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Mapping educators' insights of student problem-solving difficulties while implementing video-assisted self-regulated learning training in classrooms

Research Article

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Abstract: Developing self-regulated learning (SRL) skills among young adolescents is crucial for lifelong learning, and teachers play a vital role in fostering these skills. Problem-solving is a key SRL skill; however, both learners and teachers encounter challenges during the problem-solving process and in evaluating its incorporated strategies. To tackle these challenges, this study examined students' problem-solving difficulties using a generic video-assisted SRL training programme, based on teachers' reports, and analysed these challenges across STEM and non-STEM domains. This study focusses on identifying and classifying the difficulties of 241 students within the problem-solving framework, as reported by teachers across various disciplines and grades (6–11). The analysis revealed that the most significant difficulties arose during the problem identification, followed by time planning and management, problem exploration, solution development and solution evaluation. Specifically, STEM teachers reported relatively fewer difficulties in problem exploration than in other steps, while non-STEM teachers reported fewer challenges in presenting and communicating solutions to peers. A dedicated map named the problem-solving sort out setbacks (PS-SOS) map was created to pinpoint challenges within the problem-solving process. The application of this mapping technique can further support the development of technology-based feedback systems, including digital assistants, which offer valuable assistance to students.

Keywords: *Video-based training; Problem-solving; Problem-based learning; Self-regulated learning; K-12 education*

Introduction

Promoting self-regulated learning (SRL) is fundamental as it equips individuals with the autonomy to control their own learning journey, fostering effective learning, adaptability to novel situations and goal attainment (Alderman & MacDonald, 2015; Efklides & Metallidou, 2020; OECD, 2021). Several studies have highlighted the importance of promoting SRL skills among young adolescents, underscoring its crucial role in their lifelong learning (Alderman & MacDonald, 2015; Hanewald, 2013; Schloemer & Brenan, 2006). Leveraging video-based technology has been suggested as a means to support instruction of SRL strategies and enrich the learning experience (Dresel & Haugwitz, 2008; Jansen et al., 2020; Wang, 2011). Despite the prevalent use of video in education, research on SRL training among young adolescents remains relatively scarce (Arifin et al., 2020; Cohen et al., 2022; Dresel & Haugwitz, 2008; van Alten et al., 2020).

Within the context of SRL, problem-solving is a fundamental skill that involves a multifaceted cognitive process, requiring individuals to utilise a diverse range of skills and strategies to effectively navigate and overcome challenges (Csapó & Funke, 2017; Khoiriyah & Husamah, 2018; OECD, 2021). Educators play a pivotal role in promoting these skills in their students (De Smul et al., 2019; Sulisworo et al., 2020; Uka & Uka, 2021). Additionally, feedback assumes a crucial role in the learning process generally and in promoting SRL skills specifically (Cohen et al., 2022; Nicolaidou, 2013; van Ginkel et al., 2019). Targeted feedback allows learners to monitor progress, identify areas for improvement and adapt their strategies accordingly. Hence, incorporating feedback mechanisms, particularly in SRL training, is imperative for effective instructional practices (Araka et al., 2020; Panadero et al., 2016; Zheng, 2016). Giving feedback on problem-solving strategies, defining, measuring and evaluating the challenges related to these strategies is essential (Liu & Israel, 2022; Yavuz et al., 2017). The literature often underscores two primary challenges: the difficulties learners face during the problem-solving process and the complexities in measuring strategy utilisation (Liu & Israel, 2022; Tissenbaum, 2020).

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Furthermore, while many SRL programmes are tailored to specific fields, Zheng (2016) advocated for the efficacy of a universal, cross-disciplinary SRL intervention adaptable to any discipline. However, only a few training programmes embrace a generic cross-disciplinary SRL approach (Huertas et al., 2015). Studies integrating video into SRL training for young adolescents tend to be domain-specific, rather than generic (Fössl et al., 2016; Heaysman & Kramarski, 2022; Kostons et al., 2012; Raaijmakers et al., 2018; Yakubova et al., 2020). This aligns with the concluding insight from a meta-analysis of SRL online and blended training by Xu et al. (2022), emphasising the need to explore differences in SRL interventions between STEM (Science, technology, engineering, and mathematics) and non-STEM domains, particularly for young learners.

Therefore, this study aims to pinpoint and map the difficulties students face during problem-solving within a generic video-based SRL training programme across various disciplines, including STEM and non-STEM. It aims to identify specific steps and tasks in the problem-solving process where students encounter challenges, as observed from teachers' perspectives. Additionally, the study intends to map these difficulties separately for STEM and non-STEM disciplines to assess whether variations exist in students' challenges when implementing the same generic programme. The study contributes to constructing a comprehensive map that facilitates the identification of challenges during the problem-solving process, aiding in the development of tailored SRL training programmes.

Literature Review

SRL training for young adolescents

SRL is defined as an active process wherein learners set learning goals, monitor, regulate and control their understanding (cognition), motivation and behaviour (Pintrich, 1999; Zimmerman, 2008). Research has shown that learners can actively engage in SRL strategies throughout their educational experiences, demonstrating that these strategies can be transformed into skills through the implementation of guidance and programmes designed to promote SRL (Dresel & Haugwitz, 2008; Xu et al., 2023). The application of SRL strategies in the learning process was found to be positively related to academic achievement (Pintrich, 1999; Vrieling et al., 2018; Zimmerman, 2008). More specifically, research emphasises the significance of SRL skills in young adolescents, considering this period as crucial for social, emotional and academic development, accompanied by unique challenges (Alderman & MacDonald, 2015; Sanders et al., 2023). The acquisition of SRL skills during adolescence is pivotal for lifelong learning capabilities (Hanewald, 2013; Schloemer & Brenan, 2006) and correlates with academic achievement (Winters et al., 2008), thereby underscoring the importance of cultivating these skills from an early age (de Bruijn-Smolders et al., 2016).

Students can develop SRL skills with the guidance of their teachers, who can impart these skills through direct, implicit or explicit methods, facilitating the students' journey towards becoming independent learners (Kistner et al., 2010; Xu et al., 2023). Implicit instruction occurs when a teacher uses or encourages the SRL strategy in the classroom without explicitly mentioning it. Teaching by imitation is also considered implicit teaching, with many teachers expecting students to imitate their solution or a solution that their classmates suggest. Thus, teachers miss the opportunity to discuss SRL strategies and their effectiveness. In contrast, explicit instruction of SRL occurs when the teacher directly and explicitly demonstrates its strategies so that learners are informed about the strategies' meaning and importance, and experience these (Dignath et al., 2008; Dignath & Büttner, 2008; Hattie, 2008). Kistner et al. (2010) showed that explicit instruction significantly enhances the transferability of learned strategies to different learning situations, suggesting that students who practice employing a SRL strategy across various contexts and tasks at school are likely to adeptly apply it when tackling complex problems later on.

