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Comparing the effectiveness of software cognitive empowerment training and perceptual-motor skills reconstruction program training on academic self-efficacy and academic engagement

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Abstract

Introduction: Self-efficacy and academic engagement play important roles in academic success. We compared the effectiveness of software cognitive empowerment training and perceptual-motor skills reconstruction program training on self-efficacy and academic engagement.

Materials and Methods: The statistical community included seventh-grade male students in Mashhad, Iran, in the academic year 2022-2023. We selected forty-five students through purposive sampling. Then, they randomly assigned to three groups (software cognitive empowerment group, perceptual-motor skills reconstruction group, and control group). The experimental groups received Captain's Log software cognitive empowerment training or perceptual-motor skills training. We evaluated the participants using Academic Self-Efficacy Scale and Academic Engagement Scale. The data were analyzed using the multivariate analysis of covariance (MANCOVA) and SPSS 26 software.

Results: According to the findings, both training programs positively affected self-efficacy and academic engagement (P< 0.05). While, we found no significant differences between the two interventions (P> 0.05).

Conclusion: We revealed that software cognitive empowerment training and perceptual-motor reconstruction program training positively affected self-efficacy and academic engagement in high school students, but none of the interventions mentioned are superior to each other.

Keywords: Academic engagement, Perceptual-motor skills, Self-efficacy, Software cognitive empowerment

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Introduction

Self-efficacy is a crucial factor related to academic achievement (1-4). Students with high academic self-efficacy show high levels of persistence and effort in all stages of the learning process (5).

Academic engagement is a construct that was first proposed to understand and explain academic decline and failure. It is the basis for reformist efforts in education (6). In one of the most widely used definitions of learning engagement, Rio and Tseng have identified four dimensions of learning engagement: behavioral (student participation in learning activities such as effort, persistence, and attention), affective (student enthusiasm and interest), cognitive (student use of active self-regulation and complex learning strategies), and agentive (student constructive participation in the learning process). In other words, learning engagement is the quality of effort students put into goal-oriented learning activities that directly contribute to desired outcomes (7-9). Studies indicated that students with higher levels of cognitive function had better academic performance and experienced less burnout than students with lower cognitive functions (10).

Computer-assisted cognitive rehabilitation is a novel training technique that improves students' cognitive function (11,12). In addition, the evidence shows that perceptual-motor skills training enhances academic achievements and reduces learning problems in students (13-15).

Regarding the important role of academic self-efficacy and academic engagement in the learning process in students and using effective methods to enhance these factors, and the lack of available studies, in the present study we compared the effectiveness of software cognitive empowerment training and perceptual- motor skills reconstruction program training on academic self-efficacy and academic engagement.

Materials and Methods

In this cross-sectional study, the statistical community included all high school male seventh-grade students in Mashhad, Iran, during the academic year 2022-2023. We selected forty-five students using the purposive sampling method. Then they randomly divided into three equal groups: cognitive empowerment training, perceptual-motor skill training, and control. We calculated the sample size using a formula and prior studies (16).

The inclusion criteria included being a seventh-grade male student and not receiving any other psychological training during the study. The exclusion criteria included lack of cooperation in completing the questionnaires and not attending more than three sessions.

Research instruments

A) Academic Self-Efficacy Scale: This self-report tool was compiled by Morgan and Jinks (1999) and has 30 items and 3 subscales of talent, effort, and texture. The items are scored in a four-point Likert degree (completely agree, somewhat agree, somewhat disagree, and completely disagree). Morgan and Jinks have reported its internal consistency at 0.82. Also, Cronbach's alpha coefficient of the three talent, effort, and texture subscales have been reported as 0.78, 0.66, and 0.70, respectively (17). In Iran, Bandak et al. reported the validity of the three talent, effort, and texture subscales as good (α= 0.78, α= 0.77, and α= 0.66, respectively) (16).

