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The Effectiveness of Cognitive Empowerment Based on the Lumosity Program on Maher Crystallized Intelligence of Elementary School Boys

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A B S T R A C T

Purpose: This study aimed to evaluate the effectiveness of cognitive empowerment based on the Lumosity program in enhancing Maher crystallized intelligence of elementary school boys.

Methods and Materials: The research was conducted using a quasi-experimental design with pre-test, post-test, and follow-up stages, along with control and experimental groups. A sample of 40 male elementary students was randomly selected and divided into control and experimental groups. The experimental group underwent cognitive training using the Lumosity program, while the control group received no intervention. Intelligence was assessed using standardized tests across multiple components of intelligence, including personality-emotional, social-cultural, bodily-kinesthetic, happiness, and crystallized intelligence. Data analysis involved repeated measures ANOVA to compare intelligence scores across groups and time points.

Findings: The results revealed no significant improvement in personality-emotional intelligence, social-cultural intelligence, bodily-kinesthetic intelligence, happiness intelligence, or crystallized intelligence in the experimental group following the Lumosity-based cognitive empowerment program. Despite improvements in processing speed and attention, the training did not effectively enhance the targeted intelligence components. Factors such as the nature of the tasks, which emphasized processing speed over knowledge acquisition, and the program's lack of focus on real-life applications and social-cultural skills may have limited its impact.

Conclusion: The findings suggest that while the Lumosity-based cognitive empowerment program may enhance cognitive processing abilities, it does not significantly improve the broader dimensions of intelligence.

Keywords: *Cognitive Empowerment Based on the Lumosity Program, Maher Crystallized Intelligence, Male Elementary School Students*

1. Introduction

Intelligence serves as a metric for assessing an individual's cognitive, analytical, and critical abilities (Morovat et al., 2022). An individual's intellectual ability reflects their capacity to process information for decision-making and arriving at logical responses and solutions (Sung & Su, 2022). The level of intellectual ability is also used to measure how well an individual can recall information they have heard in the past. Moreover, intellectual ability and its measurement through intelligence tests assist teachers in evaluating students' learning levels and their need for support (Song & Cai, 2024). Generally, intelligence is crucial in determining how effectively an individual can perform a given task (Asadi Rajani, 2023; Babaei et al., 2024; Baniasadi, 2024; Dehqankar et al., 2019; Ghaebi Mihmandoust et al., 2021; Ghanbari & Saadati Shamir, 2023; Goran Savadkouhi et al., 2023; Khandani et al., 2023; Mir Arabshahi et al., 2022; Morovat et al., 2022; Nazari et al., 2021; Saadati Shamir, 2017, 2022; Saadati Shamir & Mazbouhi, 2018; Saadati Shamir & Mousavi Fazli, 2023; Saadati Shamir & Zahmatkesh, 2022; Sangari & Saadati Shamir, 2023; Yao et al., 2024; Zahmatkesh et al.).

The Lumosity cognitive empowerment program, developed by Lumos Labs, is one of the most widely used cognitive empowerment programs. The prevalence of Lumosity cognitive training is so widespread that its online advertisements, focusing on memory and attention, even appear on websites critical of cognitive training. This program is considered one of the most comprehensive programs designed to enhance human intelligence, memory, and brain performance (Ruiz-Marquez et al., 2019). The Lumosity program is grounded in extensive research and studies by researchers and provides brain exercises in the form of games using scientific methods (Bayramlar et al., 2022). The Lumosity training program is network-based and comprises various exercises that enhance individuals' cognitive abilities in six domains: processing speed (9 exercises), memory (8 exercises), attention (6 exercises), cognitive flexibility (7 exercises), problem-solving (7 exercises), and language (6 exercises) (Corti et al., 2020). The foundation for strengthening cognitive abilities in this program is brain plasticity or cognitive flexibility. According to this assumption, gray matter, neurons, and other brain structures are strengthened with continuous use, while they deteriorate if unused. Accordingly, the Lumosity cognitive training program aims to empower the neural structures involved in each cognitive ability through the consistent and daily provision of cognitive exercises. The difficulty level of each exercise in this program depends on the presence or absence of distracting factors, time limitations, pattern or rule complexity, and the required cognitive skill and effort (Balconi et al., 2020; Bartolucci & Batini, 2020; Di Lieto et al., 2020; Jalil Abkenar & Ashouri, 2016; Kajbaf et al., 2013; Mousavi Sadati et al., 2019; Ruffini et al., 2021; Speer et al., 2019). In the cognitive empowerment protocol using this program, five exercises are selected for each session, with each exercise requiring five to six minutes to complete (Shute et al., 2015). This study aimed to evaluate the effectiveness of cognitive empowerment based on the Lumosity program in enhancing various dimensions of intelligence, including personality-emotional intelligence, social-cultural intelligence, bodily-kinesthetic intelligence, happiness intelligence, and crystallized intelligence, in elementary school boys.

