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Piloting Supplementary Materials Aimed at Developing Students' Problem-Solving and Self-Regulated Learning Skills

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Abstract. Developing students' transversal skills is an important education goal, and its implementation requires equipping teachers with appropriate supplementary materials and methodological support. The aim of the research was to develop supplementary materials aimed at enhancing students' problem-solving and self-regulated learning skills, and to pilot the materials in secondary school lessons. Problem-solving and self-regulated learning skills are transversal skills, so the supplementary materials were not subject-specific and were designed to help teachers promote these students' skills in the lessons of any school subjects. The set of materials comprised 10 worksheets with both questions and prompts that could promote the development of students' problem-solving and self-regulated learning skills. In total 139 teachers applied to pilot materials for a month, and 36 of them provided feedback by completing a questionnaire. Participants represented different schools and school subjects and were teachers of Grades 5–12; the majority of them (80,6%) had more than 21 years of work experience. Overall, participants evaluated the materials as very helpful for developing students' problem-solving and self-regulated learning skills, as the materials paid particular attention to planning, self-monitoring and self-reflection through a detailed focus on each of these processes, stimulated by questions in the materials. However, the teachers also concluded that the students lacked the in-depth metacognitive skills to self-analyze and self-regulate their performance, and teachers provided feedback and valuable suggestions for improving the supplementary materials. The study contributes to the research area and work of practitioners by demonstrating that appropriately designed supplementary materials are a valuable and useful tool to help teachers develop students' problem-solving and self-regulated learning skills.

Keywords: supplementary materials; piloting; problem-solving skills; self-regulated learning skills; teacher feedback

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1. Introduction

In a rapidly developing environment, learners' skills for solving challenging tasks and using effective strategies are of great importance. The ability to use a vast array of internal cognitive processes and to self-regulate one's actions, behavior and motivation are crucial for learning and can be achieved by developing students' problem-solving (PS) and self-regulated learning (SRL) skills. PS and SRL are among the most important transversal skills, and the development of different transversal skills has received much attention in education in recent decades, because they are acknowledged as among the most important skills for the future (Suto & Eccles, 2014; Vincent-Lancrin et al., 2019). Integrating these skills into the curriculum and teaching and reinforcing them effectively in everyday lessons are essential for their successful acquisition.

Although a number of researchers have studied PS from different perspectives (e.g. OECD, 2013; Sukontawaree et al., 2022; Wu & Molnár, 2022), and the different aspects of SRL (Schunk & DiBenedetto, 2021; Zimmerman, 2015) for several decades, scientists still highlight the necessity of improving teachers' PS skills (Liljedahl & Cai, 2021), and their knowledge and skills for developing students' SRL skills (Lawson et al., 2019; Linde et al., 2022).

To advance SRL skills in the PS process, Ifenthaler (2012) elaborates on direct external support supplemented by direct instructions, indirect external support and prompts that facilitate comprehension and the use of PS strategies; these findings are confirmed by other researchers (Breitwieser et al., 2022). It is claimed that metacognition and the promotion of specific strategies are crucial for both PS and SRL (Schuster et al., 2023; Zepeda & Nokes-Malach, 2023), and asking reflective and thought-provoking questions can serve as useful prompts in the PS process. To help teachers develop students' PS and SRL skills, teachers could be supported with ready-to-use lesson plans or methodologically well developed supplementary materials, for example, worksheets, that could be applied in the learning process.

Therefore, the aim of this research was to develop a set of supplementary materials that could be used to enhance students' PS and SRL skills. The research questions were as follows: What are teachers' perceptions and experience with the materials? Can the use of such additional worksheets help to develop students' PS and SRL skills? To answer these questions, the literature on PS and SRL was reviewed, and the supplementary materials were developed and piloted. Then teachers' views and experiences of using the materials were analyzed, and the suggestions made for improving them were summarized.

2. Literature Review

The main concepts of this study are PS skills and SRL skills, as two very important transversal skills that are included in curricula in numerous countries, including Latvia (Cabinet of Ministers, 2018). Both concepts are central elements of the supplementary materials developed for teachers, and will be explained further. In addition, enhancing transversal skills for students via various methods, the

rationale for developing the supplementary materials, and the process of piloting them in the framework of the current research will be discussed.

2.1. Problem-Solving Skills

The concept of PS skills has been studied widely by the fields of psychology and education and there are various and rather different approaches to defining and researching PS skills (see Contente & Galvão, 2022; Maries & Singh, 2023; Wu & Molnár, 2022). A thorough understanding of PS skills is crucial, as they are listed among the crucial life skills (or transversal skills) that students have to acquire. One of the seminal authors in this field, Polya (1957), stated that there are several processes or steps involved in PS: 1) understanding the problem, 2) devising a plan, 3) carrying out the plan, and 4) looking back. Similar ideas are included in modern frameworks for student PS (Dostál, 2015), for example, in the international PISA assessment, that several important processes underlie PS: 1) exploring and understanding; 2) representing and formulating; 3) planning and executing; and 4) monitoring and reflecting (OECD, 2013). In psychology, PS has been studied in various ways. For example, in the approach to studying complex problems, computerized tests are typically used to assess two key aspects of PS: a) knowledge acquisition (exploring the rules of the problem); and b) knowledge application (using the acquired knowledge to solve the problem effectively) (Fischer et al., 2012). Mandal (2019), on the other hand, lists very detailed theoretical steps of PS in education settings: 1) defining the problem; 2) identifying the solution options; 3) identifying the best solution; 4) planning; and 5) evaluating the result.

Theoretically, the number of processes or steps of PS vary, though the content of these steps is similar. It is also important to acknowledge that PS processes are not linear, which means that not all processes have to follow a “theoretical sequence” and not all steps need to be followed in all cases, and some steps may be omitted (OECD, 2013). This justifies an approach that focuses on specific parts of PS separately within the learning process.

For example, a teacher could focus on planning skills in one lesson and then on the skill of evaluating the work in the next lesson. This is the approach that was used by the authors of the current study. In the field of education, there are contextual approaches to the study and development of PS, such as PS in mathematics or chemistry (Sidenvall et al., 2022; Tóthová & Rusek, 2021), and transversal skills-based approaches that aim to describe PS skills more generally, so that they can be implemented as transversal skills in different subject areas. This is in the case in Latvia, where PS and SRL skills are among the core competences that students are expected to develop in all school subjects (Cabinet of Ministers, 2018; Skola2030, 2019a). The current research is based on this approach, that of providing general materials and enabling the integration of the elements of PS and SRL in various school subjects.

