Effects of Classroom-Based Social Problem-Solving Training on Elementary School Children: Investigating the Moderating Role of Executive Function

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Data availability statement

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The authors have no conflicts of interest directly relevant to the content of this article.

Ethics approval statement

All study procedures were approved by the Ethics Review Committee of the Department of Education at the Graduate School of Human Sciences, Osaka University (No. 20097).

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Authors' contributions

Conceptualization, Y.H., H.O. and H.F.; methodology, Y.H., H.O. and H.F.; software, H.F.; validation, H.O., H.F.; formal analysis, Y.H., H.O. and H.F.; investigation, Y.H., H.O., and T.Y.; resources, Y.H., H.O. and T.Y.; data curation, Y.H., H.O., A.I. and

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Abstract

Social problem-solving (SPS) skills represent an individual's ability to effectively solve daily problems. Although previous studies have demonstrated the positive effects of SPS interventions, there is still a lack of evidence on the relevant moderating factors. Therefore, this study investigated the impact of an SPS intervention on a sample of elementary school children, by focusing on the potential moderating effects of executive function. The participants included a total of 101 fifth graders (mean age of 10.6 years), who were divided into two groups for an immediate intervention (treatment) and delayed intervention (control). The following three aspects were measured pre- and post-intervention: SPS skills, emotional regulation, and school adjustment. Pre-intervention, we measured two aspects of executive function using the Cambridge Neuropsychological Test Automated Battery, including working memory and inhibition. Following the intervention, the participants increasingly generated alternative solutions, which may have contributed to better adaptive functioning and solutions. However, we also observed some negative impacts on participants with lower executive functioning, including deteriorating effects on emotional regulation (problem solving and ruminative response styles) and life satisfaction. These findings emphasize the need to pay close attention to the individual profiles of the recipients to design more effective interventions.

Keywords: children; elementary school; problem solving; executive function; school intervention

Practitioner Points

- Improving social problem-solving skills has been an important goal for improving children's coping options, emotional stability, and school adjustment.
- Although classroom-based social problem-solving interventions increase the skills of elementary school children, their unintended effects should be monitored carefully.
- Students with lower executive function may benefit less from classroom-based social problem-solving interventions, which suggests the importance of assessing the students' individual characteristics before implementing the intervention.

Introduction

Social problem-solving (SPS) is a cognitive–emotional–behavioral process in which individuals identify effective solutions to the problems they face in their daily lives (D'Zurilla et al., 2004). It has four components: (a) problem definition and formulation, (b) the generation of alternative solutions, (c) decision making, and (d) solution implementation and verification (D'Zurilla & Goldfried, 1971). Thus, SPS is a purposeful, step-by-step approach to problem solving. Since the theoretical model of SPS was published, several variations have been proposed in the literature. One example is a model used in the Tools for Getting Along program developed by Daunic et al. Their SPS model comprises six steps: (1) recognize that a problem exists, (2) calm down and think, (3) define the problem in terms of goals and barriers, (4) generate solutions through brainstorming, (5) select a strategy by considering possible outcomes, and (6) evaluate the outcome after a solution is carried out (Daunic et al., 2006, 2012). This model program was based on a model proposed by Crick and Dodge (1994), which has provided a theoretical framework for recent SPS programs (e.g., Daunic et al., 2012; Van Loan et al., 2019). Although there are differences in the theoretical models of SPS, most intervention programs share certain common components pertaining to the problem-solving process, such as problem formulation, generating solutions, and selecting a solution.

For school children, SPS skills are considered an antecedent of socially adaptive behaviors and behavioral adjustments to various situations and contexts (Denham & Almeida, 1987). In this regard, it is especially important for children to generate alternative solutions, which involves a cognitive process of searching for other potential actions to address a given problem situation. Generating alternative solutions is further associated with behavioral adaptations such as the ability to reduce impulsive behaviors

and develop a positive attitude toward problem solving itself. By contrast, the inability to generate alternative solutions is linked to behavioral or mental health issues among children, including aggression, depressive symptoms, and social withdrawal (Kendall, 1993; Lochman & Dodge, 1994). Simultaneously, emotional regulation is viewed as an essential component for implementing SPS skills, as social problems often evoke negative emotions such as anger (Schlesier et al., 2019). Enhancing such SPS skills is crucial for improving mental health and social adjustment among school-age children.

Interventions based on the SPS theory, such as programs designed to enhance SPS skills among children (Barnes et al., 2018; Merrill et al., 2017) and problem-solving therapy for clinical populations (Krause et al., 2021), have been considered to have beneficial effects. Of particular relevance to this study, studies have indicated that such an approach can help elementary school students increase their SPS skills, including those related to positive problem orientation and the number of alternative solutions generated (Amish et al., 1988; Daunic et al., 2012; Fraser et al., 2014; Guevremont & Foster, 1993; Leff et al., 2009; Miyata et al., 2010; Rahill & Teglasi, 2003; Tanaka et al., 2016). As the goal of social skills training is to improve social adjustment, improvements in school adjustment are one of the expected outcomes of such interventions for students (Kanayama et al., 2001). In addition, emotional regulation is an essential ability for coping with one's negative emotional reactions (Nezu, 2004). While several studies have reported positive outcomes of such interventions on SPS knowledge (Daunic et al., 2012), the findings are less conclusive regarding behavioral outcomes and emotion regulation (Merrill et al., 2017). These mixed results highlight the need to identify potential moderating factors—one of which may be executive function—underlying SPS abilities.

