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Original Article

Effectiveness of training in self-regulated learning strategies and executive function enhancement on academic optimism in students with low academic achievement

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Abstract

Background: Academic achievement significantly influences life success, yet low achievement can cause cognitive and emotional challenges, including disengagement and reduced academic optimism. This study compared the effectiveness of self-regulated learning strategies and executive function enhancement training on academic optimism among students with low academic achievement in Babol, Iran.

Methods: This quasi-experimental study employed a pre-test, post-test, and three-month follow-up design with a control group. The population comprised ninth-grade female students with low academic achievement (GPA < 15, aged 14–16) from five public schools in Babol during the 2023–2024 academic year. Sixty students were purposively selected and randomly assigned to two experimental groups (n = 20 each) and one control group (n = 20). The first group received eight 90-minute sessions of self-regulated learning training. The second group underwent ten 60-minute executive function enhancement sessions. The control group received no intervention. Academic optimism was assessed using the Academic Optimism Questionnaire. Data were analyzed via mixed-model repeated-measures ANOVA using SPSS-27.

Results: The findings indicated that both interventions were effective in improving academic optimism in students with low academic achievement ($P < 0.001$). Furthermore, the results showed that the executive function enhancement training was significantly more effective than the self-regulated learning strategies training in increasing academic optimism.

Conclusion: Self-regulated learning and executive function enhancement training effectively increased academic optimism in students with low academic achievement. Executive function training showed greater efficacy, indicating that targeting cognitive skills may yield more substantial, stable improvements in academic outlook.

Introduction

Students' academic achievement is a crucial determinant of success in their developmental journey and future life. Students who demonstrate appropriate academic progress are more likely to exhibit greater focus and concentration on their learning objectives.[1] Conversely, low academic achievement is defined as a situation where a student's performance in one or more subjects is significantly below the expected level for their age, grade, or cognitive abilities.[2] This condition is typically characterized by low grades, failure to meet curriculum goals, or poor performance on standardized tests, and can be influenced by a combination of individual, family, educational, and environmental factors.[3] The American Psychological Association defines low academic achievement as academic performance that is weaker than the standard or expectations set by teachers and the curriculum, as identified through formal or informal evaluations. This state can lead to numerous cognitive, social, emotional, and even behavioral problems, ultimately resulting in academic disengagement and avoidance.[4] It is crucial to acknowledge that a correct understanding of one's individual circumstances and academic performance can significantly influence the formation of academic optimism and the acquisition of knowledge.

Academic optimism is a concept that, alongside social and economic status and previous achievements, affects students' academic performance. It is a characteristic that can create differences in academic success.[5] Optimism is a multifaceted construct encompassing emotional, social, and cognitive components. The emotional component involves being positive, cheerful, and happy. The social component is characterized by having good social relationships and receiving social support from others.

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The cognitive component allows optimistic individuals to process and interpret information in a specific way, leading to feelings of happiness and optimism.[6,7] Optimistic individuals constantly anticipate pleasant events in their lives, and human actions are largely influenced by the expected outcomes of those actions.[8] Overall, effective methods for improving academic optimism include educational approaches that simultaneously address cognition, behavior, emotions, and interactions.

Training in self-regulated learning strategies and executive function enhancement are innovative methods that follow this approach. Self-regulated learning strategies refer to a process where effective and systematic techniques can be used to guide learners' thoughts, feelings, and behaviors toward achieving specific goals.[9] These strategies include cognitive strategies, repetition and elaboration, and organization; metacognitive strategies such as planning, monitoring, and regulation; and resource management strategies.[10] Through this approach, learners gain personal control over their learning process, which leads to greater speed and accuracy in learning as well as the development of qualities such as increased self-confidence, self-efficacy, and responsibility.[11] Prior research has demonstrated the effectiveness of these interventions. For example, Ergen and Kanadlı[12] showed that teaching self-regulated learning strategies is effective for students' academic achievement. Similarly, Li et al[13] found that optimism and mental health play a chain-mediating role between self-directed learning and academic performance in college students. Hwang and Kim[14] also found that self-directed learning competency has a mediating effect on the relationship between optimism, emotional intelligence, and academic resilience in nursing students.