2.2. Self-Regulated Learning

The term SRL is a broad “umbrella term” that includes numerous variables that significantly affect the process of learning (Cleary, 2018; Panadero, 2017). SRL is the self-initiated engagement in metacognitive, motivational and behavioral processes with the intention of attaining knowledge and skills. (Zimmerman, 2015). SRL has been widely studied and most researchers describe it as a three-phase cycle, consisting of 1) a forethought phase, 2) performance or volitional phase, and 3) self-reflection phase (Zimmerman & Moylan, 2009). Each of these phases consists of a set of processes that include the use of particular strategies such as goal setting, strategic planning, time management, help-seeking and self-evaluation (Zimmerman et al., 2017), which are also important components of PS. To cope with PS tasks, students need the skills to apply these strategies and the ability to self-regulate accordingly (Van Gog et al., 2020).

The Competence Approach to Curriculum project that was introduced in Latvia in 2016 (Skola2030, 2019b) considers SLR and PS as the two of the six transversal skills. The unexpected occurrence of the Covid-19 pandemic during the introduction phase of this new competence-based curriculum project highlighted the vital importance of developing students’ PS and SRL skills, as a way to help students deal with new, unprecedented experiences (Hačatrijana, 2022; Sarva et al., 2021).

Despite the optimistic goals of education policy, teachers lack appropriate skills and knowledge of SRL to develop students’ SRL skills (Linde et al., 2022). Therefore, additional supplementary materials that provide methodological suggestions for using the materials are considered of great importance, as they not only set out the PS strategies, but also pay attention to self-regulation processes, such as task analysis, goal setting, strategic planning, outcome expectation, choosing appropriate strategies, time management, environmental structuring, seeking help, self-observation, metacognitive monitoring, self-judgment and self-reflection, which are outlined in the SRL model of Zimmerman and Moylan (2009).

2.3. Rationale for the Supplementary Materials Piloted in the Current Research

The set of materials we designed comprised 10 worksheets with detailed, step-by-step tasks for students to follow, questions that must be answered, and a brochure for teachers with a short introduction outlining the necessity of developing students' PS and SRL skills, and supplementary information and suggestions for using the worksheets. Two of the worksheets (WS) are reminder sheets (RS) that can help students’ attend to their learning by following definite steps.

Each worksheet focuses on either the three-phase SRL and PS processes as a whole, including goal setting and planning, self-observation and self-reflection, or only on a specific part of SRL or PS. For example, WS1 focuses on the ability to understand and comprehend the given task or problem (e.g., one of the instructions is, “Write down all the relevant terms or keywords related to the task!”), whereas RS7 provides a reminder about the important steps of solving the task (providing several prompts, e.g., “Have I ever encountered a similar task

before?", "Make notes or a drawing to understand the task/problem better!"). WS3 is focused on self-evaluating and monitoring progress (e.g., "Do I have a clear plan: what needs to be done and in what order?", "What else needs to be done to complete the task?"), while WS10 is focused on SRL more generally (e.g., "Which of your skills would you like to improve the most? In what ways could you do it?"). The questions included in the supplementary materials work as prompts to foster students' learning skills (Ifenthaler, 2012).

During skills development, students need to experience that they are able to solve different types of problems independently, thus, increase their confidence to handle difficulties in general, as self-efficacy goes hand in hand with metacognition and learning (Lehmann et al., 2014; Uzuntiryaki-Kondakci & Capa-Aydin, 2013). Therefore, teaching certain aspects of PS step by step can be beneficial, as students may experience that they are good at some parts of PS, such as understanding a task effectively, or knowing exactly what they were good at and what caused difficulties. For this reason, small steps can be effective and easier to implement, especially for teachers who may feel unsure about the most appropriate ways to integrate transversal skills into their lessons.

Sometimes it can be difficult to clearly distinguish between specific phases or aspects of PS (e.g., defining the problem, planning and implementing the solution, and evaluating it), as studies using factor analysis found that empirical evidence shows that the planning process goes hand in hand with the task implementation process (Hačatrljana, 2022). These processes may be clear and distinct theoretically, but may overlap in practice. It can be assumed that this overlap of PS stages reflects the trial-and-error approach typically practiced by students, which distinguishes students from 'experts' in the use of PS processes (Maries & Singh, 2023). The materials used in this study were designed to encourage students to follow a clear, step-by-step approach when solving problems.

Various authors have proposed similar approaches to enhancing PS through a step-by-step, detailed process (e.g., Dostál, 2015; Maries & Singh, 2023). It is important to use external representations, such as taking notes or drawing models, to solve problems and tasks more effectively, as it reduces the cognitive load on a person's working memory (Gupta & Zheng, 2020). If younger students do not have the habit of notetaking, highlighting important terms or drawing schemes or visuals to help them understand the problem, it is important to encourage this habit by explicitly asking them to take notes, or to highlight or to list the important terms written in the task description. This approach was incorporated in the creation of the supplementary materials, especially in worksheets focusing on PS.

The importance of teachers' role in developing PS skills is discussed in the literature (e.g., Mandal, 2019), by an emphasis on pedagogical, methodological and student-centered strategies to enhance PS skills that can also be transferred to other, general skills. In the empirical study described in the current paper, these strategies were used in a mixed manner. Although teachers were provided with ready-to-use supplementary materials to develop students' PS and SRL skills,

they were encouraged to actively adapt the materials to the needs of the target audience and to achieve the objectives of the lesson. Asking questions that encourage students to think is considered an important approach (Mandal, 2019) and is recommended by the supplementary materials for this study, as most of the worksheets contain very detailed questions to enhance students' metacognition during the learning process.

Transversal skills, including PS and SRL skills, are defined rather broadly and generally in policy documents, however, the necessity to teach them is embedded in subject-specific curricula, so teachers need a clear methodology for implementing these skills in the classroom (Vincent-Lancrin et al., 2019). The research carried out in the OECD project on developing creativity and critical thinking skills revealed that around half of teachers claimed that their high workload did not leave time for elaborating on pedagogical approaches to developing these transversal skills, and 20% of teachers reported that their subject content did not leave space for fostering critical thinking (Vincent-Lancrin et al., 2019).

Therefore, it can be concluded that teachers are primarily focused on content, also in the case of Latvia, where the introduction of transversal skills is expected to be implemented alongside the new competence-based content (Skola2030, 2019b). Due to teachers' heavy workloads, teachers will only try a new approach if it does not interfere with their main tasks of delivering the content, and if they do not have to spend extra time developing new materials to develop transversal skills. This indicates that teachers need ready-made materials (e.g., worksheets), such as the ones used in this study, but with the possibility of adapting them during the implementation phase, according to the teachers' professional competence and the needs of the particular class (Bouckaert, 2019; González et al., 2017).