Learning can be more effective when students are exposed to a technological learning environment that encourages them to pursue strategies to become independent learners (Breitwieser et al., 2023; Wang, 2011). Accordingly, researchers have recommended that SRL training be conducted with the help of online learning media, particularly video (Dresel & Haugwitz, 2008; Jansen et al., 2020). Video serves as a powerful tool for SRL training by boosting engagement, motivation and positive learning experiences while simultaneously enhancing academic performance (Galatsopoulou et al., 2022; Lai & Hwang, 2016; Moos & Bonde, 2016). Offering learners autonomy, videos enable control over the pace, location and timing of learning (He et al., 2016; Jansen et al., 2018). In successful SRL interventions, where videos are strategically incorporated, there are improvements in achievements and intentional self-directed learning skills (Vilkova, 2022; Wong et al., 2021), establishing them as valuable assets in educational interventions (Xu et al., 2022). Although video usage has increased in recent years for general purposes as well as for SRL training, only few studies have examined the incorporation of video-based technologies into SRL training programmes, which focus on explicit learning of SRL strategies among young adolescents (Fössl et

al., 2016; Heaysman & Kramarski, 2022; Kostons et al., 2012; Raaijmakers et al., 2018; Yakubova et al., 2020).

Enhancing problem-solving strategies with feedback adapted to student difficulties

Self-regulation refers to self-generated thoughts, feelings and actions that are planned and cyclically adapted for the attainment of personal goals, such as solving a problem (Zimmerman, 1998). Self-regulation models aim to explain students' proactive efforts to acquire knowledge and skills, including problem-solving (Zimmerman & Campillo, 2003). SRL integrates problem-solving across three cyclical phases: forethought, performance and self-reflection (Zimmerman, 2000). Forethought processes set the stage for problem-solving, performance phase processes occur during solution efforts and self-reflection processes follow solution performances, influencing subsequent responses. The cyclical nature of self-regulation hinges on feedback from prior performance efforts, guiding adjustments in current endeavours (Zimmerman & Campillo, 2003). In the context of problem-solving and broader learning scenarios, effective feedback is essential (Chen et al., 2018; Hattie & Timperley, 2007; Maier et al., 2016), emphasising the importance of addressing specific difficulties that students encounter within the appropriate context. Students receiving feedback, whether through conversations, comments, verbal praise or rewards, are more likely to develop robust SRL skills (Zimmerman & Barry, 2013). In computer-assisted learning, feedback stands out as the primary guiding element for students (Goldin et al., 2017; Kulik & Fletcher, 2016).

Understanding students' problem-solving processes becomes pivotal, aiding educators in assessing knowledge acquisition and offering timely support (Yavuz et al., 2017). This also helps identify practical strategies for facilitating transitions to higher phases (Liu & Israel, 2022). Despite the consensus on the need to promote problem-solving in the classroom, implementing is often complex (Reimers & Chung, 2016). Although feedback's importance is recognised, its implementation raises questions, with potential positive or negative effects contingent on design and delivery (Cáceres, 2021). Notably, feedback for young adolescent students is underexplored, and teachers often grapple with challenges in its effective delivery (Schaeffer et al., 2016; van den Bergh et al., 2013a). A study analysing primary teachers' feedback found a mere 5% explicitly linked to learning goals, indicating a need for more purposeful and goal-oriented feedback (van den Bergh et al., 2013b).

For effective feedback on problem-solving strategies, a holistic approach involving the definition, measurement and evaluation of associated challenges is necessary (Liu & Israel, 2022; Tissenbaum, 2020). While assessments often rely on students' self-reports (Liu & Israel, 2022; Molenaar et al., 2023), especially in SRL video-based training programmes for young adolescents (Fössl et al., 2016; Heaysman & Kramarski, 2022; Kostons et al., 2012; Raaijmakers et al., 2018; Yakubova et al., 2020), it is important to consider educators' perspectives actively involved in training programmes.

Multidisciplinary approaches in SRL training

Training programmes that encompass multiple facets of learning offer learners a more comprehensive understanding of the learning process, thereby becoming effective (Araka et al., 2020; Schunemann, 2017). A comprehensive review indicates that training programmes adopting a holistic approach, combining the imparting of strategies with domain-related knowledge, result in better long-term achievement outcomes (Cousins et al., 2022). While numerous SRL training programmes are tailored for specific fields, Zheng (2016) argued that promoting SRL skills in a generic programme, which can fit into any discipline, can lead to similar outcomes. The author justified this claim by emphasising that a general SRL training proves effective when the strategies employed are generalisable to various fields of discipline, given the inherently general nature of SRL. However, only a few training programmes have embraced a multidisciplinary approach by integrating training in two or more subjects across different domains, without exploring distinctions in implementation within these fields (e.g. language, mathematics, science and language learning; Huertas et al., 2015). More specifically, studies incorporating video into SRL training programmes with explicit instruction among young adolescents have typically been domain-specific, rather than generic in nature (Fössl et al., 2016; Heaysman & Kramarski, 2022; Kostons et al., 2012; Raaijmakers et al., 2018; Yakubova et al., 2020).

A meta-analysis conducted by Xu et al. (2022) explored the effectiveness of online or blended SRL training programmes. The analysis specifically examined potential variations in effectiveness linked to the specific features of the included studies, such as the discipline domain (STEM vs. non-STEM, e.g. language, history, education). According to the research findings, the implementation of SRL interventions in STEM subjects demonstrates a larger effect on academic performance within online and blended learning environments. The results also indicate that most SRL intervention studies focus on higher education, with elementary education

showing the largest effect size.

Dignath and Büttner (2008) found that SRL interventions explained approximately 44% of the variation in effect sizes for mathematics performance in primary school, while only 19% in reading/writing. In addition, Li et al. (2018) found variations in effectiveness across academic domains, with SRL strategies more impactful in improving science than in language learning. Prior research has shown that STEM subjects, including science, engineering and mathematics, necessitate greater student investment in terms of effort, resources and time (Loong, 2012; Wilson et al., 2012). Studies also revealed students' preference for STEM disciplines (Miller et al., 2018; Wolters and Pintrich, 1998), possibly contributing to the observed better outcomes of SRL interventions in STEM subjects compared to non-STEM subjects. The meta-analysis by Xu et al. (2022) suggested that future research should investigate the differences between SRL interventions in STEM and non-STEM domains, especially for young learners. Examining this aspect becomes particularly interesting when considering the implementation of a generic training programme across different fields, an area that has not been extensively explored, as mentioned earlier.

Research Objective and Questions

The research has a dual objective: firstly, to pinpoint and classify the difficulties faced by young adolescent students in problem-solving during a video-assisted SRL training programme, as reported by their teachers. Secondly, the study aims to compare the difficulties reported by STEM teachers with those reported by non-STEM teachers when implementing a shared generic SRL training programme, with a focus on students' difficulties. Considering these research objectives and the literature review, the study is guided by the following research questions:

1. What difficulties do students face in the process of problem-solving during video-assisted SRL training?
2. To what extent, if any, do difficulties in problem-solving during video-assisted SRL training vary between STEM and non-STEM disciplines?