B) Academic Engagement Scale: Rio and Tseng (2011) developed this self-report scale with 22 questions. It has four components: agency engagement, behavioral engagement, emotional engagement, and cognitive engagement, with cognitive engagement consisting of two parts: cognitive strategies and metacognitive strategies. The subjects respond the items on a 4-point Likert system (strongly disagree, disagree, agree, and strongly agree). Khodai reported the reliability coefficient of the academic engagement questionnaire with Cronbach's alpha equal to 0.91 (0.83 for agency engagement subscales, 0.85 for behavioral engagement, 0.65 for emotional engagement, and 0.83 for cognitive engagement (6).

Interventions

Captain's Log Software Cognitive Empowerment Training: This training is one of the cognitive software designed by Brain Train to rehabilitate and empower cognitive functions (18). This attractive program has more than 2000 exercises for 20 cognitive skills designed to improve individual performance (19). There is a silver level for children, a gold level for adolescents, and a diamond level for adults. Also, different difficulty levels, easy, medium, and difficult, can be selected for games. All exercises in this set have 15 stages at each level, and each stage is different from the previous stage. The closer we get to the final stages, the more difficult these stages become, and the condition for entering the next stage is to complete the task of the previous stage correctly. The implementation method is as follows: In the first session, explanations about the software, the training objectives, the workspace, and examples of instructions were described to the students so they fully understood the instructions. Initially, the software conducts a nine-step test for initial assessment for each student and provides us with cognitive exercises tailored to the cognitive weakness of each student. Based on the initial evaluation of the software and the opinion of a child and adolescent specialist, a total of five exercises (The Ugly Duckling, Domino Dynamite, Darts, Puzzle Power, Racing Robots) were selected from the cognitive areas of this software and defined for each participant by adjusting the level of difficulty, playing time, and age level. Each subject practiced two sessions per week for 45 minutes. What the participants did in each session was saved, and the exercise was continued in the next session. During the research, some participants were given necessary explanations, given that the software language used was English.

Perceptual-motor skills training: The intervention program used in the present study, which was prepared based on the Werner and Reini training programs and consisted of twelve 45-minute sessions, is given in Table 1 (15).

Table 1. Objectives and content of the perceptual-motor skills training sessions

Session	Goal	Content
1st and 2nd	Balance training and related exercises	1- Balance puzzles, 2- Balancing stick, 3- Balancing board, 4- Large tube, 5- Walking with cans, and 6- Stepping ladder
3rd and 4th	Body awareness training, the role of organs and related exercises	1- Human puzzle, 2- Drawing body parts, 3- Executing left hand commands on the right leg and vice versa, and 6- Mirror
5th and 6th	Spatial awareness training and related exercises	1- Diagram and reading arrow directions, 2- Similarities and differences puzzle, 3- Orientation, 4- Following directions, and 5- Nail board
7th and 8th	Shape perception training and related exercises	1- Sand, clay and finger painting, 2- Domino shapes, letters and numbers, 3- Puzzles, 4- Shape exercises from the background, and 5- Design and color game
9th and 10th	Visual perception training and related exercises	1- Maze, 5- What is forgotten?, 3- Visual memory exercises, 4- Thread and rosary, and 5- Hidden pictures
11th and 12th	Auditory perception training and related exercises	1- Tapping, clapping and breaking, 2- Making sentences by adding one word to other words, 3- Telling a story and repeating parts of it, 4- Saying the sentence in reverse, and 5- Clean cans

We analyzed the data using the multivariate analysis of covariance (MANCOVA) and SPSS version 26 software.

Results

Table 2 presents the descriptive data related to the variables. The results of Table 2 showed that the mean scores of talent, effort, and texture in the experimental groups in the post-test and follow-up stages were higher than the mean scores of the control group. The mean scores in the experimental groups increased from pre-test to post-test. However, these scores did not change significantly from post-test to follow-up. Also, the same changes were seen in components of academic engagements.