There are similarities in SRL and PS processes. SRL is a cyclical process that starts with planning and setting goals in a forethought phase, followed by self-monitored and self-guided activities in the performance phase, and self-reflection and adapting further activities that will be applied in the further learning process (Cleary et al., 2012), which suggests continuity of activities in order to improve the learning process. Similarly, it is important for PS, because, for complex tasks, it is crucial to follow a full cycle of PS and to understand the problem, know the best strategies to generate solutions, and to plan and execute them; however, one can use only some PS processes for very brief, specific tasks. This justifies an approach that develops students' skills gradually by training small elements of PS and SRL, like it was done the current research, and that uses feedback to advance the teacher's and student's activities in the learning process. It was important to pilot the new materials and to obtain teacher feedback on the materials that had been developed, and on teacher observations of their students' performance and attitudes.

3. Methodology

3.1. Sample

A total of 139 teachers signed up to receive new supplementary materials to use in their daily work, though only 36 participants (1 man and 35 women) provided feedback on the piloted materials by completing the assessment questionnaire. Most of the teachers who provided feedback ($n = 16$; 44%) were 55–64 years old, 11 (30,5%) were 45–54 years old, 1 was 65 or older. Of the younger teachers, 3 were aged 25–34 and 5 were aged 35–44 years. Most of the teachers had a great deal of experience in the field: 16 teachers (44%) had been working in schools for 31–40 years, 11 teachers for 21–30 years; only 9 teachers had less than 20 years' experience. The teachers represented all the regions of Latvia and different types of general education and vocational education institutions: 21 participants taught at secondary schools, 6 at gymnasiums, 5 at state gymnasiums, 2 at primary schools, 1 at a vocational education institution, and 1 teacher taught at a school for students with functional disabilities.

3.2. Instruments

Teachers were asked to complete a questionnaire after they had tried out the supplementary materials with their students (see Appendix 1). In the questionnaire, teachers were required to give their detailed opinions about three of the worksheets they had used, by evaluating nine statements about each worksheet, such as, "This worksheet helped students acknowledge their strengths and weaknesses", or "This worksheet helped students' develop the ability to analyze their work and draw conclusions", on a 6-point Likert scale. The last question was open ended, and asked teachers to elaborate on their practice in using the worksheet. They could indicate whether and what kind of adjustments they had made, what they had observed while using the worksheets, and make suggestions for improvement. The questionnaire this study used was created for the purpose of the current study and is not a standardized instrument.

3.3. Procedure

Researchers followed an action research methodology (Johnson, 2012) with the following steps. First, teachers were requested to pilot a set of materials on developing students' PS and SRL skills and the teachers who expressed interest in trying out new materials in their lessons received a set of supplementary materials comprising 10 editable worksheets (two of them were reminder sheets) and a brochure with suggestions for using it. The participants were asked to try out at least six worksheets over a one-month period. After the pilot period, teachers received a Google Forms questionnaire to evaluate at least three worksheets, rating different aspects of the worksheets on a 6-point Likert scale and answering open-ended questions on (a) the usefulness of the worksheets, (b) teachers' experiences of using the worksheets and observations of students' skills when using them, (c) whether they had adapted the worksheets, and (d) whether they had suggestions for improving them. Ethical considerations were applied and the research was approved by the Research Ethics Committee of Social Sciences and Humanities of the University of Latvia (November 21, 2022; No. 71-46/70).

4. Results

4.1. Descriptive Statistics

To achieve the aims of the research, both quantitative and qualitative data analysis was done. The descriptive data and quantitative analysis will be presented first, followed by the qualitative analysis. Altogether, the worksheets and reminder sheets were used 120 times. The pilot was mostly aimed at teachers of Grades 7–12, and the materials were mostly used by Grade 9 teachers (24 teachers), while teachers of Grade 7 ($n = 20$), 11 ($n = 19$), 10 ($n = 18$) and 8 ($n = 18$) also used it; few teachers of Grades 5 and 6 used it ($n = 3$ and $n = 7$ respectively). In the last grade of secondary school, Grade 12, the materials were used only 11 times. This could be because some of the worksheets could have been too simple, and not suitable for the oldest student age group. A Grade 10 teacher reported that students had suggested having the worksheets in an electronic format (which is generally well accepted by students), to make it easier for students to type in their answers and make amendments.

The worksheets were mostly used in class lessons ($n = 36$; 30%), which took place once a week at all the schools, which provided the class teacher with an opportunity to meet the whole class and discuss any cultural, educational, organizational, individual, class and school-related issues. One of the reasons for using the materials in the class lessons could be the absence of a strict syllabus that allowed teachers to be flexible and adjust the planned activities, which was not the case for subject lessons, particularly those subject lessons that take place once or twice a week. Worksheets were also often used in subjects such as a foreign language ($n = 26$; 21,7%), a native language ($n = 19$; 15,8%), natural sciences ($n = 14$; 11,7%), history and social science ($n = 13$; 10,8%) and mathematics ($n = 8$; 6,7%), thus, showing that transversal skills can be developed in various fields.

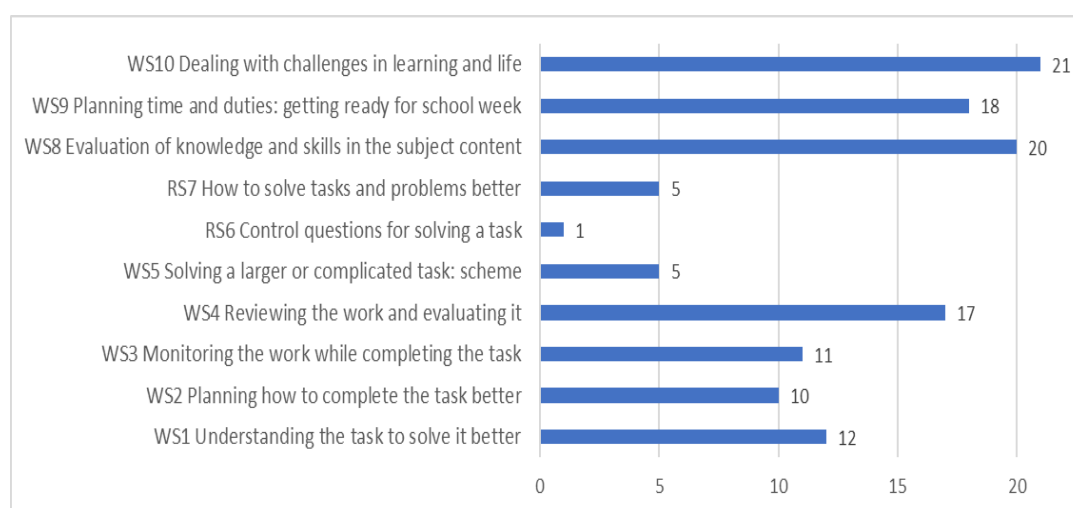


Figure 1. Frequency of using each worksheet (WS) or reminder sheet (RS)

Figure 1 shows that most of the teachers used worksheets WS10, WS9, WS8 and WS4. Reminder sheets RS6 ($n = 1$) and RS7 ($n = 5$) were used much less often. One of the reasons could be that an RS would work better as a poster in the classroom,

which students could be reminded to refer to while completing tasks. A teacher of Grade 5 acknowledged that RS7 was useful as a reminder during tests, when students needed to remember PS steps; it helped students with discipline problems, and to cope with anxiety during the test.