Another intervention is the enhancement of executive functions. Neuro-psychological theories of executive functions focus on these higher-order cognitive processes and the set of cognitive functions that are responsible for controlling thought and action.[15] These functions are critical for independent, goal-directed activity and successful adaptation. They include anticipation, goal setting, planning, self-regulation, monitoring goal execution, working memory, and effective feedback on plans.[16] Training in executive functions allows for an integrated understanding of thought, emotion, and behavior and helps individuals adapt and adjust cognitive functions related to attention, concentration, and other processes.[17,18] Research supports the efficacy of this training. Soorgi et al[19] found that executive function training is effective in improving students' academic vitality and performance. Koay and Van Meter[20] also showed that executive function and emotional self-regulation influence engagement in behaviors. Both self-regulated learning and executive function training are proactive methods that actively help learners and encompass a wide range of cognitive, behavioral, emotional, and social domains.

Despite the established importance of academic optimism in fostering academic success, there is a critical gap in comparative research evaluating the relative efficacy of self-regulated learning strategies versus executive function enhancement training, particularly among students with low academic achievement in regions like Babol. This study addresses this gap by directly comparing these interventions to determine which foundational skill set—cognitive or metacognitive—yields greater improvements in academic optimism. Such findings could inform the prioritization and sequencing of educational interventions, enabling educators to optimize resource allocation and design targeted programs that maximize positive academic outcomes for struggling learners.

Methods

This study employed a quasi-experimental design with a pre-test, post-test, and three-month follow-up using a control group. The statistical population comprised all female ninth-grade students with low academic achievement from five public schools in Babol during the 2023–2024 academic year. A sample of 60 students was selected using purposive sampling, guided by the specific purpose of identifying students who exhibited low academic achievement and were likely to benefit from interventions aimed at enhancing academic optimism. Selection was based on inclusion criteria, which included a total grade point average (GPA) below 15, being aged between 14 and 16 years, and demonstrating a willingness to participate in the study, as assessed through initial parental and student consent discussions. No additional factors beyond these criteria were considered to ensure focus on the target population. These students were then randomly assigned to one of two experimental groups (n = 20 per group) and a single control group (n = 20). Exclusion criteria included absenteeism from more than two intervention sessions or an unwillingness to continue participation. All participants and their parents were fully informed of the study's objectives and provided written informed consent. Confidentiality of all participant data was assured, and it was guaranteed that results would be published anonymously. At the conclusion of the study, all participants, including those in the control group, were debriefed about the nature and purpose of the interventions, and the control group was offered access to resources on self-regulated learning and executive function enhancement to address any potential disparities in educational opportunities.

Research tool

The Academic Optimism Questionnaire was used to collect data. This self-report tool assesses students' academic optimism across three main subscales: student trust (10 items), student perception of academic emphasis (8 items), and school identity (10 items). The questionnaire

consists of 28 items rated on a 5-point Likert scale, ranging from "Strongly Disagree" (1) to "Strongly Agree" (5). Scores range from 28 to 140, with higher scores indicating greater academic optimism.[21] The questionnaire has been validated in numerous Persian-language studies, with reported Cronbach's alpha coefficients ranging from 0.82 to 0.90, indicating good reliability.[22] In the current study, the Cronbach's alpha for the questionnaire was calculated at 0.89, confirming its high reliability for this specific sample.

Intervention programs

The two experimental groups received distinct intervention packages, while the control group received no intervention. To ensure intervention fidelity, both programs were delivered using standardized manuals developed based on established protocols for self-regulated learning and executive function training. Facilitators were trained clinical psychologists who received specialized instruction to ensure consistent delivery of the sessions, and regular supervision meetings were held to monitor adherence to the protocols. The self-regulated learning strategies training package consisted of eight 90-minute sessions, while the executive function enhancement training consisted of ten 60-minute sessions. A summary of the sessions for both programs is provided in Table 1.

Data analysis

The collected data were analyzed using mixed-model repeated-measures analysis of variance (ANOVA) with SPSS statistical software (version 27). This method allowed for the examination of within-group changes and between-group comparisons over time (pre-test, post-test, and follow-up).