Methodology

Research context and population

In this study, both teacher and student training programmes were established. The teacher training programme consisted of 10 blended sessions, a mix of face-to-face and online interactions, and was complemented by a student intervention programme called video assisted SRL training (VAST). Students were introduced to a generic problem-solving framework, which incorporates specific SRL strategies such as time management, feedback, elaboration and critical thinking. Developed based on the existing literature (Davidson & Sternberg, 2003; Kim & Hannafin, 2011; Mourtos et al., 2004; Snyder & Snyder, 2008), the framework outlines a systematic, step-by-step approach to problem-solving. This is facilitated through a digital toolbox comprising interactive videos, checklists and problem-solving performance tasks, all aligned with the framework's various steps and specific tasks. During the programme, students watched these videos in a prescribed sequence corresponding to the steps of the problem-solving process, later applying the learned strategies in groups to tackle specific problems. The videos were also available for re-watching. The detailed steps and tasks of the framework are outlined in Table 1.

During the intervention programme, which was effective in utilising SRL strategies and promoting academic achievements (Assi & Cohen, 2023), students worked in groups to solve a problem using the framework's process. Throughout the programme's implementation, their teachers described the difficulties they faced. This study involved 11 teachers who represented a range of disciplines and implemented the video-based training programme for a total of 269 students in grades 6–11 (60% junior high school teachers and 40% high school teachers). Seven teachers implemented the training in STEM disciplines (75% junior high school teachers and 25% high school teachers), and four teachers implemented the training in non-STEM disciplines (50% junior high school teachers and 50% high school teachers).

Research tool

In the course of this research, teachers were asked to provide voluntarily insights through two distinct questionnaires, each tailored to capture essential aspects of their classroom experiences. The first questionnaire focused on elucidating challenges within the classroom. First, teachers were asked to describe, in their own words, specific situations of difficulties in their classroom while implementing the SRL training. Then, they were asked to categorise the difficulties into four distinct categories: problems related to problem-solving methods, social dynamics, emotional experiences or technological hurdles. For difficulties related to problem-solving methods, teachers were asked to elaborate on unclear aspects of the method, pinpointing specific parts used incorrectly by students and detailing the challenges students encountered in learning through the designated framework. Social difficulties were outlined by describing specific instances where students

Table 1. The problem-solving framework developed within the VAST training intervention

Learning stages	Forethought		Performance	Reflection
SRL strategies related to time	(S1) Time planning		(S4) Time management	(S7) Time management evaluation
	(T1.1) Define deadline for final solution. (T1.2) Define steps deadlines. (T1.3) Assess schedule feasibility. (T1.4) Use an assistive tool to document the planned schedule.		(T4.1) Monitor planned schedule. (T4.2) Detect time deviations. (T4.3) Reschedule deadlines. (T4.4) Assess reschedule feasibility.	(T7.1) Detect time deviations. (T7.2) Define reasons for time deviations. (T7.3) Use time deviations reasoning to explore alternatives for future problems.
Problem-solving strategies integrating other SRL strategies (critical thinking, elaboration, and feedback)	(S2) Problem identification	(S3) Problem exploration	(S5) Solution development	(S6) Solution evaluation
	(T2.1) Define the problem in your own words to ensure understanding. (T2.2) Determine the rules and constraints. (T2.3) Define criterion for judging solution. (T2.4) Break the problem down into smaller questions. (T2.5) Reflect on the activity in this step.	(T3.1) Identify related topics based on prior knowledge. (T3.2) Determine the given/known information that might assist in solving the problem. (T3.3) Identify and complete information gap necessary for moving forward with the solution. (T3.4) Pose operational questions concerning the problem. (T3.5) Reflect on the activity in this step.	(T5.1) Identify candidate solutions. (T5.2) Analyze candidate solutions - using constraints and criteria. (T5.3) Investigate needed information for each solution. (T5.4) Choose the best solution according to the criteria. (T5.5) Implement a detailed work plan. (T5.6) Reflect on the activity in this step.	(T6.1) Present and communicate the solution (when relevant). (T6.2) Justify/defend/Update the solution. (T6.3) Monitor the problem-solving process. (T6.4) Improve the problem-solving process. (T6.5) Reflect on the activity in this step.

(S#), chronological step number; (T#), chronological task number; SRL, self-regulated learning; VAST, video assisted SRL training.

faced challenges in their social interactions within the classroom. Emotional difficulties were explored by documenting situations where students experienced emotional responses during the implementation of the method, including the emotions felt and the contributing factors. Technological difficulties were addressed by describing situations where technological challenges hindered the learning process, along with specific details about the nature of these challenges.

The second questionnaire shifted the focus to successful practices in dealing with difficulties. Teachers were presented with open-ended questions, asking them to describe successful experiences while delivering the intervention programme to their students. Acknowledging the difficulty, the teachers asked to respond to open questions about describing their difficulty, detailing how they dealt with it and describing the achieving success.

The collected information from both questionnaires was combined into a consolidated dataset. Each response received a unique serial number, and additional details, including teacher ID, class grade and teaching domain, were incorporated. This comprehensive dataset serves as a robust resource, facilitating an in-depth analysis of diverse challenges across various classroom contexts.

Research method and procedure

This study explores challenges faced by students, as reported by their teachers. To comprehensively understand these challenges, a combination of qualitative and quantitative methods was employed, with a primary emphasis on the latter. Initially, a detailed qualitative analysis was conducted to identify student difficulties from the teachers' data. This involved a thematic analysis technique, where data were coded to reveal various student difficulties. Following the identification, the next step was to classify these difficulties using a problem-solving framework

specifically developed for this study. This framework defined several steps and tasks of problem-solving, allowing to map each identified difficulty to its related task in the problem-solving process. This classification was crucial for understanding the context in which difficulties occurred and provided a structured way to analyse the data. Moreover, in instances where certain difficulties did not fit within the established framework, a decision was made to exclude these from the analysis. To ensure the validity of the qualitative analysis, two experts in the field of SRL independently verified the mapping of identified difficulties to the problem-solving framework. Their insights were then synthesised and compared to provide a comprehensive overview of the identified difficulties.

Moving beyond mere identification, the frequency of each difficulty for every task within the problem-solving framework was calculated. Following that, quartiles were computed separately to compare the occurrences of difficulties across all tasks, shedding light on tasks that presented more challenges. Finally, the same calculation was performed for two groups separately: the STEM and non-STEM groups, aiming to compare the differences between the two groups. JASP 17.01 software (Developed by University of Amsterdam) was utilised for data analysis.

Findings

This study explores SRL strategies within the context of problem-solving. The following section presents the difficulties that students encounter while working independently on learning tasks.

Teachers' responses categorisation

A total of 40 responses were provided by teachers, yielding various difficulties (N = 241) encountered by students. These difficulties were categorised according to the steps of problem-solving as they align with the three phases of SRL: forethought, performance and reflection, while working independently. Notably, certain difficulties pertaining to issues such as motivation, emotions and technology, were not clearly associated with any specific task or step in the framework. Thus, these difficulties were excluded from the analysis. Examples of the classification process are shown in Table 2.

Distribution of categorised students' difficulties

To assess the frequency of difficulties reported by teachers across different tasks and steps, a quartile calculation was employed. The objective was to pinpoint tasks in which students commonly encountered difficulties working independently. The results of the analysis are presented in Table 3.