4.2. Teacher Ratings of the Worksheets

First, teachers had to rate the general usefulness of each WS or RS, based on whether they believed the particular material helped them in their work (see Figure 2). It is clear that materials received generally high approval ratings from the teachers.

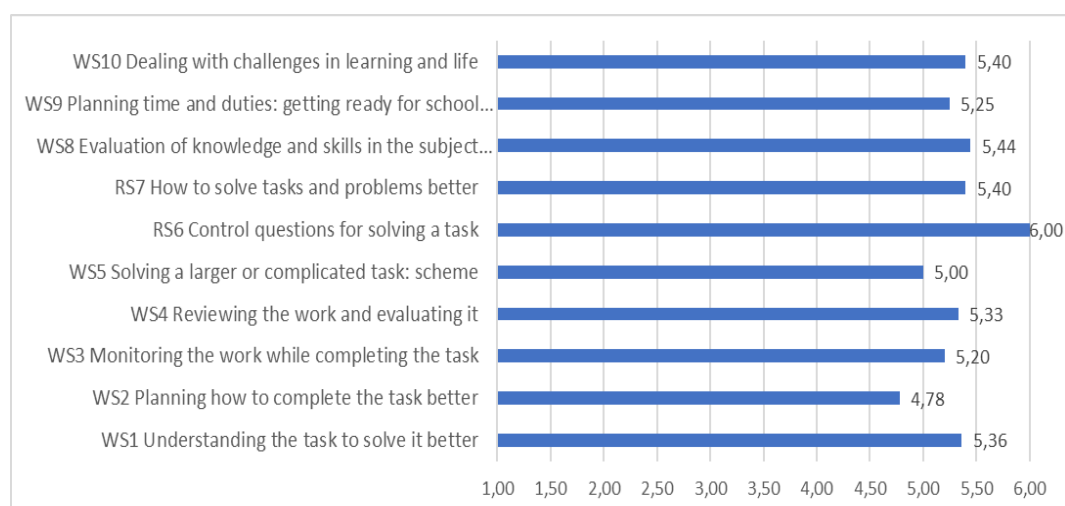


Figure 2. Average evaluations by teachers of the general usefulness of each worksheet

In the results section, only a selection of teachers' evaluations is presented. We show important findings, for example, whether the teachers' ratings correspond with or deviate from the initial aims set for a WS by the researchers.

Although the set of supplementary materials as a whole was intended to develop PS and SRL, each worksheet had a specific and more narrow purpose and content. WS1 was aimed at training the skill of understanding the task or the problem. Answers teachers gave in relation to these aspects are presented in Figure 3. It can be seen that teachers acknowledged the focus of this WS in their evaluations, and they rated the PS aspect higher, by acknowledging that a thorough understanding of the task is an important part of PS.

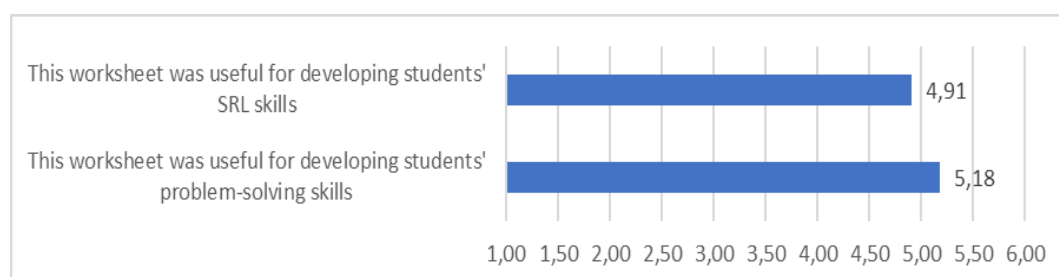


Figure 3. Selection of teachers' average evaluations of the WS1

Figure 4 shows that, according to the teachers, WS2, which initially focused on training students' skills to plan and think about solutions to a problem, was considered to be more useful for developing SRL than PS. This indicates that planning is something that teachers associate more with SRL and is applicable not only to PS, but to a variety of tasks.

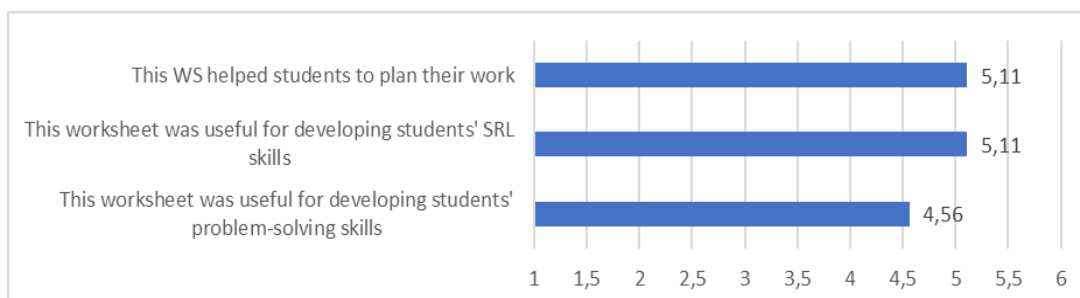


Figure 4. Selection of teachers' average evaluations of WS2

WS3 was aimed at developing students' skills of monitoring their work in progress and making changes to their initial plans to successfully continue a task. Teachers' ratings show that they found the worksheet more helpful for developing students' skills for analyzing their work, than for monitoring the work in progress (see Figure 5).