Executive function refers to the higher-order cognitive ability to control and optimize one's behavior for a specific goal while driving its components, including working memory, shifting (cognitive flexibility), and inhibition (Huizinga et al., 2006; Miyake et al., 2000; Miyake & Friedman, 2012). Executive function continues to develop gradually from infancy to the late teens, whereas the ability to control impulsivity and desire is formed during school childhood (D'Intino, 2022; Moriguchi, 2019). As executive function involves emotion regulation, planning, and successful goal-setting, it is a foundational ability that influences cognitive processing and problem-solving among children (Lecce et al., 2020; Sankalaite et al., 2021). Indeed, evidence from a review (Merrill et al., 2017) suggests that executive function is centrally involved in SPS, particularly in self-regulation, which is a prerequisite thereof (Blair & Diamond, 2008; Elias et al., 1997; Liew, 2012; Nakazawa, 1991; White et al., 2013). According to these findings, students' executive function levels may influence their use of SPS skills and self-regulatory abilities developed as a result of the intervention programs, although the role of executive function in SPS process has not been well-investigated (Bailey & Im-Bolter, 2020).

Despite the growing research on SPS interventions, the evidence on Japanese elementary school children has been scarce (Miyata et al., 2010; Takahashi et al., 2009; Tanaka et al., 2016). Therefore, the current study aimed to 1) examine how an SPS intervention affected problem-solving skills and social adjustment among Japanese elementary school children and 2) explore the moderating effect of executive function on the effects of the intervention. We hypothesized that the SPS intervention improves SPS skills, emotional regulation, and school adjustment. As the moderating effect of executive function has not been investigated in the literature, we did not formulate

specific hypotheses about the direction of the moderating effects. The effects of the intervention were examined using exploratory analyses.

Methods

Participants

The initial study sample included 127 fifth-grade public elementary school students (57 boys, 70 girls). The school was a mainstream school located in a suburban area of Japan. The study area was considered to be dominated by families with an average income level, although their socio-economic status was not evaluated in this study.

We assigned students from four classes to two groups for either immediate treatment (treatment group) or delayed treatment (control group). While all students completed self-reported measures in the pre- and post-intervention periods, we only evaluated the level of executive function in the pre-intervention period since executive function was expected to be stable over the study period (12 weeks). Students with special educational needs (n = 15) were excluded from this study. We also excluded 11 students who did not complete the executive function test or questionnaires. Consequently, the final study sample consisted of 101 participants, including 50 in the treatment group (28 girls, 22 boys) and 51 in the control group (29 girls, 22 boys). The mean ages were 10.6 years (SD = 0.29) for the treatment group and 10.6 years for the control group (SD = 0.30) (Table 1).

[Table 1 near here]

This study was conducted in accordance with local regulations and ethical standards. After obtaining permission from the school principal, we explained the study's purpose and contents to the teachers and parents. We also informed them of their ability to decline participation using the parental opt-out consent. All study procedures were approved by the Ethics Review Committee of the Department of Education at the Graduate School of Human Sciences, Osaka University (No. 20097).

SPS intervention

We implemented the SPS intervention program once every two weeks (six total sessions, each 45 minutes in length) from May to July 2019. The program was developed by Okuno et al. and was based on problem-solving therapy practices (D'Zurilla, 1995; Okuno et al., 2019). Table 2 lists the themes for each session. The intervention focused on developing the participants' problem solving, emotion regulation, and coping skills. To reduce the burden on the participants, we did not require them to complete any homework tasks, but instead conducted a review of the prior session at the beginning of each successive session. Each session was video recorded for further analysis with the permission of the participants' guardians and the school authority. The SPS intervention was conducted by an experienced clinical psychologist (third author), who was one of the developers of the original program. A supervisor (last author), the lead researcher of the program, reviewed video recordings to check the quality of the program implementation.

[Table 2 near here]

Measures

Children's Social Problem-Solving Scale (C-SPSS)

The C-SPSS measures problem-solving skills among children (Miyata et al., 2010) based on theoretical problem-solving skill constructs (D'Zurilla & Goldfried, 1971; Sato et al., 2006). It consists of 28 items across the following four subscales: (1) problem orientation, (2) problem definition and formulation (including rational, impulsive/inattentive, and avoidant), (3) generation of alternative solutions, and (4) decision making. For the subscales (1) problem orientation, (2) problem definition and formulation, and (4) decision making, the respondents selected from the listed options for each item. Their responses were then scored using the C-SPSS scoring criteria (Miyata et al., 2010). For the subscale (3), scores were calculated by summing up the number of strategies that the respondents provided in open-ended statements pertaining to the two presented situations. Cronbach's alpha was not calculated owing to the characteristics of the C-SPSS. The reliability and validity of the instrument in the context of Japanese elementary school children were confirmed by a previous study (Miyata et al., 2010). Higher scores on the subscales (1) problem orientation, (2) problem definition and formulation (rational), (3) generation of alternative solutions and (4) decision making indicate higher social problem-solving abilities, whereas higher scores on the maladaptive approaches represented by the items in the subscale (2) problem definition and formulation (impulsive/inattentive, avoidant) indicate lower social problem-solving abilities.