2. Methods and Materials

2.1. Study Design and Participants

This study is an experimental, quasi-experimental, and fundamental research study conducted using a quantitative method. The statistical population included all male elementary school students in Tehran in 2023. A multistage cluster random sample was selected from non-profit boys' schools in District 2 of Tehran and randomly assigned to experimental and control groups. The sample size was 40 individuals, randomly divided into two groups of 20 for cognitive empowerment and control. The sample size was determined based on Cohen's table for experimental research, considering an alpha of .05, a relatively large effect size (.40), and medium power (.50), resulting in 16 individuals per group, totaling 32, with a sample of 40 considered to account for potential attrition.

2.2. Measure

The Multifaceted Maher Crystallized Intelligence Test was developed by Sa'adati Shamir and Zahmatkesh (2022) to construct and standardize various dimensions of crystallized intelligence in students aged 7 to 9. The crystallized intelligence test assesses four major types of intelligence, a total of 15 types of intelligence, and 90 sub-components. The first three types of intelligence each include four sub-components, with each sub-component containing four questions worth three points each, for a total of 12 points per sub-component. The happiness intelligence

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section contains 50 questions covering five types of intelligence, each with 10 sub-components. This section has no separate questions; scores for this section are derived from the three preceding intelligences. The first three intelligences in this test comprise a total of 40 questions, with a maximum raw score of 120 and a maximum response time of 120 minutes, with an IQ ceiling of 160. The test assesses four major intelligences: (1) personality-emotional intelligence (personality intelligence, emotional intelligence), (2) social-cultural intelligence (social intelligence, cultural intelligence, managerial intelligence, spiritual intelligence, economic intelligence, philosophical intelligence), (3) bodily-kinesthetic intelligence (athletic intelligence, technical intelligence), and (4) happiness intelligence (cognitive intelligence, analytical intelligence, practical intelligence, creative intelligence, and metacognitive intelligence), measuring a total of 15 types of intelligence. The scoring method of the crystallized intelligence test is such that probable responses from the participant are categorized into two types: 1) responses are evaluated at the levels of knowledge and comprehension, and 2) levels of analysis and synthesis, based on Bloom's taxonomy of cognitive domains. For administration, after the participant indicates readiness, the first question is posed. If the participant responds within 30 seconds, the answer is recorded. If they hesitate for more than 30 seconds and cannot answer, a brief hint related to the question is provided, and the question is repeated. If they still cannot respond after the hint and another 30 seconds, the next question is posed. If the participant's explanation demonstrates understanding and analysis or synthesis, and they provide a partial explanation, they are awarded two points. However, if their answer is distant from the correct answer, no points are awarded. A response provided independently, demonstrating understanding and analysis, earns two points; if correct without a hint, an additional point for no hint requirement is added. If a hint is necessary, the point for no hint is not awarded. The study by Sa'adati Shamir and Mousavi (2022) showed that the construct validity of this test, based on exploratory factor analysis, was .89, and its reliability was .90, measured by Cronbach's alpha (Saadati Shamir & Mousavi Fazli, 2023; Saadati Shamir & Zahmatkesh, 2022; Sangari & Saadati Shamir, 2023).