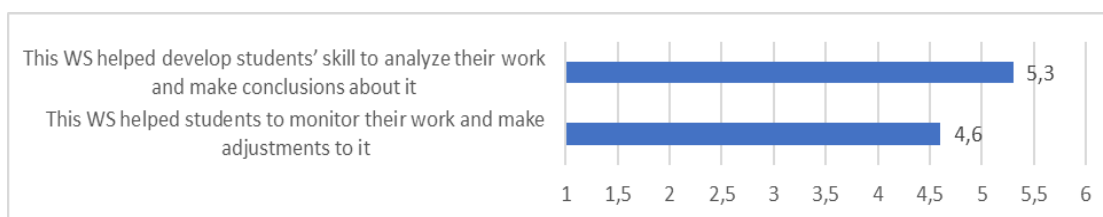


Figure 5. Selection of teachers' average evaluations of WS3

In some instances, teachers' ratings coincided precisely with the initial aim of the materials. For example, WS8 was intended to foster students' SRL, in particular, the skill to precisely analyze the extent to which they had acquired knowledge of a particular study topic. It can be seen in Figure 6 that teachers gave these aspects high ratings.

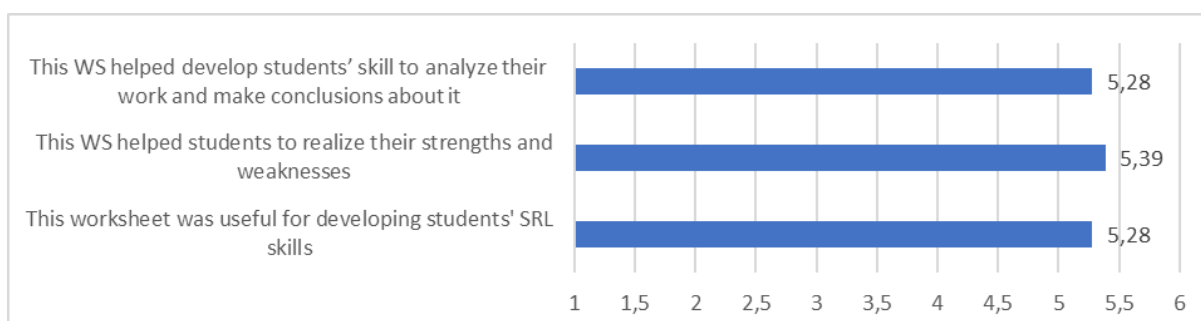


Figure 6. Selection of teachers' average evaluations of WS8

Similarly, WS9 was aimed at developing students' skills to plan their time and duties, and it is clear from Figure 7 that WS9 was highly rated by teachers as helpful for developing these particular skills, and SRL in general.

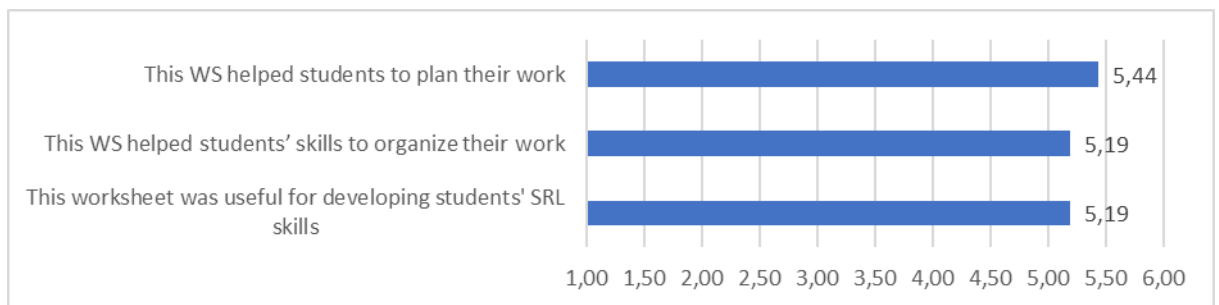


Figure 7. Selection of teachers' average evaluations of WS9

4.3. Teacher Feedback and Suggestions for Improving WS 1-10

Respondents were asked to provide a detailed reflection on the piloted set of materials by analyzing the usefulness of the worksheets and their observations while using them and, finally, to provide suggestions for their improvement. A summary of teachers' reflections about each of the worksheets is presented.

Teachers acknowledged that WS1 was useful for developing thinking and encouraging students to go deeper into understanding the task, although it was time-consuming at first. Some teachers applied the worksheet for group work, and a teacher of Grade 7 reported that it was useful for developing in-depth understanding of any task and its implementation and, particularly, explaining the task to peers. Teachers suggested removing the second question, as it was similar to another one.

WS2 - Plan how to do the task better - was considered to be useful during the completion of the task, as it encouraged students to think about step-by-step solution processes. However, a teacher observed low involvement by some students, as they were reluctant to use their metacognitive skills, and to self-monitor and analyze their learning process. One reason for this finding could be that students lack self-regulated learning skills (Panadero, 2017). Furthermore, according to teachers' observations, students had not had enough practice in developing these skills, because they had not been exposed to similar tasks before. Some students were hesitant to complete the worksheets, because they considered the tasks to be redundant, and that the tasks would not have a direct impact on their performance in the subject. Overall, teachers acknowledged that it was a useful WS, as it helped students analyze their mistakes, reconsider work strategies and develop SRL skills, though it also required a lot of additional time during the lesson. There were no suggestions for its improvement.

Teachers stated that WS3 - Reconsider your work during the task completion - was time consuming, though the skills gained paid off in the long term. The WS was considered to be useful for developing SRL skills, and it gave students the chance to cooperate with classmates and seek help from a person or a consultation. Teachers pointed out that it would be more useful in the preparation

process of the PS task, as not all students can divide their attention between completing the task and answering the WS questions simultaneously. There were controversial conclusions on the last item: "Imagine how a person you consider very smart and knowledgeable would do this task!", as students of Grades 10-12 found it as "not a serious" or even "humiliating task", while the Grade 9 teacher found it a highly valuable item, concluding, however, that it would be more appropriate for primary school students. It was suggested that one of two similar questions be removed.

Respondents admitted that WS4 helped students evaluate their work and develop SRL skills, as students had to analyze their work by comparing their expectations with their actual performance, and look for multiple ways of solving the same problem. Teachers concluded that the WS reduced teachers' work, as students need to learn to analyze their progress every day, and that students are usually aware of their strengths. Although the teachers observed that some students perceived the work with the WS as an unnecessary burden that consumed their time, teachers believed that the repeated use of this worksheet after each major task would build a habit of reflection and evaluation.

WS5 was useful for developing PS skills, and the schematic depiction of the solution steps while doing the task promoted a systematic approach to task solution and encouraged students to take responsibility during the process. This WS was mostly suitable for use in parallel with doing comprehensive tasks (and not for simple and easy-to-do tasks). A teacher reported that students in Grade 10 suggested that it would be better to have the worksheet in an electronic format, which would make it easier to do corrections and adjust the process.