In subscale (3) generation of alternative solutions, the respondents were presented with the following two situations: 1) Your friend did not show up at the meeting place; and 2) You tried to talk to your friend, but they ignored you. To examine the respondents' solutions to these situations , we classified the responses into the

following categories based on a previous study among Japanese school children (Takahashi et al., 2009): (1) prosocial, referring to a socially appropriate way of dealing with the situation (e.g., "Talk to another friend or teacher," "Ask about the friend's reason," or "Play with other friends"), (2) aggressive, referring to physical, verbal, or relational aggression or threats (e.g., "Reprove the friend," "Ignore the friend," or "Break a pencil"), (3) avoidant, referring to a coping style that indicates a passive or nonassertive response to the situation (e.g., "Forget the problem," "Give up solving the problem," or "Think nothing"), and (4) irrelevant/other, referring to nonsense or other responses that did not fit into the other categories. Responses from category (4) irrelevant/other were excluded from further analysis. In this study, two independent research assistants who did not know the study hypothesis classified the responses, showing a Cohen's kappa coefficient that indicated high agreement (κ = .88). A third rater evaluated and made the final decision on any cases of discordance between the first two raters.

Emotional regulation and adaptation to the school environment: Emotional Regulation Scale for Elementary and Middle School Students (ERS-EM)

The ERS-EM is a self-reported measure that assesses the process by which individuals regulate their emotions upon encountering unpleasant events (Murayama et al., 2017). It comprises 16 items that are each rated on a 4-point Likert scale, ranging from 1 (*almost never*) to 4 (*almost all the time*). These items are spread across four subscales, including problem solving, cognitive reappraisal, rumination, and distraction, wherein higher scores indicate a stronger tendency to use the respective strategies to regulate emotions. In this context, higher problem solving, cognitive reappraisal and distraction scores are correlated with better outcomes (e.g., lower depression and aggression), whereas higher rumination scores are correlated with worse outcomes (Murayama et al., 2017). In this

study, we obtained high Cronbach's alphas ranging from .73 (cognitive reappraisal) to .83 (problem solving), except for the distraction subscale (α =.64).

Adaptation Scale for School Environments on Six Spheres (ASSESS)

The ASSESS evaluates children's subjective feelings of adaptation to the school environment (Inoue et al., 2018; Kurihara & Inoue, 2010). It contains 34 items that are each rated on a 5-point Likert scale, ranging from 1 (*not at all true*) to 5 (*extremely true*). To measure subjective school adjustment, these items are spread across six subscales, including life satisfaction, teacher support, friendships, social skills, non-intrusive relationships, and learning. Scores are then converted to T scores based on the manual, with higher scores indicating better school adjustment. In this study, the scale received adequately high Cronbach's alphas, ranging from .72 (social skills) to .87 (teacher support).

Executive function

Cambridge Neuropsychological Test Automated Battery (CANTAB)

In the pre-intervention period, we measured executive function using two CANTAB tasks (CANTAB Cognitive Research Software, n.d.), including the spatial working memory (SWM) task and stop signal test (SST), and noted the responses via an iPad®. The tasks evaluated the students' working memory and inhibition. Shifting (cognitive flexibility) was not evaluated because Japanese versions of the test instructions were not available at the time of this study. These CANTAB tasks were conducted simultaneously for the participants in each class.

The SWM task assesses the ability to retain spatial information and manipulate the information stored in the working memory. In thistask, the participants were asked to find a token hidden in boxes (4–8) that were randomly displayed on the screen. Two indices were used to represent the outcome. Specifically, the Between Errors index

(SWM-BE) involves the selection of boxes that are already determined as empty (related to working memory capacity), whereas the Strategy index (SWM-S) indicates the efficiency of the heuristic strategy.

The SST is a stop signal response inhibition test that requires participants to select one of two options and touch an arrow that appears as quickly and accurately as possible, depending on the direction in which it points. Participants must withhold their response when a beep sound is emitted. Thus, the SST measures response inhibition, as indexed by stop signal reaction time (SST-SSRT).

Table 1 lists information on the students' performance on the CANTAB task performance. In all three indices, lower scores indicate higher abilities.

Statistical analysis

We employed linear regression models to estimate how the intervention affected the C-SPSS, ASSESS, and ERS-EM indices, with the response variables including post-intervention C-SPSS, ERS-EM, and ASSESS scores. The regression models included the treatment term (treatment = 1 vs. control = 0) and pre-intervention score of the outcome variable. The effects of the intervention were estimated using the slope of the treatment term. To improve the validity of the estimates, we also included three CANTAB indices (i.e., SWM-BE, SWM-S, and SST-SSRT) in the models as potential confounding variables, as these factors may confound the treatments effects. Continuous variables were standardized before analyses to calculate standardized effects. The count data of alternative solution response categories of the C-SPSS were analyzed using Poisson regression models; in these cases, the response variables were the response counts in each category (prosocial, aggressive, and avoidant). Explanatory variables were the same as those in the liner regressions.

To examine whether executive function moderated the effects of the intervention, we included an interaction term (intervention [treatment vs. control] x CANTAB score) in the abovementioned models (intervention x SWM-BE, intervention x SWM-S, and intervention x SST-SSRT, respectively). If the interaction term was significant, then we further investigated the moderating effect via a simple slope test based on ±1 *SD*. There were no multicollinearity problems.

We conducted our statistical analysis using the R version 4.2.1 statistical software (R Core Team, Vienna, Austria), with the significance threshold set at a two-tailed $p < .05$. We excluded the problem definition and formulation-avoidant subscales of the C-SPSS from our analysis because the index did not satisfy the assumption for parallel slopes. Finally, we used Pearson's correlation coefficients to calculate correlations between the explanatory variables (Supplemental Table 1).