2.3. Intervention

The session content and structure were derived from the empowerment protocol by Shute, Ventura, and Ke (2015). Games used in each Lumosity-based empowerment session target specific cognitive components for enhancement. For instance, in the first session, the games "Direction and Flow," "Ball Recall," and "Raindrop" are used, all of which enhance attention and focus. Games in other sessions are grouped based on a common cognitive component. Some games improve multiple cognitive components and may be used in several sessions. In this protocol, each session includes multiple games to emphasize cognitive empowerment over game mastery. Additionally, cognitive empowerment programs are based on brain flexibility, where a key technique is varying task presentation to reinforce the enhanced cognitive ability in different ways and across various tasks. Programs like Lumosity-based cognitive empowerment emphasize strengthening foundational cognitive abilities rather than game-specific skills, considering that individuals engage with real-life tasks, not games, in daily life. Accordingly, multiple games are provided in each session to enable individuals to develop cognitive abilities (e.g., attention) rather than mastering a specific game (Shute et al., 2015).

2.4. Data Analysis

Data analysis involved repeated measures ANOVA to compare intelligence scores across groups and time points.

3. Findings and Results

In the study, parental education levels were recorded for both control and experimental groups. Among mothers, 80% in the control group and 85% in the experimental group had a bachelor's degree, while 20% in the control group and 15% in the experimental group held a master's degree. For fathers, 65% in the control group and 70% in the experimental group had a bachelor's degree, while 35% in the control group and 30% in the experimental group had a master's degree. The mean age of mothers in the control group was 37.64 years with a standard deviation of 4.9, and in the experimental group, it was 38.61 years with a standard deviation of 5.3. For fathers, the mean age in the control group was 40.28 years with a standard deviation of 7.9, and in the experimental group, it was 41.32 years with a standard deviation of 6.7.

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To examine the effectiveness of cognitive empowerment based on the Lumosity program on students' personality-emotional intelligence, a repeated measures ANOVA was conducted. The results of this test and an examination of its assumptions are presented below (see Table 1).

Table 1

Statistical Description of Intelligence Scores in Three Measurement Stages in the Experimental Group

Main Component	Sub-component	Pre-test Mean (SD)	Post-test Mean (SD)	Follow-up Mean (SD)
Personality-Emotional Intelligence	Personality Intelligence	112.57 (10.90)	114.47 (10.06)	114.23 (9.75)
	Emotional Intelligence	114.23 (7.86)	115.95 (7.61)	115.57 (7.42)
	Total	113.09 (8.32)	114.97 (7.82)	114.92 (7.73)
Socio-Cultural Intelligence	Philosophical Intelligence	110.80 (8.70)	111.95 (8.95)	112.28 (9.01)
	Cultural Intelligence	110.19 (9.45)	110.95 (9.52)	111.28 (9.05)
	Economic Intelligence	112.23 (10.44)	113.38 (9.94)	113.80 (10.38)
	Social Intelligence	115.47 (10.82)	116.66 (10.84)	116.38 (10.34)
	Spiritual Intelligence	107.71 (11.95)	107.95 (12.12)	108.19 (11.53)
	Managerial Intelligence	114.28 (8.98)	115.42 (9.31)	115.33 (9.28)
	Total	111.71 (8.04)	112.54 (8.04)	112.78 (7.88)
Bodily-Kinesthetic Intelligence	Athletic Intelligence	110.76 (11.96)	113.04 (13.04)	112.33 (11.58)
	Practical-Technical	107.80 (9.58)	110.33 (10.79)	111.36 (9.78)
	Total	108.97 (9.14)	110.19 (8.97)	110.28 (9.68)
Happiness Intelligence	Analytical Intelligence	110.14 (9.39)	111.28 (10.15)	111.54 (10.24)
	Creative Intelligence	111.23 (7.44)	117.52 (13.55)	118.57 (13.88)
	Metacognitive Intelligence	107.33 (10.56)	109.23 (12.08)	109.71 (11.61)
	Practical Intelligence	106.80 (8.76)	108.95 (9.26)	108.66 (9.46)
Crystallized Intelligence	Total	109.02 (8.51)	111.60 (10.34)	112.10 (10.61)

The results of Levene's test for personality-emotional intelligence showed non-significant values for pre-test ($F = 1.968$, $p = 0.354$), post-test ($F = 1.326$, $p = 0.259$), and follow-up stages ($F = 0.491$, $p = 0.489$), indicating homogeneity of variances.