The set of materials also contained two reminder sheets. Only one teacher used RS6, only once, but they reported it could be very useful if used systematically and regularly as a reminder. RS7 was used 5 times and was reported to be very useful, as it gave students the opportunity to look up and recall the PS steps, particularly during independent work (to check, "Have I done everything that was necessary?"), and it helped students who lacked self-discipline and have anxiety during tests.

While working with WS8 - What is my knowledge and skills on the topic? - teachers observed that it was easy for students to work with the first part of the WS (evaluation of their skills in relation to the topic), though students struggled to analyze their work in depth and develop further action steps. Teachers concluded that the worksheet was useful for developing SRL skills, as students learned to self-evaluate their work; the worksheet was used to provide self-reflection at the end of the theme. Teachers agreed that students should be taught to analyze and self-reflect on their work regularly. There was a suggestion to add follow-up activities that required students to put forward further steps for their development, and to self-assess their implementation.

WS9 aimed to develop students' time-management skills, and was indicated as immensely important, especially for junior students, as there are no paper-based

report books to plan their week and write down their home tasks anymore (note: in Latvia, an electronic system is used for reporting grades, lesson schedule etc.). Upper-secondary class students claimed that they used electronic devices to plan their week, and that this method was more convenient. Teachers indicated that the completed worksheet provided immensely useful information for class teachers, as they could see the students' weekly workload. It was suggested that the worksheet could be improved by adding the times and a space to reflect on time spent doing homework and planning consultation times at school.

While working with WS10, teachers observed that students did not find it difficult to answer yes/no questions, but it was more difficult when there were open questions that "encourage students to be responsible, to evaluate and analyze their learning and actions"; the worksheet was considered as "a good basis for a further extended conversation with each individual". The worksheet provides a significant foundation for student interaction and teaches them to adjust their activities and choose the most appropriate strategies to achieve better results and to learn from their peers.

On the whole, the WS and RS were considered to be useful resources for developing students' PS and SRL skills; some worksheets served as great starting points for further discussions. Some worksheets were considered to be more appropriate for younger students than older ones. Teachers reported using the worksheets both for individual work and work in pairs, and combined these two approaches for more effective work. For some students, it was their first experience analyzing themselves in such a detailed manner, and it required a great deal of time and effort to think and reflect. The questions in the worksheets stimulated a detailed step-by-step approach to exploring and understanding tasks, as opposed to straightforward task solving without properly understanding what to do. Teachers concluded that students lacked in-depth thinking skills, and there should be further work involved in enhancing students' PS and SRL skills through developing metacognitive skills.

5. Discussion

The results of the current study raise a number of questions for discussion, both about teachers' experiences with the piloted supplementary materials, and about students' SRL and PS skills. These questions will be explored further by highlighting the most important points. Although the worksheets were available in an easily editable format and teachers could adjust them to the students' age group or needs, the majority of teachers admitted that they used the materials without making any major changes, thus, engaging mostly in the "application of materials phase" (Bouckaert, 2019). One of the reasons for this approach could be teachers' heavy workload, which is why they highly appreciated the possibility to use ready-made materials that could be easily integrated in their lessons. Large-scale projects on transversal skills have demonstrated that teachers are willing to try new approaches if they feel that the approaches do not interfere with their plans (e.g., Vincent-Lancrin et al., 2019). Another reason why teachers used the worksheets without customizing them could be the short time available for piloting - just one month. This could mean that, if teachers find the worksheets

suitable for their class and learning objectives, they first use the materials in their original format and only after piloting can they see what adjustments or changes are necessary. The process of using existing materials can serve as an example and inspiration for teachers to create their own materials, and could be an important aspect of teachers' professional growth (Baştürkmen & Bocanegra-Valle, 2018; Bouckaert, 2019; González et al., 2017; Sidenvall et al., 2022).

However, some teachers reported making slight adjustments that were not related to the content, but to the process of using the materials. For example, if teachers realized that they would not have enough time to work with the worksheet in a written form individually, or that the oral form or pair/group work would be more appropriate for the aims and possibilities of the specific lesson, they adjusted the instructions and process of using the materials in pairs or groups, which shows that they made professional decisions while they were implementing the materials (Bouckaert, 2019; González et al., 2017).

Teachers also observed that students faced difficulties with "thinking and reflecting" on the questions asked in the worksheets, and concluded that students had to be provided with more regular exposure to such tasks, so that they became accustomed to them and developed a habit of self-regulating and monitoring their learning process. Other researchers also discuss the challenges related to, in particular, developing students' monitoring skills (Engelmann & Bannert, 2021). Teachers also mentioned that some of the materials might not be suitable for senior students. Overall, this indicates that the implementation and development of students' transversal skills as defined in the curriculum in Latvia (Cabinet of Ministers, 2018) is still developing and that suitable materials have to be developed for each age group.

It was also mentioned that using the worksheets was rather time consuming, therefore, it was suggested that some of them should be divided into two sheets, for example, WS2, on planning how to solve a task, could be divided into parts A and B, or shortened. Similar comments were received for a few other worksheets, such as WS3, on monitoring students' progress. It can be concluded that, if students were used to self-regulating their learning in the process of PS and used metacognition, self-monitoring and self-reflection regularly, less time would be devoted to thinking, as the metacognitive processes would develop and gradually become an automatic part of PS (Contente & Galvão, 2022; Gupta & Zheng, 2020). However, at the initial stage of developing these skills, materials must not be too comprehensive. Results show that teachers mostly applied the supplementary materials in the class lessons, followed by foreign language classes and native language classes. Some of the worksheets were indeed more appropriate for class lessons, for example WS9, Planning your tasks for the week, which was used 13 times in class lessons and 3 times in subject lessons, and WS10, which was used 8 times in class lessons, as it does not require specific subject skills to be involved, and 6 times in subject lessons. Some teachers also reported that there was too little time to use additional materials in subject lessons fully, due to time constraints and the volume of the course syllabus, which is the main focus during the lesson. It is known that subject content knowledge is, indeed, particularly important for

delivering effective PS activities in class (Maries & Singh, 2023). It can be concluded that teachers should be provided with very targeted methodological help and training about how to explicitly apply PS and SRL skills in various school subjects. This conclusion is supported by research that found such interventions to be effective (Benick et al., 2021; Linde et al., 2023).

