignath & Büttner, 2008; Dignath & Veenman, 2021; Jansen et al., 2019; Panadero, 2017; Sitzman & Ely, 2011). In future studies, it is crucial to prioritize providing all necessary information for thorough investigation and to use appropriate statistical procedures. Moreover, since the quality of meta-analytic data depends on the practices in primary research, primary researchers should be even more diligent in reporting their research design, methodology, and statistical analyses with thoroughness and care (Ahn et al., 2012). Preregistered studies could be one potential solution to address this issue (Anderson et al., 2019; Gehlbach & Robinson, 2018).

The findings should be considered by taking into account some limitations of the study.

First, only a few studies were identified that could be included in the analysis. This limitation may be attributed, on the one hand, to the exclusion of gray literature from the analysis. On the other hand, the diversity of VET systems worldwide (Cedefop, 2021; Pilz, 2016; Valiente & Scandurra, 2017) might have resulted in SRL being promoted in different ways, making it difficult to identify consistent patterns. Another limitation of this study is the exclusive focus on English-language publications, which may have led to the exclusion of programs and interventions aimed at promoting SRL that were developed, implemented, and tested in other national languages. Consequently, valuable insights from studies conducted in different language regions might not have been captured in our analysis.

Secondly, a meta-analysis was not conducted after data synthesis for two main reasons: The predefined scope of the work and the lack of homogeneity among the studies (Boland et al., 2017). The diverse outcomes and intervention programs made meaningful comparisons impossible, as vocational students were exposed to different interventions over varying time periods.

8 Conclusion

Based on the available research, it appears that the promotion of SRL in VET has not been extensively explored by researchers. The limited empirical evidence and theoretical frameworks suggest that more research is necessary to better understand and address this subject. Further research could provide valuable insights and contribute to advancing both knowledge and practice in this area.

VET is intended to equip and empower young people with the knowledge and skills needed to learn and work autonomously, preparing them for employment in today's dynamically changing world (Persico et al., 2015). SRL in VET is crucial for students to actively learn from practical task experiences. Becoming a skilled professional is key to securing and sustaining employability across lengthening working lives, making the development of skillful professionals an essential societal goal. VET aims to foster independent and self-directed learners, and SRL is a promising skill to achieve this objective (De Bruijn & Leeman, 2011; Jossberger et al., 2010).

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Ethics Statement

This paper fully complies with the principles and guidelines for IJRVETs Ethical Statement for publications. The conducted research did not include human participants whereas informed consent was not necessary.

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