Table 2. The scores of academic self-efficacy and academic engagement in different stages in students

Variable	Cognitive rehabilitation group			Perceptual-motor skills training group			Control		
	Pre-test	Post-test	Follow-up	Pre-test	Post-test	Follow-up	Pre-test	Post-test	Follow-up
Talent	40.20 ± 6.03	45.07 ± 4.68	45.60 ± 5.79	40.60 ± 4.45	42.93 ± 3.83	43.09 ± 4.90	38.26 ± 7.60	38.86 ± 6.06	37.90 ± 6.53
Effort	13.33 ± 1.67	15.67 ± 1.75	15.47 ± 1.82	12.67 ± 1.79	13.93 ± 1.50	14.11 ± 1.69	12.73 ± 2.60	11.48 ± 2.64	11.26 ± 2.43
Texture	39.07 ± 4.63	44.67 ± 3.10	44.33 ± 4.20	38.13 ± 4.06	41.80 ± 3.52	42.05 ± 2.89	36.93 ± 7.24	37.46 ± 4.79	37.80 ± 4.76
Agency engagement	12.26 ± 2.25	14.86 ± 3.15	14.78 ± 3.47	13.60 ± 3.11	15.60 ± 3.22	15.66 ± 3.19	14.47 ± 2.80	14.38 ± 3.33	14.29 ± 3.24
Behavioral engagement	17.06 ± 2.65	19.80 ± 1.89	19.88 ± 2.16	17.94 ± 1.22	19.19 ± 2.01	19.26 ± 2.35	17.13 ± 2.50	16.89 ± 1.96	16.78 ± 3.22
Emotional engagement	12.00 ± 1.85	15.60 ± 1.72	15.68 ± 2.31	11.93 ± 1.94	15.73 ± 1.66	15.60 ± 2.13	12.40 ± 2.55	11.97 ± 2.22	11.47 ± 2.80
Cognitive engagement	24.00 ± 2.87	29.45 ± 3.44	29.36 ± 3.95	25.33 ± 2.54	30.60 ± 4.96	30.76 ± 2.87	23.73 ± 6.06	23.33 ± 4.46	23.53 ± 4.54

We used the Shapiro-Wilk test to assess the normality of the variables. The results indicated the normality of the distribution of these variables (P> 0.05). In addition, we reported the homogeneity of variances in academic self-efficacy using the Levene's test (P> 0.05). The Box's M test also showed that the homogeneity of the variance-covariance matrix has been achieved (P> 0.05, F= 0.87, Box's M= 61.07).

We assessed the sphericity assumption through Mauchly sphericity test. However, this assumption was not met in the texture component (P< 0.05), and we used the Greenhouse-Geiser epsilon correction. In other components, we found this assumption was met (P> 0.05). The results of the multivariate test showed that Wilks' lambda was significant only for the main effect of time (P< 0.05) but not for the main effects of the group and the interaction effect of time within the group (P> 0.05). We presented the results of the repeated measures analysis of variance for the self-efficacy dimensions in Table 3.

Table 3. Investigating between-group differences in self-efficacy dimensions in experimental groups

Variable	Source of changes	Sum of squares	Freedom degree	Mean squares	F	P	Parabolic eta squared
Talent	Time	246.07	2	123.03	54.20	0.001	0.66
	Group membership	1.34	1	1.34	0.007	0.932	0.02
	Time*Group membership	2.16	2	1.08	0.48	0.62	0.02
Effort	Time	34.20	2	17.10	2.06	0.001	0.41
	Group membership	7.52	1	7.52	0.73	0.19	0.11
	Time*Group membership	3.44	2	1.72	0.19	0.60	0.05
Texture	Time	242.87	1.53	121.43	72.52	0.001	0.72
	Group membership	0.28	1	0.28	0.08	0.78	0.003
	Time*Group membership	0.69	1.53	0.34	0.21	0.82	0.01

Table 3 showed that in the two experimental groups, there was a significant difference in the main effect of time (P< 0.05). However, there was no significant difference in the main effect of the group and the interactive effect of time in the group in all self-efficacy dimensions (P> 0.05). In Table 4, we presented the results of the Bonferroni post hoc test to compare the means according to the stages in two groups.