Results

Interventional effects

Post-intervention, the treatment (vs control) group had significantly higher scores on the generation of alternative solutions subscale in the C-SPSS index ($b = 0.45$, $p = .004$) (Table 3), but showed negative impacts on the problem definition and formulation (rational) subscale ($b = -0.39$, $p = .032$). For the classified solutions, the treatment (vs control) group also exhibited significant increases in the "aggressive" and "avoidant" categories (aggressive: $b = 0.45$, $p = .017$; avoidant: $b = 0.62$, $p = .002$), but this was not the case for the "prosocial" category (Table 4).

[Tables 3 and 4 near here]

The intervention did not result in significant improvements in the ERS-EM or ASSESS scores (Table 5). Conversely, the treatment group showed lower post-intervention scores on teacher support (b = -0.51, p = .001), prosocial skills (b = -0.42, p = .004), and learning adaptation (b = -0.55, p < .001). The estimates and confidence intervals were similar when the three CANTAB indices were included in the original regression models (Supplemental Table S2-S4).

[Table 5 near here]

Interaction between the intervention and executive function

We explored interactions between the intervention and CANTAB measures based on the C-SPSS, ERS-EM, and ASSESS measures. First, we found no significant interactions for most C-SPSS measures. Although we observed a significant interaction (intervention x SST-SSRT) effect on the number of Prosocial responses (b = -0.15, p = .047, 95%CI [-0.30, 0.00]), the simple slopes were not significant for both subgroups of SST-SSRT performance (b = 0.18, SE = 0.11, p = .09 for participants with high performance, b = -0.13, SE = 0.11, p = .27 for participants with low performance) (Figure 1A).

Second, we observed significant interactions (intervention x SWM-BE) on the ERS-EM subscales with respect to problem solving (b = -0.39, p =.027, 95%CI [-0.75, -0.05]) and rumination (b = -0.39, p = .011, 95%CI [-0.68, -0.09]). Based on the simple slope analysis, the intervention negatively affected the ERS-EM problem solving of participants with low performance in the SWM-BE (+1 SD; b = -0.67, SE = 0.24, p = .01), but did not show a significant effect on those with high performance (b = 0.13, SE = 0.25, p = .62) (Figure 1B). By contrast, the intervention reduced rumination

among participants with low performance in SWM-BE (+1 *SD*) (*b* = -0.57, *SE* = 0.20, *p* = .01), but did not show a significant effect on those with high performance (*b* = 0.20, *SE* = 0.21, *p* = .35) (Figure 1C).

We observed a significant interaction effect between the intervention and SWM-S on the life satisfaction subscale of the ASSESS (*b* = -0.32, *p* = .033, 95%CI [-0.62, -0.03]). The simple slope analysis showed that the intervention negatively affected life satisfaction among participants with low performance in the SWM-S (+1 *SD*) (*b* = -0.53, *SE* = 0.21, *p* = .01), but did not have a significant effect on those with high performance (*b* = 0.12, *SE* = 0.22, *p* = .58) (Figure 1D).

[Figure 1 near here]

Discussion

In this study, we conducted a classroom-based SPS intervention among elementary school children to evaluate its effects on their SPS skills, emotional regulation, and school adjustment, focusing on the potential moderating role of executive function. Overall, the participants who received the intervention showed an increased ability to generate alternative solutions; however, they also exhibited significant increases in aggressive or avoidant solutions and a decrease in rational problem formulation. Moreover, these participants showed worse outcomes on the three subscales of school adjustment when compared to the control group. Finally, executive function moderated the interventional effect, with negative impacts on problem-solving and life satisfaction among participants with lower functioning on the SWM task.

Interventional outcomes

Participants who received the intervention showed a significant increase in the number

of alternative solutions they provided to deal with the presented situations. During the problem-solving process, individuals first gather information about the problem to clarify and understand it, then identify the demands and obstacles, generate alternative solutions, and set realistic problem-solving goals to reduce any emotional distress (D'Zurilla et al., 2004). When confronted with these types of situations, the ability to generate alternative solutions plays a central role in SPS. In this context, an increase in the variety of available solutions may help children cope with stressful situations that occur in daily life (Elias et al., 1997). However, our participants showed an increased number of aggressive and avoidant responses, which requires a careful interpretation. For instance, such children are more likely to adopt coping strategies such as aggression and distraction rather than problem-solving due to a lower sense of control over their problems (Compas et al., 1988; Otake et al., 1998). A previous study also found that aggressive solution planning was associated with actual aggressive behaviors among children (Takahashi et al., 2009). The available evidence indicates the need to exercise caution after observing the factors that suggest the potential for increased aggression. The same study also suggested that it was important to help fourth and fifth graders focus on generating constructive solutions. For children in this demographic, SPS interventions may require additional supplemental training to increase their ability to generate pro-social solutions, as well as careful monitoring for potential adverse responses.

After receiving the intervention, the treatment group also showed significantly worse outcomes in terms of school adjustment, as reflected by the ASSESS subscales of teacher support, social skills, and learning adaptation. Although the reasons for these outcomes are unclear, one explanation may be the existence of significantly lower executive function (SWM-BE) in the treatment group at baseline. Executive function is

associated with academic performance, interpersonal problems, and school adjustment in children (Jacobson et al., 2011; Pascual et al., 2019). The executive function results produced by our participants did not change after statistical adjustments, but intergroup baseline differences may have influenced the results.