The analysis aimed to identify where students commonly faced difficulties by mapping these onto the SRL phases:

- **SRL Phase 1: Forethought.** The analysis revealed that the highest number of difficulties were encountered during the forethought phase of SRL, particularly in the problem identification step. Teachers reported that in problem identification step, students struggled with defining the problem (n = 17), identifying constraints (n = 17), establishing solution criteria (n = 17), engaging in effective questioning (n = 17) and practicing reflection (n = 12). Regarding the time planning step, students encountered significant barriers, with all the tasks within this step falling into the second-highest quartile of difficulty (n = 9). Moreover, the reflection task in the problem exploration step posed a significant challenge (n = 8), underscoring the complexity of the reflection at this SRL phase.
- **SRL Phase 2: Performance.** This phase was marked by notable difficulties in time management, illustrating the difficulties students faced in executing and managing their strategies and actions. All time management tasks were placed in the second-highest quartile (n = 9). Within solution development, the reflection task was identified as having a high number of difficulties compared to other tasks (n = 6). This suggests a consistent need for reflective practices throughout the performance phase.
- **SRL Phase 3: Reflection.** Interestingly, teachers observed fewer challenges in all the tasks within the time management evaluation step (n = 4), indicating a possible area of strength for students. Presenting and communicating solutions to peers was identified as a particularly challenging task (n = 8), suggesting the need for a greater focus on these skills in the reflection phase.

The difficulties faced by students, as reported by teachers, were analysed and visualised on the problem-solving sort out setbacks (PS-SOS) map, reframed to underscore the integration of SRL phases with problem-solving steps. This map offers an overview of specific tasks and steps within the SRL-problem-solving framework where students encountered difficulties. Each quartile indicates the difficulty level of a particular task, with the red colour indicating the highest percentile, with 25% of the observed difficulties are at or above this level of challenge and 75% are less challenging, and the green colour indicating the lowest percentile, with 25% of the observed difficulties are at or below this level of challenge and 75% are more challenging. The colour

Table 2. Examples of classifying teacher-reported student difficulties across problem-solving framework tasks during independent work

Response ID	Teacher's code	Teacher's response	Classification difficulties per PS tasks	Classification difficulties per SRL phase
18	T7	'While performing the task, the students experienced difficulty. At first, the students did not understand where and what the problem is'.	T2.1–T2.4 (Problem identification).	Forethought
		'The students encountered difficulties in the phase of problem exploration and solution development; In problem exploration, the some of the students did not think deeply about what criteria they should take in order to plan the task and this affected the solution they proposed'.	T3.1–T3.4 (Problem exploration), T5.1–T5.5 (Solution development).	Forethought, Performance
		'Students are not used to such complex tasks. Some students heavily depend on the teacher and do not apply the new knowledge they acquired independently; Instead, they request the teacher to repeat the instructional materials'.	T2.5, T3.5, T5.6 & T6.5 (Reflection on problem identification, problem exploration, solution development & solution evaluation steps).	Forethought, Performance, Reflection
22	T3	'The Students encountered difficulty in creating a schedule and making edits to the times'.	T1.1–T1.3 (Time planning), T4.1–T4.4 (Time management), T7.1–T7.3 (Time management evaluation).	Forethought, Performance, Reflection
		'It was not clear to the students how to define the problem and how to begin solving it'.	T2.1–T2.4 (Problem identification), T3.1–T3.4 (Problem exploration),	Forethought
		'The students encountered difficulties related to self-reflection and self-evaluation'.	T2.5, T3.5, T5.6 & T6.5 (Reflection on problem identification, problem exploration, solution development & solution evaluation steps), T6.3–T6.4 (Monitor & Improving the problem-solving process).	Forethought, Performance, Reflection
24	T4	'I had to repeat the task multiple times and address each student personally. They found it difficult to understand the task. Some managed to continue after overcoming the frustration with the assignment'.	T2.1–T2.5 (Problem identification).	Forethought

Table 3. Quartile calculation of difficulty numbers in 32 problem-solving tasks

	Valid	Missing	Mean	Standard deviation	Minimum	Maximum	25th percentile	50th percentile	75th percentile
Students' difficulties	32	0	7.53	4.50	1.00	17.00	4.00	7.00	9.00

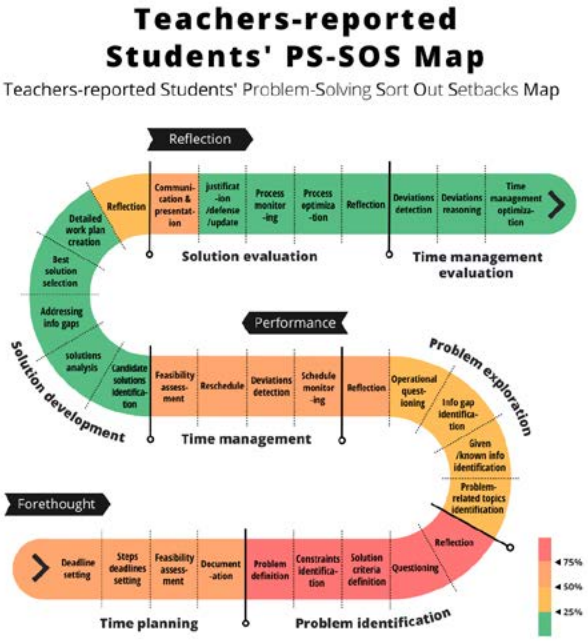


Figure 1: Teacher-reported students' PS-SOS map: Demonstrating students' difficulties mapped against SRL phases and problem-solving steps and tasks, providing a holistic view of the relative share of students' difficulties in each task. For example, the number of difficulties in the task 'Deadline setting' (indicated by the orange colour) is greater than 50% of the other tasks. PS-SOS, problem-solving sort out setbacks; SRL, self-regulated learning.

scale further signifies the quantity of difficulty levels associated with each task. Figure 1 presents the PS-SOS map, visually representing the reported difficulties by teachers.

Students' difficulties in STEM vs. non-STEM

To compare the frequency of students' difficulties reported by STEM teachers with those reported by non-STEM teachers across different tasks and steps within the SRL phases, a quartile calculation was conducted for each population separately. The primary objective was to identify tasks where students encountered more difficulties within each population and subsequently compare the two cases. The results of the analyses are presented in Table 4.

The analysis revealed the following results:

SRL Phase 1: Forethought

- Time planning step: In both STEM and non-STEM groups, a relatively higher number of student difficulties were classified in time planning tasks than in other tasks in the whole learning process (In each task within this step, n = 5 in STEM and n = 4 in non-STEM).
- Problem identification step: Both STEM and non-STEM groups faced the most difficulties within this step, particularly in problem definition, constraints identification, solution criteria definition and questioning tasks (In each of these tasks, n = 7 in STEM and n = 10 in non-STEM). Additionally, according to the STEM teachers' report, reflection on problem identification was less challenging (n = 5) than other tasks in this step, while non-STEM teachers observed a significant number of difficulties in this task, as much as in other tasks within this step (n = 7).
- Problem exploration step: According to the non-STEM teachers' population, the tasks within the problem exploration step were found to be significantly challenging for students compared to other tasks within the problem-solving framework. Meanwhile, according to the STEM teachers' population, these tasks were found to be slightly challenging for students compared to other tasks in the problem-solving framework, particularly in problem-related topics identification, given/known information identification, and information gap identification (In each task within this step, n = 3 in STEM and n = 4 in non-STEM).