Mauchly's test for sphericity for personality-emotional intelligence was significant ($W = 0.325$, $\chi^2(2) = 16.396$, $p = 0.001$), indicating a violation of the sphericity assumption. Consequently, Greenhouse-Geisser and Huynh-Feldt corrections were applied.

Table 2

Group Effects Analysis for Comparisons of Personality-Emotional Intelligence

Source	Sum of Squares	df	Mean Square	F	Significance Level	Effect Size
Group	451.100	1	451.100	1.023	0.781	0.006
Error	16705.758	38	439.615			

The analysis of group effects indicated that there was no significant difference in personality-emotional intelligence scores between the experimental and control groups ($F = 1.023$, $p = 0.781$).

Levene's test results for socio-cultural intelligence were non-significant for the pre-test ($F = 0.564$, $p = 0.654$), post-test ($F = 0.253$, $p = 0.619$), and follow-up ($F = 0.521$, $p = 0.476$), confirming homogeneity of variances.

Table 3

Group Effects Analysis for Comparisons of Socio-Cultural Intelligence

Source	Sum of Squares	df	Mean Square	F	Significance Level	Effect Size
Group	844.128	1	844.128	1.447	0.568	0.009
Error	22176.454	38	583.602			

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The analysis showed no significant difference in socio-cultural intelligence between the experimental and control groups (F = 1.447, p = 0.568).

Levene's test results for bodily-kinesthetic intelligence were non-significant for the pre-test (F = 0.569, p = 0.684), post-test (F = 0.816, p = 0.374), and follow-up (F = 1.570, p = 0.221), indicating homogeneity of variances.

Table 4

Group Effects Analysis for Comparisons of Bodily-Kinesthetic Intelligence

Source	Sum of Squares	df	Mean Square	F	Significance Level	Effect Size
Group	3406.517	1	3406.517	1.543	0.127	0.009
Error	84891.915	38	2233.996			

The analysis revealed no significant difference in bodily-kinesthetic intelligence scores between the experimental and control groups (F = 1.543, p = 0.127).

Levene's test results for happiness intelligence were non-significant for the pre-test (F = 2.356, p = 0.158), post-test (F = 2.376, p = 0.134), and follow-up (F = 2.174, p = 0.152), supporting the homogeneity assumption.

Table 5

Group Effects Analysis for Comparisons of Happiness Intelligence

Source	Sum of Squares	df	Mean Square	F	Significance Level	Effect Size
Group	203.735	1	203.735	1.057	0.651	0.054
Error	7307.274	38	192.303			

The analysis showed no significant difference in happiness intelligence between the experimental and control groups (F = 1.057, p = 0.651).

Levene's test results for crystallized intelligence were non-significant for the pre-test (F = 2.965, p = 0.184), post-test (F = 3.628, p = 0.067), and follow-up (F = 2.259, p = 0.144), indicating homogeneity of variances.

The field data analysis using Smart PLS yielded the following results.

Table 6

Group Effects Analysis for Comparisons of Crystallized Intelligence

Source	Sum of Squares	df	Mean Square	F	Significance Level	Effect Size
Group	722.806	1	722.806	0.851	0.348	0.037
Error	32271.771	38	849.240			

The analysis indicated that there was no significant difference in crystallized intelligence scores between the experimental and control groups (F = 0.851, p = 0.348).

4. Discussion and Conclusion

The analysis of the present study's data revealed that cognitive empowerment based on the Lumosity program does not have a significant effect on the personality-emotional intelligence of elementary school boys. This finding is inconsistent with the results of Iqbal et al. (2022), which focused on emotional intelligence as the ability to manage emotions (Iqbal et al., 2022). In interpreting these findings, it is essential to consider the nature of personality-emotional intelligence and cognitive empowerment. Personality-emotional intelligence involves an inner capacity that values and appreciates all differences and personalities without judgment. Just as an intelligent individual can enhance empathy with those raised in a particular culture by understanding its characteristics, a person with personality-emotional intelligence can connect with others without mental biases, achieving positive results (Bayramlar et al., 2022). This intelligence includes abilities such as self-motivation, perseverance through challenges and frustration, impulse control, delaying gratification, emotion regulation, and managing stress to maintain clear thinking, along with empathy and optimism (Lanius, 2022).