Overall, we observed a limited range of improvement. To increase the positive effects on SPS, future studies may need to implement a longer interventional duration with more sessions. Indeed, most previous SPS interventions have implemented programs consisting of 10 to 27 sessions (Daunic et al., 2012; Haeffel et al., 2017; Leff et al., 2009; Merrill et al., 2017), whereas our study only included six sessions because of the limited time available for other curricula. Moreover, universal classroom-based interventions are associated with smaller effects compared with targeted interventions (Fazel et al., 2014; Sanchez et al., 2018), which indicates the need to modify the program characteristics and frequencies to achieve improvements in other behavioral and psychological outcomes.

The effect of the current intervention on SPS is slightly different from those reported in previous research (Daunic et al., 2012, 2019; Van Loan et al., 2019). These inconsistencies may be attributed to differences in educational settings, (i.e., the United States and Japan), intervention contents, and participants' backgrounds. Thus, caution is needed in interpreting the findings of the current study in other cultural contexts. A more careful adaptation of SPS interventions may be required for students with diverse backgrounds (Higgen & Mösko, 2021).

Moderating potential of executive function

Executive function performance had no effect on the improved SPS skills, as measured using the C-SPSS. By contrast, we observed significant an interaction effect between the intervention and executive function on the three indicators of emotional regulation

and school adjustment (i.e., problem solving, rumination, and life satisfaction). While our intervention reduced rumination among participants with low executive function, it also reduced their problem-solving coping styles and life satisfaction. On the ERS-EM, problem solving reflects a response style that is related to proactive cognitive and behavioral responses aimed at solving problems that arise in real life (Murayama et al., 2017). On the ASSESS, life satisfaction reflects a degree of satisfaction or enjoyment with life as a whole, indicating a general sense of adjustment. In turn, diminished scores on these variables suggest that school adjustment has declined. While our intervention was linked with decreased rumination among participants with lower executive function, focusing the overall results, which suggest negative effects for those children, is also important. Although few studies have investigated the moderating role of cognitive function, Haeffel et al. (2017) reported such a moderating effect (i.e., imposed by intelligence quotient) on SPS interventional effectiveness, referring to a negative impact on the post-intervention outcome (i.e., depression) in adolescents with low intellectual abilities. However, the researchers were unsure regarding why the level of cognitive function moderated the SPS intervention effect (Haeffel et al., 2017). As a possible explanation, they suggested that an understanding of emotional responses in the interpersonal relationships used in the SPS program may lead to increased depression among participants with low intelligence who fail to apply the learned skills.

Given the limited amount of knowledge on the interaction between executive function and the SPS intervention, no clear theoretical interpretation exists at this time. Notably, SPS interventions contain many cognitive elements that are linked to problem-solving skills. In this regard, a certain level of executive function (e.g., working memory) or intellectual ability may be required to adequately apply SPS skills in real life, especially because working memory is an important factor in school adjustment for

children (Pauli-Pott et al., 2021). Despite the differences in the target populations and outcomes, both the current findings and those from previous studies suggest that executive function may be associated with the effects of SPS interventions. Unfortunately, we could not elucidate the mechanisms responsible for the negative effects observed in this study. To identify how SPS interventions affect children in regular classrooms, it is necessary to clarify the underlying mechanism and specific area of usefulness in general versus clinical populations.

Limitations

This study had several limitations. First, we did not randomize the group allocations, meaning that potential confounding factors could have affected the estimated interventional effect. In children, school adjustment is affected by various background characteristics, including family socioeconomic status, overall cognitive function (Mason et al., 2020; Mimizuka, 2007), perceived social support (Kitahara et al., 2020), classroom atmosphere (Kawaguchi & Maeba, 2007), and the quality of interactions with teachers (Wang & Fletcher, 2016). Although these factors may have influenced the results, we did not measure them in this study. Simultaneously, the skill level of the teachers may also have confounded the results. Future studies should employ randomization to exclude the influence of these factors and biases in the estimation. In addition, identifying the potential confounding factors that alter the direction of the effectiveness is particularly critical in both research and school practice. An exploration of the potential confounding factors would be required to yield better outcomes and prevent negative outcomes of students (e.g., Vlachou et al., 2017; Vlachou & Stavroussi, 2016). Second, most of the outcome measures were based on subjective self-reports from children. As has been discussed (Hein et al., 2020; Van Loan et al., 2019), objective measures such as performance-based observations by multiple raters (e.g.,

parents, teachers, or peers) could help assess behavioral changes more reliably. Finally, it is important to conduct a follow-up evaluation to identify any long-term interventional effects (Daunic et al., 2019; Smith et al., 2014), regardless of whether they are positive or negative. Theoretically, an increase in the number of generated alternative solutions will lead to an improvement in later school adjustment. However, further empirical evidence would be required to extend the existing knowledge on SPS interventions. Although a precise estimation of long-term effects is difficult owing to various biases (e.g., selection bias), accumulating knowledge is essential for improving the effectiveness of school-based interventions.

Conclusion

SPS skills are important for children's social adjustment and mental health. In this study, a classroom-based SPS intervention helped a sample of children generate more alternative solutions, but simultaneously increased their use of aggressive and avoidant solutions. Moreover, the intervention produced a deteriorating effect on participants with lower executive functioning based on the scores representing emotional regulation skills and school adjustment. Our research findings indicate that the effects of SPS interventions can be affected by the baseline characteristics of children. These potential negative impacts emphasize the need to consider the individual profiles of SPS intervention recipients. The diversity in student's abilities and characteristics may affect the expected effects of SPS interventions. Theoretical considerations and exploring other possible moderating factors will facilitate a more nuanced understanding of the heterogeneity of the SPS intervention effects in schools.