SRL Phase 2: Performance

- Time management step: In both STEM and non-STEM groups, a relatively high number of student difficulties were classified as time management tasks (In each task within this step, n = 5 in STEM and n = 4 in non-STEM).

SRL Phase 3: Reflection

- Solution Evaluation Step: According to the non-

Table 4. STEM and non-STEM quartile calculations of difficulty numbers in 32 problem-solving tasks

	Valid		Mean	Standard deviation	Minimum	Maximum	25th percentile	50th percentile	75th percentile
STEM students' difficulties	32	0	3.68	1.89	1.00	7.00	2.00	3.00	5.00
Non-STEM students' difficulties	32	0	3.84	2.74	0.00	10.00	2.00	4.00	4.00

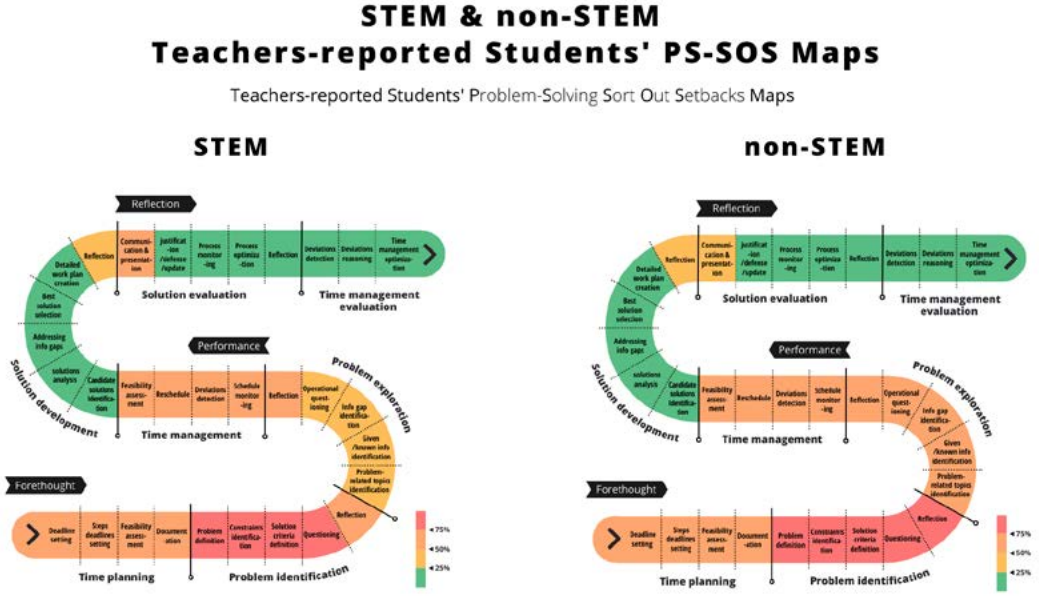


Figure 2: STEM and non-STEM teachers-reported students' PS-SOS maps. PS-SOS, problem-solving sort out setbacks.

STEM teachers' population, within the solution evaluation step, the task of presenting and communicating solutions to peers was found to be slightly challenging for students (n = 3) compared to other tasks in this step, while according to the STEM teachers' population, this task was found to be significantly challenging (n = 5) for students compared to the other tasks.

This analysis provides valuable insights into the specific areas where students in different disciplines struggle within the SRL-problem-solving framework, highlighting the importance of tailored approaches to address these challenges. For each group, STEM and non-STEM, the difficulties that students faced during problem-solving, as identified by their teachers, were compared across different tasks within the framework and visualised as the PS-SOS Map using the previously mentioned calculation. The two PS-SOS maps are presented in Figure 2.

Discussion

Teacher-reported student challenges

Assessing SRL strategies and pinpointing students' challenges in problem-solving poses intricate challenges (Liu & Israel, 2022; Molenaar et al., 2023; Tissenbaum, 2020; Yavuz et al., 2017). This study aims to bridge the gap by organising the difficulties students encounter in problem-solving into the three phases of SRL: forethought, performance and reflection. The identified obstacles pertain to students grappling with video-based SRL training in the explicit teaching mode. The resultant PS-SOS map aims to streamline the creation of support mechanisms, offering precise scaffolding in real time for students navigating independent problem-solving processes.

In particular, the investigation reveals that students encountered the most difficulty in problem identification, potentially impacting their ability to assess solutions.

Additionally, challenges surfaced in planning and time management. Given that problem identification and time planning and management are vital skills for problem-solving (Davidson & Sternberg, 2003; Kim & Hannafin, 2011; Mourtos et al., 2004; Snyder & Snyder, 2008), these study findings highlight the critical need for additional support in these areas during SRL training.

Feedback plays a pivotal role in learning, offering students insights into their competencies and suggestions for enhancement (Cohen et al., 2022). Nevertheless, students in this study grappled significantly when presenting solutions for peer feedback during the solution evaluation phase. Challenges may stem from collaborative issues, lack of confidence and unfamiliarity with evaluation and reflection strategies. The reported difficulties in the reflection task underscore the need for targeted support in developing communication skills for feedback, especially in collaborative settings (Nicolaidou, 2013; van Ginkel et al., 2019).

Students' difficulties in STEM vs. non-STEM

Efforts to introduce a generic video-based training programme for SRL in the explicit teaching mode across various fields highlighted a gap in understanding how it differs between STEM and non-STEM students (Xu et al., 2022). In this investigation, both populations faced notable challenges, particularly in defining the problem and effectively managing time. This in in line with the findings of the overall population, showing that students had significant problems in these aspects during this SRL training initiative.

Moreover, the study identified distinctions in the experiences of STEM and non-STEM teachers when implementing the video-based training programme. According to the STEM educators' report, students encountered a relatively lower number of difficulties in investigating the problem than in the other tasks in the learning process. Conversely, non-STEM teachers experienced a higher number of difficulties in the problem exploration phase than in other tasks. These findings align with previous research, indicating that SRL training programmes in scientific fields yielded a more pronounced enhancement in SRL skills than those in the non-STEM programmes (Dignath & Büttner, 2008; Li et al., 2018; Loong, 2012; Wilson et al., 2012).

Another interesting discovery was that non-STEM teachers' students reported fewer troubles presenting solutions for feedback than in other learning tasks, whereas STEM teachers' students found this part challenging. This is in line with the overall study, showing that students across the board had significant problems presenting solutions for feedback during the evaluation phase.

Limitations and Future Research

It is important to highlight that the problem-solving framework and video-based training were introduced simultaneously to both educators and learners for the first time. The unique nature of this approach introduces a learning curve for both teachers and students, necessitating a careful examination of its impact on teaching methodologies and student outcomes. This underscores the necessity for further exploration and implementation.

Additionally, the information regarding student challenges is solely based on teacher reports, which may not comprehensively capture individual variations among students. Acknowledging this, there might be aspects of student challenges that are less visible to teachers or may be interpreted differently. To enhance our understanding, including a wider array of educators who work with young adolescents is crucial. Equally important is incorporating students' voices directly, offering a fuller picture of their challenges and enriching our approach to addressing them. Furthermore, the study's participant pool was limited and lacked diversity. Further research with a larger population size is recommended to generalise the findings to the broader population and, consequently, to enable more detailed statistical analysis, particularly when comparing STEM and non-STEM groups.