In-depth comprehension of PS and SRL concepts is crucial for successfully implementing the development of these skills in the everyday learning activities of students (Sidenvall et al., 2022). Several processes involved in PS and SRL (for example, planning, monitoring and evaluating processes) are alike. Teachers' ratings of WS in the current study confirm that, in some cases, the materials helped foster both PS and SRL skills, as it might be hard to distinguish them from a practical perspective. These blurred boundaries of very similar processes during PS and SRL from the viewpoint of teachers can be explained by the overlap of the two concepts, and by the crucial role of metacognition in both of them (Zepeda & Nokes-Malach, 2023).

6. Limitations and Recommendations for Future Research

This study faced a few limitations, and the first one was related to the small number of participants: 139 teachers were willing to pilot the materials in their classes, but only 36 provided feedback afterwards. Although it is not a representative example of teachers in the country, the participants who provided feedback were from all the regions of Latvia and represented all types of education institutions, therefore, the survey provides significant data, though it would be necessary to increase the number of participants if the piloting is repeated, by targeting a greater number of schools and teachers teaching students' of different age groups. Another limitation was linked to the time available for the pilot - only a month. This time should be extended, to enable teachers to use the materials for a longer time and to provide feedback at different points in time longitudinally.

7. Conclusions

The results of the current research indicate that supplementary materials (worksheets and reminder sheets) were highly valued by teachers, who considered it to be an important support for developing students' PS and SRL skills. The materials that were provided were found to contribute to students' thinking skills, as they had to pay close attention to the step-by-step, guided PS processes, while self-regulating their performance using metacognitive skills, while analyzing and self-reflecting on their performance during the tasks. At the same time, it is concluded that it was not easy for students to "reflect and think deeply". Students having insufficient PS and SRL skills imply that teachers lack adequate methodological support and materials to provide students with sufficient practice to develop these transversal skills in their everyday practice.

The current study shows that teachers' professionalism and willingness to improve their work by including new practices in their everyday work is not dependent on their ages. Despite participants' long professional work experience (the majority of the participants were teachers with 21–40 years of work

experience), they were willing to try out and pilot new materials to help students advance their PS and SRL skills.

Although the necessity to develop PS and SRL skills has been proven in the scientific literature worldwide, research shows that the development of these skills in practice should be improved. Therefore, future research should investigate how to support teachers in developing students' PS and SRL skills.

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Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as potential conflicts of interest.

8. References

- Baştürkmen, H., & Bocanegra-Valle, A. (2018). Materials design processes, beliefs and practices of experienced ESP teachers in university settings in Spain. *English Language Education*, 11, 13–27. https://doi.org/10.1007/978-3-319-70214-8_2
- Benick, M., Dörrenbächer-Ulrich, L., Weißenfels, M., & Perels, F. (2021). Fostering self-regulated learning in primary school students: Can additional teacher training enhance the effectiveness of an intervention? *Psychology Learning & Teaching*, 20(3), 324–347. <https://doi.org/10.1177/14757257211013638>
- Bouckaert, M. (2019). Current perspectives on teachers as materials developers: Why, what, and how? *RELC Journal*, 50(3), 439–456. <https://doi.org/10.1177/0033688218810549>
- Breitwieser, J., Neubauer, A. B., Schmiedek, F., & Brod, G. (2022). Self-regulation prompts promote the achievement of learning goals – But only briefly: Uncovering hidden dynamics in the effects of a psychological intervention. *Learning and Instruction*, 80, 101560. <https://doi.org/10.1016/j.learninstruc.2021.101560>
- Cabinet of Ministers (Republic of Latvia). (2018). *Rule No. 747 from 27.11.2018*. <https://likumi.lv/ta/en/en/id/303768-regulations-regarding-the-state-basic-education-standard-and-model-basic-education-programmes>
- Cleary, T. J. (2018). *The self-regulated learning guide: Teaching students to think in the language of strategies*. Routledge.
- Cleary, T. J., Callan, G. L., & Zimmerman, B. J. (2012). Assessing self-regulation as a cyclical, context-specific phenomenon: Overview and analysis of SRL microanalytic protocols. *Education Research International*. Article 428639. <https://doi.org/10.1155/2012/428639>
- Contente, J., & Galvão, C. (2022). STEM education and problem-solving in space science: A case study with CanSat. *Education Sciences*, 12(4), 251. <https://doi.org/10.3390/educsci12040251>
- Dostál, J. (2015). Theory of problem solving. *Procedia - Social and Behavioral Sciences*, 174, 2798–2805. <https://doi.org/10.1016/j.sbspro.2015.01.970>
- Engelmann, K., & Bannert, M. (2021). Analyzing temporal data for understanding the learning process induced by metacognitive prompts. *Learning and Instruction*, 72, 101205. <https://doi.org/10.1016/j.learninstruc.2019.05.002>

- Fischer, A, Greiff, S., & Funke, J. (2012). The process of solving complex problems. *The Journal of Problem Solving*, 4(1), 3. <https://doi.org/10.7771/1932-6246.1118>
- Hačatrjana, L. (2022). Flexibility to change the solution: an indicator of problem-solving that predicted 9th grade students' academic achievement during the distance learning, in parallel to reasoning abilities and parental education. *Journal of Intelligence*, 10(1), 7. <https://doi.org/10.3390/jintelligence10010007>
- González, G. T., Estrada, F. J. P., & González, G. H. T. (2017). How teachers design and implement instructional materials to improve classroom practice. *Intangible Capital*, 13(5), 967–1043. <https://doi.org/10.3390/su13148115>
- Gupta, U., & Zheng, R. Z. (2020). Cognitive load in solving mathematics problems: Validating the role of motivation and the interaction among prior knowledge, worked examples, and task difficulty. *European Journal of STEM Education*, 5(1), 5. <https://doi.org/10.20897/ejsteme/9252>
- Ifenthaler, D. (2012). Determining the effectiveness of prompts for self-regulated learning in problem-solving scenarios. *Journal of Educational Technology & Society*, 15(1), 38–52.
- Johnson, A. P. (2012). *A short guide to action research* (4th ed.). Pearson.
- Lawson, M. J., Vosniadou, S., Van Deur, P., Wyra, M., & Jeffries, D. (2019). Teachers' and students' belief systems about the self-regulation of learning. *Educational Psychology Review*, 31, 223–251.
- Lehmann, T., Haehnlein, I., & Ifenthaler, D. (2014). Cognitive, metacognitive and motivational perspectives on preflexion in self-regulated online learning. *Computers in Human Behavior*, 32, 313–323. <https://doi.org/10.1016/j.chb.2013.07.051>
- Liljedahl, P., & Cai, J. (2021). Empirical research on problem solving and problem posing: a look at the state of the art. *ZDM – Mathematics Education*, 53(4), 723–735.
- Linde, I., Sarva, E., & Daniela, L. (2022). Teachers' beliefs and preferred approaches to address self-regulated learning development for their students. *Human, Technologies and Quality of Education*, 533–546. <https://doi.org/10.22364/htqe.2022.38>
- Linde, I., Sarva, E., & Daniela, L. (2023) The impact of an online professional development course on teachers' comprehension and self-efficacy in developing students' self-regulated learning skills. *Sustainability*, 15(12), 9408. <https://doi.org/10.3390/su15129408>
- Mandal, M. (2019). Role of teacher in teaching problem-solving skills. *Scholarly Research Journal for Interdisciplinary Studies*, 6(51), 12234–12240.
- Maries, A., & Singh, C. (2023). Helping students become proficient problem solvers. Part I: A brief review. *Education Sciences*, 13, 156. <https://doi.org/10.3390/educsci13020156>
- OECD. (2013). *PISA 2012 Assessment and Analytical Framework: Mathematics, reading, science, problem solving and financial literacy*. OECD Publishing.
- Panadero, E. (2017). A review of self-regulated learning: Six models and four directions for research. *Frontiers in Psychology*, 8, 422. <https://doi.org/10.3389/fpsyg.2017.00422>
- Polya, G. (1957). *How to solve it. A new aspect of mathematical method* (2nd ed.). Princeton University Press.
- Sarva, E., Linde, I., & Daniela, L. (2021). Self-regulated learning in remote educational context. *Human, Technologies and Quality of Education*, 376–389. <https://doi.org/10.22364/htqe.2021.27>
- Schunk, D. H., & DiBenedetto, M. K. (2021). Self-efficacy and human motivation. *Advances in Motivation Science*, 8, 153–179.