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1 Table 1. Sex, age, and CANTAB scores across the study sample

	Treatment (n = 50)	Control (n = 51)	t	df	p
Sex, n (boys: girls)	22:28	22:29	-0.09	99	.93
Age in years, Mean (SD)	10.6 (0.3)	10.6 (0.3)	-0.45	99	.65
CANTAB					
SWM-BE, Mean (SD)	17.9 (6.9)	14.5 (8.3)	2.26	99	.03
SWM-S, Mean (SD)	8.8 (1.8)	8.2 (2.2)	1.51	99	.13
SST-SSRT, Mean (SD)	277.2 (67.9)	282.8 (68.8)	0.41	99	.68

CANTAB: Cambridge Neuropsychological Test Automated Battery
SWM-BE: Spatial Working Memory Between Error
SWM-S: Spatial Working Memory Strategy
SST-SSRT: Stop Signal Task Stop Signal Reaction time

2

3

4

Table 2. Material covered in the SPS intervention program.

	Theme and Contents
Session 1	Understanding the problem and goal setting: Understanding the principles of problem solving
Session 2	Gathering information to understand the problem: Defining the problem situation and feelings
Session 3	Generating alternative solutions: Realizing that there are multiple potential solutions by brainstorming alternative solutions
Session 4	Estimating the consequences of the implemented solution: Implementing the solution
Session 5	Selecting the appropriate solution: Choosing a solution based on factors such as safety and fairness. Promoting this practice
Session 6	Summary and reflection: Review of sessions 1–5

SPS: Social Problem Solving

1 Table 3. Effects of the intervention on the C-SPSS scores.

Dependent variable	Group	Pre *M (SD)*	Post *M (SD)*	*b*	95% CI	*p*
1) Problem orientation	Treatment	2.38 (0.67)	2.58 (0.74)	0.29	-0.08, 0.66	.124
	Control	2.57 (0.71)	2.45 (0.67)			
2) Problem definition & formulation						
2a) rational[a]	Treatment	5.59 (1.15)	5.45 (1.12)	-0.39	-0.75, -0.03	.032
	Control	5.81 (1.10)	5.95 (1.07)			
2b) impulsive/inattentive	Treatment	2.61 (0.69)	2.62 (0.70)	0.19	-0.16, 0.54	.290
	Control	2.57 (0.53)	2.48 (0.61)			
3) Generation of alternative solutions	Treatment	3.23 (1.51)	5.22 (2.28)	0.45	0.14, 0.76	.004
	Control	2.93 (0.92)	3.97 (1.76)			
4) Decision making[b]	Treatment	3.14 (1.05)	3.48 (0.93)	0.14	-0.21, 0.50	.433
	Control	3.56 (0.79)	3.54 (0.86)			

Treatment group, n = 50; Control group, n = 51

[a]: Treatment group, n = 49

[b]: Control group, n = 50

C-SPSS: Children's Social Problem-Solving Scale

2

Table 4. Interventional effects on the number of categories of generated solutions

Category	Number of responses	Treatment		Control		*b*	95% CI	*p*
		Pre	Post	Pre	Post			
Prosocial								
	0–1	2	0	0	0	.04	-0.11, 0.19	.606
	2–3	10	5	15	7			
	4–5	15	12	21	13			
	6–7	13	16	10	18			
	8+	10	17	5	13			
Aggressive								
	0–1	44	28	44	37	0.45	0.08, 0.82	.017
	2–3	3	18	7	10			
	4+	3	4	0	4			
Avoidant								
	0–1	42	30	44	41	0.62	0.23, 1.03	.002
	2–3	4	16	3	10			
	4+	3	4	0	0			

Table 5. Interventional effects on ERS-EM and ASSESS scores

Dependent variable	Group	Pre	Post	*b*	95% CI	*p*
		M (SD)	*M (SD)*			
ERS-EM						
Problem solving	Treatment	10.58 (3.34)	10.40 (3.67)	-0.31	-0.65, 0.03	.071
	Control	11.27 (3.35)	11.84 (3.15)			
Cognitive reappraisal	Treatment	11.24 (3.95)	12.12 (4.09)	-0.28	-0.64, 0.09	.133
	Control	12.90 (3.04)	13.92 (3.48)			
Rumination	Treatment	9.32 (3.33)	9.36 (3.52)	-0.22	-0.50, 0.07	.138
	Control	9.24 (3.42)	10.04 (3.33)			
Distraction	Treatment	7.08 (2.37)	7.44 (2.83)	0.12	0.21, 0.44	.473
	Control	7.08 (2.67)	7.12 (2.64)			
ASSESS						
Life satisfaction	Treatment	54.78 (11.98)	53.33 (13.10)	-0.24	-0.54, 0.06	.120
	Control	59.31 (11.57)	59.94 (13.69)			
Teacher support[a]	Treatment	57.73 (13.90)	56.18 (15.66)	-0.5	-0.81, -0.21	.001
	Control	60.63 (13.85)	66.14 (14.39)			
Friend support[b]	Treatment	55.20 (13.61)	54.98 (15.17)	-0.2	-0.52, 0.12	.224
	Control	57.41 (13.54)	59.63 (16.28)			
Non-infringing relationships[c]	Treatment	55.63 (13.48)	55.00 (13.06)	-0.21	-0.53, 0.10	.186
	Control	57.41 (13.49)	59.08 (14.83)			
Prosocial skills	Treatment	55.88 (12.56)	54.88 (11.85)	-0.42	-0.70, -0.14	.004
	Control	55.02 (10.28)	59.35 (12.46)			
Learning adaptation[d]	Treatment	58.06 (12.91)	52.35 (11.59)	-0.55	-0.81, -0.28	<.001
	Control	57.18 (14.63)	59.35 (15.33)			