Table 4. Bonferroni post hoc test to compare the mean of self-efficacy dimensions according to stages in the experimental groups

Variable	Group	Pre-test-Post-test		Follow-up-Pre-test		Follow-up-Post-test	
		Mean difference	P	Mean difference	P	Mean difference	P
Talent	Cognitive rehabilitation group	-4.87	0.001	-5.40	0.001	0.53	1.00
	Perceptual-motor skills training group	-2.33	0.02	-2.49	0.02	-0.16	1.00
Effort	Cognitive rehabilitation group	-2.34	0.001	-2.14	0.001	0.20	1.00
	Perceptual-motor skills training group	-1.26	0.02	-1.44	0.02	-0.18	1.00
Texture	Cognitive rehabilitation group	-5.60	0.001	-5.26	0.001	0.34	1.00
	Perceptual-motor skills training group	-3.67	0.001	-3.92	0.001	-0.26	1.00

Table 4 showed that in both experimental groups, the means increased significantly from pre-test to post-test stages and from pre-test to follow-up. Also, the difference in means was significant (P< 0.05). Other results showed no significant change from post-test to follow-up stages (P> 0.05). There was no difference between two trainings on students' self-efficacy. The results of Levene's test showed the homogeneity of academic engagement components (P> 0.05). The Box's M test showed homogeneity of the variance-covariance matrix (P> 0.05, F= 1.47, Box's M= 219.42). The results of the Mauchly sphericity test showed that the sphericity assumption is not met in the agency engagement component (P< 0.05), and we used the Greenhouse-Geiser epsilon correction. This assumption was met in other components (*P*> 0.05). The multivariate test results showed significant effect only for the time (*P*< 0.05). However, the main effects of the group and the interactive effect of time within the group were insignificant (*P*> 0.05). Table 5 presents the results of the repeated measures analysis of variance for the dimensions of academic engagement.

Table 5. Investigating between-group differences in academic engagement components in experimental groups

Variable	Source of changes	Sum of squares	Freedom degree	Mean squares	F	P	Parabolic eta squared
Agency engagement	Time	37.622	1.432	26.281	3.122	0.001	0.69
	Group membership	17.778	1	17.778	1.067	0.31	0.07
	Time*Group membership	2.289	1.432	1.599	0.190	0.75	0.01
Behavioral engagement	Time	52.267	2	26.133	4.04	0.001	0.72
	Group membership	2.50	1	2.50	0.328	0.57	0.01
	Time*Group membership	13.067	2	6.533	2.325	0.10	0.07
Emotional engagement	Time	54.48	2	27.24	4.30	0.001	0.68
	Group membership	19.60	1	19.60	2.71	0.11	0.10
	Time*Group membership	11.40	2	5.70	2.71	0.07	0.08
Cognitive engagement	Time	44.28	2	22.14	5.137	0.001	0.80
	Group membership	18.67	1	18.67	0.581	0.45	0.02
	Time*Group membership	5.75	2	2.87	0.458	0.63	0.01

Table 5 showed no significant difference between the two experimental groups in terms of the main effects of the group and the interactive effect of time within the group (*P*> 0.05). Table 6 presents the results of the Bonferroni post hoc test to compare the means according to the stages in two groups.

Table 6. Bonferroni post hoc test to compare the mean of academic engagement components according to stages in the experimental groups

Variable	Group	Pre-test-post-test		Follow-up-Pre-test		Follow-up-post-test	
		Mean difference	**P**	**Mean difference**	**P**	**Mean difference**	**P**
Agency engagement	Cognitive rehabilitation group	-2.26	0.03	-2.52	0.04	0.08	1.00
	Perceptual-motor skills training group	-2.00	0.02	-2.06	0.03	0.06	1.00
Behavioral engagement	Cognitive rehabilitation group	-2.74	0.002	-2.82	0.001	0.08	1.00
	Perceptual-motor skills training group	-1.25	0.003	-1.32	0.001	0.07	1.00
Emotional engagement	Cognitive rehabilitation group	-3.60	0.001	-3.68	0.001	0.08	1.00
	Perceptual-motor skills training group	-3.80	0.001	-3.67	0.001	0.13	0.45
Cognitive engagement	Cognitive rehabilitation group	-5.45	0.001	-5.36	0.001	0.009	1.00

Perceptual-motor skills training group	-5.27	0.001	-5.43	0.001	0.16	1.00

The results of Table 6 showed that in the experimental groups, the means increased from pre-test to post-test and follow-up, and there was a significant difference ($P< 0.05$), but there was no significant change from post-test to follow-up stages ($P> 0.05$). In other words, there was no difference between two interventions on students' academic engagement.