In addition, challenges associated with motivation, emotions and technology were challenging to attribute to specific steps or tasks. Consequently, additional research is warranted to identify effective strategies for motivation and emotional support that could augment the mapping framework. Collecting data on these types of difficulties at the task level and in accordance with the problem-solving process is essential for a better understanding of the challenges students face.

Conclusion

In conclusion, it is essential to tackle the challenges students encounter in problem-solving tasks to enhance effective learning and SRL skills. Teachers play a pivotal role in gaining insights and utilising them to train their students. The problem-solving framework and PS-SOS map can assist in pinpointing problematic steps and tasks. Furthermore, it is crucial to comprehend the challenges students face when implementing generic video-based SRL training in STEM and non-STEM domains separately. This understanding is vital for assessing the effectiveness of such programmes across diverse subjects and serves as a foundation for further exploration in an under-researched domain. To

address these challenges effectively, the development of personalised training and support mechanisms for educators and students is essential. Utilising tools like chatbots or virtual assistants can aid in the real-time identification, understanding and addressing of student difficulties. Professional development programmes for teachers could be implemented to equip them with strategies for leveraging difficulty-based feedback in their teaching. Prioritising the resolution of these difficulties is imperative in enhancing problem-solving skills through future training programmes. Additionally, research should delve into the potential of difficulty-based feedback from teachers or technology to facilitate the learning journey for students. For students, the creation of accessible and responsive feedback systems that use technology, like AI-driven tutoring systems, could provide personalised support. Furthermore, implementing peer support and mentoring programmes where students can share strategies and solutions could foster a collaborative learning environment, empowering students to face challenges together.

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References

Alderman, M. K., & MacDonald, S. (2015). A self-regulatory approach to classroom management: Empowering students and teachers. *Kappa Delta Pi Record, 51*(2), 52–56. https://doi.org/10.1080/00228958.2015.1023145

Araka, E., Maina, E., Gitonga, R., & Oboko, R. (2020). Research trends in measurement and intervention tools for self-regulated learning for e-learning environments—systematic review (2008–2018). *Research and Practice in Technology Enhanced Learning, 15*(1), 1–21. https://doi.org/10.1186/S41039-020-00129-5

Arifin, S., Setyosari, P., Sa'dijah, C., & Kuswandi, D. (2020). The effect of problem-based learning by cognitive style on critical thinking skills and students' retention. *Journal of Technology and Science Education, 10*(2), 271–281. https://doi.org/10.3926/jotse.790

Assi, A., & Cohen, A. (2023). Video-based SRL program for teachers and students. In Proceedings of the 15th International Conference on Education Technology and Computers (pp. 175-182).

Breitwieser, J., Nobbe, L., Biedermann, D., & Brod, G. (2023). Boosting self-regulated learning with mobile interventions: Planning and prompting help children maintain a regular study routine. *Computers & Education, 205*(2023), 1-17. https://doi.org/10.1016/j.compedu.2023.104879

Cáceres, M., Nussbaum, M., González, F., & Gardulski, V. (2021). Is more detailed feedback better for problem-solving? *Interactive Learning Environments, 29*(7), 1189–1210. https://doi.org/10.1080/10494820.2019.1619595

Chen, X., Breslow, L., & De Boer, J. (2018). Analyzing productive learning behaviors for students using immediate corrective feedback in a blended learning environment. *Computers & Education, 117*(2), 59–74. https://doi.org/10.1016/j.compedu.2017.09.013

Cohen, G., Assi, A., Cohen, A., Bronshtein, A., Glick, D., Gabbay, H., & Ezra, O. (2022). Video-Assisted Self-Regulated Learning (SRL) Training: COVID-19 Edition. In: Hilliger, I., Muñoz-Merino, P.J., De Laet, T., Ortega-Arranz, A., Farrell, T. (eds.), *Educating for a New Future: Making Sense of Technology-Enhanced Learning Adoption. EC-TEL 2022. Lecture Notes in Computer Science*, (p.p. 59-73). Springer, Cham. https://doi.org/10.1007/978-3-031-16290-9_5

Cousins, E., Bol, L., & Luo, T. (2022). Exploring long term impacts of self-regulated learning interventions in K 12 contexts: A systematic review. *Current Issues in Education, 23*(1), 1–26. https://doi.org/10.14507/cie.vol23iss1.2013

Csapó, B., & Funke, J. (2017). *The nature of problem solving*. OECD. http://dx.doi.org/10.1787/9789264273955-en

Davidson, J. E., & Sternberg, R. J. (Eds.). (2003). *The psychology of problem solving*. Cambridge University Press.

de Bruijn-Smolders, M., Timmers, C. F., Gawke, J. C., Schoonman, W., & Born, M. P. (2016). Effective self-regulatory processes in higher education: Research findings and future directions. A systematic review. *Studies in Higher Education, 41*(1), 139–158. https://doi.org/10.1080/03075079.2014.915302

De Smul, M., Heirweg, S., Devos, G., & Van Keer, H. (2019). School and teacher determinants underlying teachers' implementation of self-

regulated learning in primary education. *Research Papers in Education, 34*(6), 701–724. https://doi.org/10.1080/02671522.2018.1536888

Dignath, C., & Büttner, G. (2008). Components of fostering self-regulated learning among students: A meta-analysis on intervention studies at primary and secondary school level. *Metacognition and Learning, 3*(3), 231–264. https://doi.org/10.1007/s11409-008-9029-x

Dignath, C., Buettner, G., & Langfeldt, H. P. (2008). How can primary school students learn self-regulated learning strategies most effectively? A meta-analysis on self-regulation training programmes. *Educational Research Review, 3*(2), 101–129. https://doi.org/10.1016/j.edurev.2008.02.003

Dresel, M., & Haugwitz, M. (2008). A computer-based approach to fostering motivation and self-regulated learning. *The Journal of Experimental Education, 77*(1), 3–20. https://doi.org/10.3200/JEXE.77.1.3-20

Efklides, A., & Metallidou, P. (2020). *Applying metacognition and self-regulated learning in the classroom*. Oxford Research Encyclopedia of Education. https://doi.org/10.1093/acrefore/9780190264093.013.961

Fössl, T., Ebner, M., Schön, S., & Holzinger, A. (2016). A field study of a video supported seamless-learning-setting with elementary learners. *Educational Technology & Society, 19*(1), 321–336. https://www.jstor.org/stable/jeductechsoci.19.1.321

Galatsopoulou, F., Kenterelidou, C., Kotsakis, R., & Matsiola, M. (2022). Examining students' perceptions towards video based and video assisted active learning scenarios in journalism and communication courses. *Education Sciences, 12*(2), 74. https://doi.org/10.3390/educsci12020074

Goldin, I., Narciss, S., Foltz, P., & Bauer, M. (2017). New directions in formative feedback in interactive learning environments. *International Journal of Artificial Intelligence in Education, 27*(3), 385–392. https://doi.org/10.1007/s40593-016-0135-7

Hanewald, R. (2013). Transition between primary and secondary school: Why it is important and how it can be supported. *Australian Journal of Teacher Education, 38*(1), 62–74. https://doi.org/10.14221/ajte.2013v38n1.7

Hattie, J. (2008). Visible learning: A synthesis of over 800 meta-analyses relating to achievement. Routledge.

Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of Educational Research, 77*(1), 81–112. https://doi.org/10.3102/003465430298487

Heaysman, O., & Kramarski, B. (2022). Enhancing students' metacognition, achievement and transfer between domains: Effects of the simulative 'SRL-AIDE' parallel teacher–student program. *International Journal of Educational Research, 116*(2022), 102074. https://doi.org/10.1016/j.ijer.2022.102074

He, W., Holton, A., Farkas, G., & Warschauer, M. (2016). The effects of flipped instruction on out of class study time, exam performance, and student perceptions. *Learning and Instruction, 45*(2016), 61–71. https://doi.org/10.1016/j.learninstruc.2016.07.001

Huertas, A., Vesga, G., Vergara, A., & Romero, M. (2015). Effect of a computational scaffolding in the development of secondary students' metacognitive skills. *International Journal of Technology Enhanced Learning, 7*(2), 143–159. https://doi.org/10.1504/IJTEL.2015.072030

Jansen, R. S., van Leeuwen, A., Janssen, J., Conijn, R., & Kester, L. (2020). Supporting learners' self-regulated learning in Massive Open Online Courses. *Computers & Education, 146*(2020), 103771. https://doi.org/10.1016/j.compedu.2019.103771

Jansen, R. S., van Leeuwen, A., Janssen, J., Kester, L. (2018). Validation of the Revised Self-regulated Online Learning Questionnaire. In V. Pammer-Schindler, M. Pérez-Sanagustín, H. Drachsler, R. Elferink, & M. Scheffel, (Eds.), *Lifelong technology-enhanced learning. EC-TEL 2018. Lecture Notes in computer science* (pp. 116–121). Springer. https://doi.org/10.1007/978-3-319-98572-5_9

Kim, M. C., & Hannafin, M. J. (2011). Scaffolding problem solving in technology-enhanced learning environments (TELEs): Bridging research and theory with practice. *Computers & Education, 56*(2), 403–417. https://doi.org/10.1016/j.compedu.2010.08.024

Kistner, S., Rakoczy, K., Otto, B., Dignath-van Ewijk, C., Büttner, G., & Klieme, E. (2010). Promotion of self-regulated learning in classrooms: Investigating frequency, quality, and consequences for student performance. *Metacognition and Learning, 5*(2), 157–171. https://doi.org/10.1007/s11409-010-9055-3

Khoiriyah, A. J., & Husamah, H. (2018). Problem-based learning: Creative thinking skills, problem-solving skills, and learning outcome of seventh grade students. *JPBI (Jurnal Pendidikan Biologi Indonesia), 4*(2), 151–160. https://doi.org/10.22219/jpbi.v4i2.5804

Kostons, D., Van Gog, T., & Paas, F. (2012). Training self-assessment and task-selection skills: A cognitive approach to improving self-regulated learning. *Learning and Instruction, 22*(2), 121–132. https://doi.org/10.1016/j.learninstruc.2011.08.004

Kulik, J. A., & Fletcher, J. D. (2016). Effectiveness of intelligent tutoring systems: A meta-analytic review. *Review of Educational Research, 86*(1), 42–78. https://doi.org/10.3102/0034654315581420

Lai, C. L., & Hwang, G. J. (2016). A self-regulated flipped classroom approach to improving students' learning performance in a mathematics course. *Computers & Education, 100*(2016), 126–140. https://doi.org/10.1016/j.compedu.2016.05.006

Li, J., Ye, H., Tang, Y. Z., & Hu, X. (2018). What are the effects of self-regulation phases and strategies for Chinese students? A meta-analysis of two decades research of the association between self-regulation and academic performance. *Frontiers in Psychology, 9*(2018), 1-13. https://doi.org/10.3389/fpsyg.2018.02434

Liu, T., & Israel, M. (2022). Uncovering students' problem-solving processes in game-based learning environments. *Computers & Education, 182*(2022), 104462. https://doi.org/10.1016/j.compedu.2022.104462

Loong, T. E. (2012). Self-regulated learning strategies and their effects on math performance of pre-university international students in Malaysia. *Journal of Education and Vocational Research, 3*(3), 89–97. https://doi.org/10.22610/jevr.v3i3.54

Maier, U., Wolf, N., & Randler, C. (2016). Effects of a computer-assisted formative assessment intervention based on multiple-tier diagnostic items and different feedback types. *Computers & Education, 95*(2016), 85–98. https://doi.org/10.1016/j.compedu.2015.12.002

Miller, K., Sonnert, G., & Sadler, P. (2018). The influence of students' participation in STEM competitions on their interest in STEM careers. *International Journal of Science Education, Part B, 8*(2), 95–114. https://doi.org/10.1080/21548455.2017.1397298

Molenaar, I., de Mooij, S., Azevedo, R., Bannert, M., Järvelä, S., & Gašević, D. (2023). Measuring self-regulated learning and the role of AI: Five years of research using multimodal multichannel data. *Computers in Human Behavior, 139*(2023), 1-9. https://doi.org/10.1016/j.chb.2022.107540

Moos, D. C., & Bonde, C. (2016). Flipping the classroom: Embedding self-regulated learning prompts in videos. *Technology, Knowledge and Learning, 21*(2016), 225–242. https://doi.org/10.1007/s10758-015-9269-1

Mourtos, N. J., Okamoto, N. D., & Rhee, J. (2004). *Defining, teaching, and assessing problem solving skills*. In Z. Pudlowski (Ed.), 7th UICEE Annual Conference on Engineering Education (pp. 1–5). Clayton, Vic. : UNESCO International Centre for Engineering Education.

Nicolaidou, I. (2013). E-portfolios supporting primary students' writing performance and peer feedback. *Computers & Education, 68*(2013), 404–415. https://doi.org/10.1016/j.compedu.2013.06.004

OECD. (2021). *OECD skills outlook 2021: Learning for life*. OECD Publishing. https://doi.org/10.1787/0ae365b4-en

Panadero, E., Klug, J., & Järvelä, S. (2016). Third wave of measurement in the self-regulated learning field: When measurement and intervention come hand in hand. *Scandinavian Journal of Educational Research, 60*(6), 723–735. https://doi.org/10.1080/00313831.2015.1066436

Pintrich, P. R. (1999). The role of motivation in promoting and sustaining self-regulated learning. *International Journal of Educational Research, 31*(6), 459–470. https://doi.org/10.1016/S0883-0355(99)00015-4

Raaijmakers, S. F., Baars, M., Schaap, L., Paas, F., Van Merriënboer, J., & Van Gog, T. (2018). Training self-regulated learning skills with video modeling examples: Do task-selection skills transfer? *Instructional Science, 46*(2), 273–290. https://doi.org/10.1007/s11251-017-9434-0

Reimers, F. M., & Chung, C. K. (Eds.). (2019). Teaching and learning for the twenty-first century: Educational goals, policies, and curricula from six nations. Harvard Education Press.

Sanders, S., Rollins, L. H., & McFall, A. (2023). Aiming high: Applying goal setting to social and emotional learning skills in the elementary classroom. *Beyond Behavior, 32*(1), 4–14. https://doi.org/10.1177/10742956221145692

Schaeffer, L. M., Margulieux, L. E., Chen, D., & Catrambone, R. (2016). Feedback via educational technology. In L. Lin & R. Atkinson (Eds.), *Educational technologies: Challenges, applications, and learning outcomes*. (pp. 59–72). Nova Science Publishers.