Treatment group, n = 50; Control group, n = 51[a]: Treatment group, n = 48; Control group, n = 50

[b]: Treatment group, n = 48; Control group, n = 49

[c]: Treatment group, n = 48

[d]: Control group, n = 50

ERS-EM: Emotional Regulation Scale for Elementary and Middle School Students

ASSESS: Adaptation Scale for School Environments on Six Spheres

Figure Captions

Figure 1. Interaction effect between the intervention and executive function among the participants

A: Prosocial responses of the C-SPSS generation of alternative solutions

B: ERS-EM Problem solving

C: ERS-EM Rumination

D: ASSESS Life satisfaction

A CANTAB score of -1 SD indicates higher performance, while a score of +1 *SD* indicates lower performance.

CANTAB: Cambridge Neuropsychological Test Automated Battery; C-SPSS: Children's Social Problem-Solving Scale; SWM (BE): Spatial working memory (Between Errors); SWM (S): Spatial working memory (Strategy); ERS-EM: Emotional Regulation Scale for Elementary and Middle School Students; ASSESS: Adaptation Scale for School Environments on Six Spheres

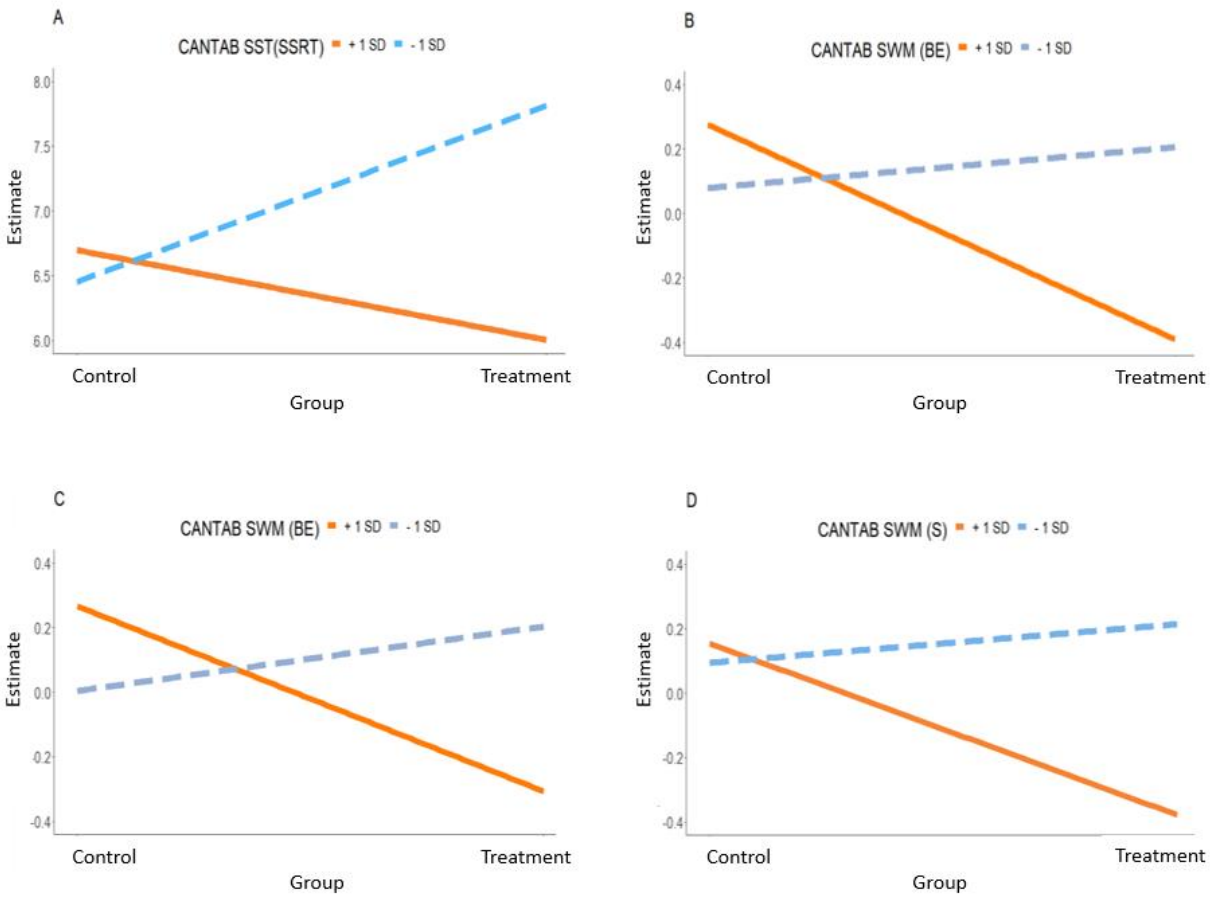
A
CANTAB SST(SSRT) +1 SD -1 SD
Estimate
8.0
7.5
7.0
6.5
6.0
Control
Treatment
Group
B
CANTAB SWM (BE) +1 SD -1 SD
Estimate
0.4
0.2
0.0
-0.2
-0.4
Control
Treatment
Group
C
CANTAB SWM (BE) +1 SD -1 SD
Estimate
0.4
0.2
0.0
-0.2
-0.4
Control
Treatment
Group
D
CANTAB SWM (S) +1 SD -1 SD
Estimate
0.4
0.2
0.0
-0.2
-0.4
Control
Treatment
Group