Results

The demographic characteristics of the participants indicated that all were female ninth-grade students with a GPA below 15, aged between 14 and 16 years. Table 2 presents the mean and standard deviation of academic optimism scores and their subscales for all three groups across the three measurement points. As shown, the mean academic optimism scores for the two experimental groups were similar to the control group at the pre-test. However, at the post-test and follow-up, the mean scores of the experimental groups were significantly different from the control group. The group receiving executive function enhancement training showed a more pronounced increase in academic optimism compared to the self-regulated learning group.

The normality of the data distribution was assessed using the Shapiro-Wilk test. The results indicated that the significance level for all variables was greater than 0.05, confirming that the data were normally distributed. Additionally, Levene's test showed no significant difference in variance among the study groups for the academic optimism variable, thus satisfying the assumption of homogeneity of variances.

A repeated-measures ANOVA was conducted to test the research hypotheses. The results in Table 3 demonstrate a significant main effect for "group" ($P<0.001$), indicating a meaningful difference in academic optimism scores among the three groups. This effect was associated with a large effect size for the total academic optimism score ($\eta^2=0.71$), suggesting a substantial difference in the impact of the interventions across groups. The main effect for "stages of education" (pre-test, post-test, and follow-up) was also significant ($P<0.001$), with a large effect size ($\eta^2=0.82$), indicating that changes in academic optimism scores over time were highly pronounced within groups. Furthermore, a significant interaction effect was found between "group" and "stages of education" ($P<0.001$), with a large effect size ($\eta^2=0.72$), demonstrating that the interventions had markedly different impacts on academic optimism across the groups over time.

For the subscales, the effect sizes for the group effect were moderate to large (η^2 ranging from 0.51 to 0.60),

Table 1. Summary of intervention program sessions

Session	Executive function enhancement training	Self-regulated learning strategies training
1	Introduction to executive functions and their role in behavioral control and learning.	Introduction to the concept of self-regulated learning and its importance for academic success.
2	Working memory exercises: using memorization techniques.	Training in cognitive strategies: repetition, elaboration, and information organization.
3	Response inhibition exercises: controlling impulses and distracting behaviors.	Training in metacognitive strategies: planning and setting learning goals.
4	Cognitive flexibility exercises: adapting approaches to problem-solving.	Training in metacognitive strategies: monitoring progress and self-assessment.
5	Planning exercises: setting short-term and long-term goals.	Training in resource management strategies: time management and optimizing the learning environment.
6	Organization exercises: sorting and categorizing information.	Training in resource management strategies: seeking support from peers and teachers.
7	Emotional control exercises: managing emotions in stressful situations.	Integration of strategies and practical application to various subjects.
8	Sustained attention training: focusing on a task for an extended period.	Summary, problem-solving, and emphasis on consistency.
9	Self-monitoring: evaluating performance and adjusting behavior.	-
10	Summary and transfer of learned skills to real-world settings.	-

Table 2. Mean and standard deviation of academic optimism scores across all groups

Variable	Group	Pre-test	Post-test	Follow-up
		Mean ± SD	Mean ± SD	Mean ± SD
Trust	Self-regulated learning	17.31 ± 1.42	20.64 ± 2.39	20.73 ± 2.54
	Executive function enhancement	17.38 ± 1.53	23.78 ± 3.13	23.91 ± 3.09
	Control	17.28 ± 1.25	17.36 ± 1.30	17.52 ± 1.25
Perception	Self-regulated learning	14.36 ± 1.91	18.51 ± 3.06	18.66 ± 2.64
	Executive function enhancement	14.62 ± 1.49	22.30 ± 5.32	22.52 ± 1.86
	Control	14.45 ± 1.66	14.59 ± 1.36	14.74 ± 1.80
School identity	Self-regulated learning	19.23 ± 1.07	22.77 ± 4.81	22.90 ± 4.69
	Executive function enhancement	19.28 ± 1.05	26.59 ± 2.37	26.63 ± 1.97
	Control	19.23 ± 0.80	19.32 ± 1.07	19.44 ± 1.32
Academic optimism (Total)	Self-regulated learning	50.89 ± 4.20	61.91 ± 6.67	62.29 ± 6.78
	Executive function enhancement	51.28 ± 4.36	72.67 ± 5.33	73.06 ± 5.18
	Control	50.96 ± 4.68	51.26 ± 4.47	51.69 ± 4.11