Discussion

We compared the effectiveness of software cognitive empowerment training and perceptual-motor reconstruction program training on academic self-efficacy and academic engagement in male high school students. The results revealed that both interventions significantly increased academic self-efficacy and academic engagement, while there were no significant differences between the two interventions. We did not find any study comparing the effectiveness of two interventions.

In this line, Abduallhi, Rezaei, and Staki investigated 30 students with low academic achievement at the second secondary level of the gifted schools of Khoy City, Iran. They conducted 16 sixty-minute cognitive rehabilitation programs. They found that this intervention increased significantly cognitive functions and academic performance in these students (20). These results are consistent with our findings regarding the effectiveness of cognitive rehabilitation programs.

Also, Gao and Izadpanah assessed the relationship between computer games and academic engagement with the mediating role of creativity in 453 students in Zanjan City, Iran. The research instruments included the Computer Game Questionnaire, the Academic Engagement Questionnaire, the Creativity Questionnaire, and the Computer Self-Efficacy Questionnaire.

They found a significant relationship between computer games, computer self-efficacy, creativity, and academic engagement. They stated that holding classes related to computer games and computer self-efficacy in educational institutes enhances academic engagement (21).

Also, Wiest et al. assessed the effectiveness of computerized cognitive training on 17 students divided into experimental and control groups. The experimental group received a 20-hour training intervention. The results showed significant improvement in the working memory ability of the experimental group (22). Although Wiest et al. investigated working memory, not academic performance or engagement, we know working memory is important for learning.

In addition, the results of Wong et al.'s study on at-risk students showed positive effects of computerized cognitive training on their academic performance (23).

Regarding the effectiveness of perceptual-motor skills training, Rafiee, Ramezani, and Kashi conducted a perceptual-motor skills training program focused on balance, spatial awareness, temporal awareness, body awareness, and lateralization through 16 forty-five minute sessions on 24 girls with the mean age of 10.5 years in Tehran City, Iran. They used the Stroop and the theory of mind tests to collect data. They concluded that perceptual motor skills training increased selective attention and developed theory of mind in female students (24). However, they studied different variables such as selective attention and theory of mind, but selective attention strongly impacts learning ability and academic performance. So, these findings support our results. In addition, a systematic review revealed that motor skills improve cognitive functions and academic performance in preschoolers (25).

This study was limited to a single geographic region and gender (men) and used a self-report instrument. Future studies on larger sample sizes and both genders, different cultures, and longer follow-ups may yield more accurate results. Also, this study was a quasi-experimental design, and the possibility of random assignment of individuals to the experimental and control groups in the manner possible in true experimental studies was not achieved. In addition, this study was conducted only within the city of Mashhad, and geographical and cultural differences limit the generalization of the results to other regions of the country.

Participants were allowed to withdraw from the study at any time they wished. They were assured that the study would not be financially burdensome and that their information would remain confidential. Also, this study was approved by the Ethics Committee of Mashhad University of Medical Sciences).

Conclusion

These findings indicated that software cognitive empowerment training and perceptual-motor reconstruction program training positively affected self-efficacy and academic engagement variables. However, none of the interventions mentioned are superior to each other.

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Conflict of Interest

The authors declare no conflict of interest.

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Ethical Considerations

Participants were allowed to withdraw from the study at any time they wished. They were assured that their information would remain confidential. Also, this study was approved by the Ethics Committee of Mashhad University of Medical Sciences.

Code of Ethics

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Authors' Contributions

All authors equally contributed in designing and conducting the research, and writing the manuscript. The first author and the corresponding author contributed in revising the final manuscript.

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