- Schuster, C., Stebner, F., Geukes, S., Jansen, M., Leutner, D., & Wirth, J. (2023). The effects of direct and indirect training in metacognitive learning strategies on near and far transfer in self-regulated learning. *Learning and Instruction, 83*, 101708. <https://doi.org/10.1016/j.learninstruc.2022.101708>
- Sidenvall, J., Granberg, C., Lithner, J., & Palmberg, B. (2022). Supporting teachers in supporting students' mathematical problem solving. *International Journal of Mathematical Education in Science and Technology*, <https://doi.org/10.1080/0020739X.2022.2151067>
- Skola2030. (2019a). Caurviju prasmes [Transversal skills]. <https://www.skola2030.lv/lv/macibu-saturs/merki-skolenam/caurviju-prasmes>
- Skola2030. (2019b). Kompetenču pieeja mācību saturā [Competence approach to curriculum]. <https://www.skola2030.lv/lv/par-projektu>
- Sukontawaree, N., Poonputta, A., & Prasitnok, O. (2022). Development of problem-solving abilities in science by inquiry-based learning with cooperative learning for Grade 4 students. *Journal of Educational Issues, 8*(2), 771–782.
- Suto, I., & Eccles, H. (2014). *The Cambridge approach to 21st century skills: definitions, development and dilemmas for assessment*. IAEA Conference, Singapore, 2014.
- Tóthová, M., & Rusek, M. (2021). Developing students' problem-solving skills using learning tasks: An action research project in secondary school. *Acta Chimica Slovenica, 68*, 1016–1026. <https://doi.org/10.17344/acsi.2021.7082>
- Uzuntiryaki-Kondakci, E., & Capa-Aydin, Y. (2013). Predicting critical thinking skills of university students through metacognitive self-regulation skills and chemistry self-efficacy. *Educational Sciences: Theory and Practice, 13*(1), 666–670.
- Van Gog, T., Hoogerheide, V., & Van Harsel, M. (2020). The role of mental effort in fostering self-regulated learning with problem-solving tasks. *Educational Psychology Review, 32*, 1055–1072.
- Vincent-Lancrin, S., González-Sancho, C., Bouckaert, M., de Luca, F., Fernández-Barrerra, M., Jacotin, G., Urgel, J., & Vidal, Q. (2019). *Fostering students' creativity and critical thinking: What it means in school, educational research and innovation*. OECD Publishing. <https://doi.org/10.1787/62212c37-en>
- Wu, H., & Molnár, G. (2022). Analysing complex problem-solving strategies from a cognitive perspective: The role of thinking skills. *Journal of Intelligence, 10*(3), 46. <https://doi.org/10.3390/jintelligence10030046>
- Zepeda, C. D., & Nokes-Malach, T. J. (2023). Assessing metacognitive regulation during problem solving: A comparison of three measures. *Journal of Intelligence, 11*(1), 16. <https://doi.org/10.3390/jintelligence11010016>
- Zimmerman, B. J. (2015). Self-regulated learning: Theories, measures, and outcomes. In J. D. Wright (Ed.), *International encyclopedia of the social and behavioral sciences* (pp. 541–546). Elsevier Science and Technology. <https://doi.org/10.1016/B978-0-08-097086-8.26060-1>
- Zimmerman, B. J., & Moylan, A. R. (2009). Self-regulation: Where metacognition and motivation intersect. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.), *Handbook of metacognition in education* (pp. 299–315). Routledge.
- Zimmerman, B. J., Schunk, D. H., & DiBenedetto, M. K. (2017). The role of self-efficacy and related beliefs in self-regulation of learning and performance. In A. J. Elliot, C. S. Dweck, & D. S. Yeager (Eds.), *Handbook of competence and motivation: Theory and application* (pp. 313–333). The Guilford Press.

Appendix 1

Questionnaire for teachers' assessment of the piloted supplementary materials used in the current study

Please rate each of the following statements with 1-6 points (1-“Completely disagree”; 6-“Completely agree”), based on your evaluation of the particular worksheet.

1. This worksheet was useful for developing students' problem-solving skills
2. This worksheet was useful for developing students' self regulated learning skills
3. This worksheet helped students' develop the skills to organise their work
4. This worksheet helped students to realise their strengths and weaknesses
5. This worksheet helped students plan their work
6. This worksheet helped students monitor their work and make adjustments to it
7. This worksheet helped students' develop the skills to analyse their work and make conclusions about it
8. This worksheet encouraged students to think about various strategies for solving the task or a problem
9. In general this worksheet was useful in the work with students

Please write your observations regarding this worksheet:

- (a) In your opinion, what was more useful or less useful and while working with this worksheet and why?
- b) Your experience and observation of students' skills while working with this worksheet.
- (c) Did you adapt this worksheet and how?
- (d) Please provide any suggestions for improving the worksheet.