Figure 1

Supplemental Table S1. Pearson's correlation coefficient between the indices measured at pre-intervention

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
C-SPSS																	
1. Problem orientation	-																
2. Definition & formulation (Rational)	-0.06	-															
3. Definition & formulation (Impulsive/inattentive)	0.16	0.29	-														
4. Generation of alternative solutions	0.03	0.05	0.03	-													
5. Decision making	0.07	0.28	0.03	-0.08	-												
ERS-EM																	
6. Problem solving	0.00	0.41	0.16	-0.04	0.32	-											
7. Cognitive reappraisal	0.11	0.29	0.28	-0.11	0.15	0.56	-										
8. Rumination	-0.38	0.11	-0.22	-0.01	0.11	0.20	-0.10	-									
9. Distraction	0.22	-0.03	0.17	0.10	0.04	0.20	0.36	-0.13	-								
ASSESS																	
10. Life satisfaction	0.26	0.10	0.13	0.02	0.20	0.32	0.39	-0.22	0.38	-							
11. Teacher support	0.16	0.15	-0.03	0.01	0.17	0.37	0.18	0.00	0.14	0.37	-						
12. Friend support	0.09	0.21	0.10	0.01	0.03	0.44	0.28	-0.04	0.26	0.51	0.58	-					
13. Non-infringing relationships	0.22	0.11	-0.05	-0.01	0.23	0.11	0.04	-0.31	0.02	0.31	0.28	0.22	-				
14. Prosocial skills	0.28	0.24	0.38	0.16	0.17	0.39	0.36	-0.12	0.30	0.48	0.24	0.41	0.06	-			
15. Learning adaptation	0.24	0.28	0.16	-0.04	0.27	0.25	0.26	-0.20	0.22	0.33	0.19	0.20	0.37	0.31	-		
CANTAB																	
16. SST_SSRT	0.06	0.02	-0.03	0.01	-0.09	-0.12	0.01	-0.15	0.07	-0.01	0.03	0.11	-0.03	0.04	-0.16	-	
17. SWM_BE	0.08	-0.04	0.13	0.05	-0.05	-0.04	-0.02	-0.06	-0.05	-0.06	-0.12	0.05	0.01	0.03	0.03	0.11	-
18. SWM_S	-0.07	0.00	0.03	0.11	0.02	-0.06	-0.10	0.09	-0.09	-0.17	-0.12	-0.03	-0.17	-0.07	-0.11	0.14	0.60

Correlation coefficient calculated from pre-point scores.

C-SPSS: Children’s social problem-solving scale

ERS-EM: Emotional regulation and adaptation to the school environment Emotional regulation scale for elementary and middle school students

ASSESS: Adaptation scale for school environments on six spheres

CANTAB: Cambridge neuropsychological test automated battery

SST_SSRT: Stop signal test, Stop Signal Reaction Time index

SWM_BE: Spatial working memory, Between Errors index

SWM_S: Spatial working memory, Strategy index

Supplemental Table S2. Effects of the intervention adjusted for CANTAB indices on the C-SPSS scores.

Dependent variable	*b*	95% CI	*p*
Problem orientation	0.30	-0.09, 0.68	.127
Problem definition & formulation			
(rational)	-0.37	-0.74, -0.01	.044
(impulsive/inattentive)	0.17	-0.20, 0.54	.367
Generation of alternative solutions	0.49	0.18, 0.81	.003
Decision making	0.10	-0.26, 0.45	.595

The estimates (*b*) was adjusted for pre-score of each dependent variable and CANTAB indices.
C-SPSS: Children's social problem-solving scale
CANTAB: Cambridge neuropsychological test automated battery

Supplemental Table S3. Effects of the intervention adjusted for CANTAB indices on the number of categories of generated solutions

Category	*b*	95% CI	*p*
Prosocial	0.06	-0.10, 0.22	.489
Aggressive	0.48	0.11, 0.86	.012
Avoidant	0.63	0.23, 1.05	.003

The estimates (*b*) was adjusted for pre-score of each dependent variable and CANTAB indices.
CANTAB: Cambridge neuropsychological test automated battery

Supplemental Table S4. Effects of the intervention adjusted for CANTAB indices on ERS-EM and ASSESS scores.

Dependent variable	*b*	95% CI	*p*
ERS-EM			
Problem solving	-0.29	-0.65, 0.06	.101
Cognitive reappraisal	-0.27	-0.65, 0.11	.157
Rumination	-0.22	-0.51, 0.08	.151
Distraction	0.14	-0.20, 0.48	.420
ASSESS			
Life satisfaction	-0.20	-0.51, 0.12	.216
Teacher support	-0.47	-0.78, -0.16	.003
Friend support	-0.20	-0.53, 0.13	.237
Non-infringing relationships	-0.23	-0.56, 0.09	.160
Prosocial skills	-0.49	-0.77, -0.20	<.001
Learning adaptation	-0.51	-0.79, -0.23	<.001

The estimates (*b*) was adjusted for pre-score of each dependent variable and CANTAB indices.
ERS-EM：Emotional regulation and adaptation to the school environment Emotional regulation scale for elementary and middle school students
ASSESS: Adaptation scale for school environments on six spheres
CANTAB: Cambridge neuropsychological test automated battery