Table 3. Summary of repeated-measures ANOVA results

Variable	Source	SS	df	MS	F	P	η^2
Trust	Group	556.43	2	278.22	33.11	0.001	0.54
	Stages	345.92	1	345.92	112.51	0.001	0.66
	Group × Stages	198.21	2	99.10	32.23	0.001	0.53
Perception	Group	817.06	2	408.53	43.50	0.001	0.60
	Stages	520.00	1	520.00	249.10	0.001	0.81
	Group × Stages	290.32	2	145.16	69.54	0.001	0.71
School identity	Group	702.50	2	351.25	30.19	0.001	0.51
	Stages	420.71	1	420.71	74.49	0.001	0.57
	Group × Stages	255.22	2	127.61	22.59	0.001	0.44
Academic optimism (Total)	Group	6189.19	2	3094.60	69.14	0.001	0.71
	Stages	3833.30	1	3833.30	255.10	0.001	0.82
	Group × Stages	2216.81	2	1108.41	73.76	0.001	0.72

indicating meaningful differences in trust, perception, and school identity across groups. The stages effect showed large effect sizes for trust ($\eta^2 = 0.66$), perception ($\eta^2 = 0.81$), and school identity ($\eta^2 = 0.57$), reflecting substantial changes over time. The interaction effects also demonstrated moderate to large effect sizes (η^2 ranging from 0.44 to 0.71), underscoring the differential impact of the interventions on each subscale over time.

The Bonferroni post-hoc test was performed to further investigate the significant main effects and interactions. The results in Table 4 show significant differences in academic optimism scores and their subscales between the pre-test and post-test, as well as between the pre-test and the follow-up. This indicates that both interventions had a significant effect on improving academic optimism ($P < 0.001$). However, the comparison between post-test and follow-up scores was not statistically significant, suggesting that the effects of the interventions were stable over the three-month follow-up period.

As shown in Table 5, there were no significant differences between the groups at the pre-test stage, indicating homogeneity at the outset. However, at the post-test and follow-up stages, both experimental groups showed a significant increase in academic optimism scores compared to the control group ($P < 0.001$). Furthermore, the comparison between the two experimental groups revealed a significant difference in academic optimism scores, with the executive function enhancement group showing superior performance.

Discussion

The current study aimed to compare the effectiveness of self-regulated learning strategies and executive function enhancement training on academic optimism in a sample of students with low academic achievement. The findings revealed that both interventions were effective in significantly improving students' academic optimism. Crucially, the results demonstrated that the executive function enhancement training had a significantly greater impact on academic optimism compared to the self-

Table 4. Bonferroni post-hoc test results for paired within-group comparisons

Variable	Paired comparison	Mean difference	SE	*P*
Trust	Pre-test - Post-test	3.33	0.28	0.001
	Pre-test - Follow-up	3.42	0.27	0.001
	Post-test - Follow-up	0.09	0.13	0.999
Perception	Pre-test - Post-test	3.99	0.51	0.001
	Pre-test - Follow-up	4.16	0.26	0.001
	Post-test - Follow-up	0.18	0.18	0.999
School identity	Pre-test - Post-test	3.65	0.46	0.001
	Pre-test - Follow-up	3.75	0.43	0.001
	Post-test - Follow-up	0.10	0.09	0.999
Academic optimism (Total)	Pre-test - Post-test	10.90	0.91	0.001
	Pre-test - Follow-up	11.30	0.72	0.001
	Post-test - Follow-up	0.40	0.40	0.999

Table 5. Bonferroni post-hoc test results for between-group comparisons at different stages

Stage	Group comparison	Mean difference	SE	*P*
Pre-test	Self-regulated learning - Control	0.12	0.51	0.999
	Executive function enhancement - Control	0.31	0.51	0.999
	Self-regulated learning - Executive function enhancement	-0.19	0.51	0.999
Post-test	Self-regulated learning - Control	10.65	0.59	0.001
	Executive function enhancement - Control	21.41	0.59	0.001
	Self-regulated learning - Executive function enhancement	-10.76	0.59	0.001
Follow-up	Self-regulated learning - Control	10.59	0.55	0.001
	Executive function enhancement - Control	21.11	0.55	0.001
	Self-regulated learning - Executive function enhancement	-10.51	0.55	0.001

regulated learning strategies training. These findings, which also showed stability of the intervention effects over a three-month follow-up period, offer valuable insights into targeted educational interventions.