Schloemer, P. & Brenan, K. (2006). From students to learners: Developing self-regulated learning. *Journal of Education for Business, 82*(2), 81–87. https://doi.org/10.3200/JOEB.82.2.81-87

Schunemann, N., Sporer, N., Vollinger, V. A., & Brunstein, C. (2017). Peer feedback mediates the impact of self-regulation procedures on strategy use and reading comprehension in reciprocal teaching groups. *Instructional Science, 45*(4), 395–415. https://doi.org/10.1007/s11251-017-9409-1

Snyder, L. G., & Snyder, M. J. (2008). Teaching critical thinking and problem-solving skills. *The Journal of Research in Business Education, 50*(2), 90–99.

Sulisworo, D., Fatimah, N., & Sunaryati, S. S. (2020).

A quick study on SRL profiles of online learning participants during the anticipation of the spread of COVID-19. *International Journal of Evaluation and Research in Education, 9*(3), 723–730. https://doi.org/10.11591/ijere.v9i3.20642

Tissenbaum, M. (2020). I see what you did there! Divergent collaboration and learner transitions from unproductive to productive states in open-ended inquiry. *Computers & Education, 145*(2020), 1-15. https://doi.org/10.1016/j.compedu.2019.103739

Uka, A., & Uka, A. (2020). The effect of students' experience with the transition from primary to secondary school on self-regulated learning and motivation. *Sustainability, 12*(20), 2–16. https://doi.org/10.3390/su12208519

van Alten, D. C. D., Phielix, C., Janssen, J., & Kester, L. (2020). Self-regulated learning support in flipped learning videos enhances learning outcomes. *Computers & Education, 158*(2020), 1-16. https://doi.org/10.1016/j.compedu.2020.104000

van den Bergh, L., Ros, A., & Beijaard, D. (2013a). Feedback during active learning: Elementary school teachers' beliefs and perceived problems. *Educational Studies, 39*(4), 418–430. https://doi.org/10.1080/03055698.2013.767188

van den Bergh, L., Ros, A., & Beijaard, D. (2013b). Teacher feedback during active learning: Current practices in primary schools. *British Journal of Educational Psychology, 83*(2), 341–362. https://doi.org/10.1111/j.2044-8279.2012.02073.x

van Ginkel, S., Gulikers, J., Biemans, H., Noroozi, O., Roozen, M., Bos, T., van Tilborg, R., van Halteren, M., & Mulder, M. (2019). Fostering oral presentation competence through a virtual reality-based task for delivering feedback. *Computers & Education, 134*(3), 78–97. https://doi.org/10.1016/j.compedu.2019.02.006

Vilkova, K. (2022). The promises and pitfalls of self-regulated learning interventions in MOOCs. *Technology, Knowledge and Learning, 27*(3), 689–705. https://doi.org/10.1007/s10758-021-09580-9

Vrieling, E., Stijnen, S., & Bastiaens, T. (2018). Successful learning: Balancing self-regulation with instructional planning. *Teaching in Higher Education, 23*(6), 685–700. https://doi.org/10.1080/13562517.2017.1414784

Wang, T. H. (2011). Developing web-based assessment strategies for facilitating junior high school students to perform self-regulated learning in an e-learning environment. *Computers & Education, 57*(2), 1801–1812. https://doi.org/10.1016/j.compedu.2011.01.003

Wilson, Z. S., Holmes, L., deGravelles, K., Sylvain, M. R., Batiste, L., Johnson, M., McGuire, S. Y, Pang, S. S., & Warner, I. M. (2012). Hierarchical mentoring: A transformative strategy for improving diversity and retention in undergraduate STEM disciplines. *Journal of Science Education and Technology, 21*(1), 148–156. https://doi.org/10.1007/s10956-011-9292-5

Winters, F. I., Greene, J. A., & Costich, C. M. (2008). Self-regulation of learning within computer-based learning environments: A critical analysis. *Educational Psychology Review, 20*(4), 429–444. https://doi.org/10.1007/s10648-008-9080-9

Wolters, C. A., & Pintrich, P. R. (1998). Contextual differences in student motivation and self-regulated learning in mathematics, English, and social studies classrooms. *Instructional Science, 26*(1998), 27–47. https://doi.org/10.1023/A:1003035929216

Wong, J., Baars, M., de Koning, B., & Paas, F. (2021). Examining the use of prompts to facilitate self-regulated learning in massive open online courses. *Computers in Human Behavior, 115*(3), 1–27. https://doi.org/10.1016/j.chb.2020.106596

Xu, Z., Zhao, Y., Zhang, B., Liew, J., & Kogut, A. (2022). A meta-analysis of the efficacy of self-regulated learning interventions on academic achievement in online and blended environments in K-12 and higher education. *Behaviour & Information Technology, 42*(16), 2911–2931. https://doi.org/10.1080/0144929X.2022.2151935

Xu, Z., Zhao, Y., Liew, J., Zhou, X., & Kogut, A. (2023). Synthesizing research evidence on self-regulated learning and academic achievement in online and blended learning environments: A scoping review. *Educational Research Review, 32*(2023), 1-17. https://doi.org/10.1016/j.edurev.2023.100510

Yakubova, G., Hughes, E. M., & Chen, B. B. (2020). Teaching students with ASD to solve fraction computations using a video modeling instructional package. *Research in Developmental Disabilities, 101*(2020), 1-11. https://doi.org/10.1016/j.ridd.2020.103637

Yavuz, G., Yasemin, D., & Arslan, Ç. (2017). Elementary School Students Perception Levels of Problem-Solving Skills. *Universal Journal of Educational Research, 5*(11), 1896–1901. https://doi.org/10.13189/ujer.2017.051106

Zheng, L. (2016). The effectiveness of self-regulated learning scaffolds on academic performance in computer-based learning environments: A meta-analysis. *Asia Pacific Education Review, 17*(2), 187–202. https://doi.org/10.1007/s12564-016-9426-9

Zimmerman, B. J. (1998). Developing self-fulfilling

cycles of academic regulation: An analysis of exemplary instructional models. In D. H. Schunk & B. J. Zimmerman (Eds.), *Self-regulated learning: From teaching to self-reflective practice* (pp. 1–19). Guilford.

Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In M. Boekaerts, P. R. Pintrich, & M. Zeidner, (Eds.), *Handbook of self-regulation* (pp. 13–39). Academic Press.

Zimmerman, B. (2008). Investigating self-regulation and motivation: Historical background, methodological developments, and future prospects. *American Educational Research Journal, 45*(1), 166–183. https://doi.org/10.3102/0002831207312909

Zimmerman, B., & Barry J. (2013). From cognitive modeling to self-regulation: A social cognitive career path. *Educational Psychologist, 48*(3), 135–147. https://doi.org/10.1080/00461520.2013.794676

Zimmerman, B. J., & Campillo, M. (2003). Motivating self-regulated problem solvers. In J. E. Davidson & R. J. Sternberg, (Eds.), *The psychology of problem solving* (pp. 233–262). Cambridge.