The finding that executive function enhancement training was highly effective is consistent with and expands upon prior research linking executive cognitive skills to academic success and psychosocial well-being.[23] Executive functions, including working memory, cognitive flexibility, and inhibitory control, are considered foundational cognitive skills that enable individuals to plan, focus, and manage their behaviors and emotions to achieve goals.[15] For students with a history of low academic achievement, deficits in these fundamental skills often contribute to poor performance. By directly targeting and strengthening these core cognitive processes, the training likely provided students with the necessary mental tools to engage more effectively in academic tasks. This improved cognitive capacity could have fostered a more positive sense of agency and control over their learning, directly contributing to an increase in their academic optimism.[23] This is supported by previous studies, such as the one by Soorgi et al,[19] which found that executive function training improved students' academic vitality and performance. The current study's results are also in alignment with findings by Becker and Tetzner,[24] who demonstrated a direct link between cognitive abilities and academic outcomes in adolescents, suggesting that interventions targeting these abilities can have a profound impact.

The self-regulated learning strategies training also proved effective in enhancing academic optimism, which is a key component of academic motivation and resilience. This result is consistent with the literature, indicating a strong relationship between self-directed learning and positive academic attitudes.[25] The training provided students with a structured framework for setting goals, monitoring their progress, and managing their time and resources. This process of gaining control over one's own learning journey can cultivate a sense of self-efficacy and competence, which are central tenets of academic optimism.[26,27] The findings align with the work of Hwang and Kim,[14] who found a mediating effect of self-directed learning competency on the relationship between optimism and academic resilience. Furthermore, our results resonate with Li et al,[13] who showed that self-directed learning plays a significant role in improving optimism and mental health in a student population. The effectiveness of this training package underscores the importance of teaching students to be active participants

in their own learning process, a skill that can transcend academic settings.

The most notable finding of this study is the greater efficacy of the executive function enhancement training. This suggests that while self-regulated learning strategies are beneficial, they may be more effectively implemented when students possess the foundational cognitive skills that executive function training aims to strengthen. In essence, teaching students to plan and organize (self-regulation) is more impactful when they have the underlying working memory and inhibitory control (executive functions) to execute those plans. This finding strongly supports a sequenced intervention approach, where foundational cognitive skills are prioritized before introducing metacognitive strategies, as this may maximize the impact on academic optimism and overall academic outcomes. Such an approach could guide educators and practitioners in designing more effective intervention programs, ensuring that students build a robust cognitive foundation before engaging in self-regulated learning practices. This finding holds significant practical implications for educational practitioners, suggesting that a sequenced intervention approach, where foundational cognitive skills are addressed first, may be a more potent strategy for improving academic attitudes and outcomes in struggling learners.

The findings should be interpreted with consideration for several limitations. The study's sample was limited to female students from a specific city, which may restrict the generalizability of the results to other populations. The quasi-experimental design, while robust, also has limitations compared to a true randomized controlled trial. Additionally, the potential for instructor effects must be acknowledged, as different facilitators may have delivered the self-regulated learning and executive function enhancement training packages, potentially influencing the consistency and efficacy of the interventions.

Conclusion

Based on the findings, both self-regulated learning strategies and executive function enhancement training were effective in significantly improving academic optimism in students with low academic achievement. A notable finding was the superior efficacy of the executive function enhancement training, which suggests that strengthening fundamental cognitive skills may have a more profound and lasting impact on students' positive academic outlook compared to teaching learning strategies alone. We recommend that educators and school psychologists consider incorporating executive function assessments and training as a primary intervention for students exhibiting low academic optimism and achievement, as this approach may provide a foundational cognitive framework that enhances the effectiveness of subsequent learning strategies. These results indicate that tailored interventions can be instrumental in fostering academic optimism, thereby potentially mitigating the challenges associated with low academic achievement and promoting a more positive and engaged learning experience.

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Authors' Contribution

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Competing Interests

The authors declare that they have no competing interests.

Ethical Approval

The research adhered to ethical standards and received approval from the Ethics Committee of Islamic Azad University, Ahvaz Branch (approval code: IR.IAU.AHVAZ.REC.1403.450).

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