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Personality-emotional intelligence enables individuals to recognize and regulate emotions in themselves and others. Its diverse skills encompass decision-making, responsibility, empathy, communication, interpersonal relationships, problem-solving, emotional expression, assertiveness, self-actualization, optimism, and stress tolerance (Corti et al., 2020). Improving personality-emotional intelligence requires training in emotional management and personality traits. Parental guidance in managing their own and their child's emotions also supports the development of children's personality-emotional intelligence (Correia, 2021). Cognitive empowerment, although effective in enhancing executive functions, does not focus on emotion recognition and understanding in its exercises. Additionally, these findings suggest that cognitive empowerment may not effectively strengthen the neural bases for understanding emotions and personality traits, resulting in no significant improvement in personality-emotional intelligence.

The analysis also did not support the hypothesis that cognitive empowerment based on the Lumosity program affects social-cultural intelligence in elementary school boys, indicating no significant effect. Social-cultural intelligence pertains to the ability to function effectively in different cultural situations, particularly in groups with varying thoughts, behaviors, and cultures. This intelligence reflects the capacity to navigate ambiguous social-cultural situations and is linked to the ability to manage, create, and moderate shared meanings within social environments. Recognizing and respecting traditions and customs are encompassed in social-cultural intelligence (Ayoko et al., 2022). It emphasizes understanding, managing societal living standards, social institutions, aesthetic values, official language, and social contexts, highlighting the importance of recognizing cultural differences (Kovalenko, 2021). To improve this ability, individuals need both cognitive intelligence and experience with diverse groups. Teaming children with differing thoughts, behaviors, and cultures can enhance this intelligence over time (Zhang et al., 2021). Rule-based group games also promote social-cultural intelligence (Ayoko et al., 2022). The lack of significant impact from cognitive empowerment on social-cultural intelligence may be because the program lacks tasks specifically for social and cultural skill development, as most cognitive empowerment tasks are designed to be culturally neutral, making them accessible to individuals from various backgrounds. Additionally, while Lumosity-based cognitive empowerment compares performance with peers, individuals complete tasks independently, which does not generally improve social and cultural abilities.

The findings further did not confirm that cognitive empowerment based on the Lumosity program affects bodily-kinesthetic intelligence in elementary school boys, indicating no significant effect. These results contrast with the findings of Cheng et al. (2012), where cognitive empowerment was implemented in single-domain and multi-domain formats over 24 sessions, using different measurement tools (Cheng et al., 2012). Thus, differences in empowerment methods and assessment tools may explain the variance in results. Bodily-kinesthetic intelligence is the ability to control the body and use movements to achieve various goals, with body-mind coordination being the core element, allowing individuals to exhibit optimal bodily responses (Kusumaningrum et al., 2022). This intelligence includes skills in handling objects, fine motor control, and full-body coordination (Hassoun, 2020). In Lumosity-based cognitive empowerment, tasks often rely on finger use; for example, the color-matching game requires individuals to recognize and match colors by pointing with a finger, while in direction and flow games, finger-based responses are also used. However, tasks designed for general cognitive processing speed may not significantly enhance fine and gross motor coordination or visual-motor integration, only possibly improving visual-cognitive processing speed. Additionally, Lumosity-based empowerment lacks tasks aimed at gross motor movement enhancement. It seems that improvement in bodily-kinesthetic intelligence requires synchronized and medium-term training of fine and gross motor movements (Alizadeh et al., 2021; Lawlor-Savage et al., 2021), which is not achieved through Lumosity-based cognitive empowerment.

Furthermore, the analysis did not support the hypothesis that cognitive empowerment based on the Lumosity program influences happiness intelligence in elementary school boys, indicating no significant effect. To explain this hypothesis, it is essential to examine the components of happiness intelligence, which includes analytical, creative, metacognitive, and practical intelligence. Analytical intelligence relates to problem-solving, planning, and task management skills, typically measured through academic and real-life tasks. Although analytical skills may improve through designed tasks, they primarily develop through real-life experiences requiring analysis (Zhang et al., 2020). Although Lumosity offers analytical tasks, they are not directly related to real-life scenarios, which may explain the lack of significant improvement. Creative intelligence also

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emerges through innovation in repetitive scenarios, yet Lumosity-based empowerment encourages consistent responses rather than creativity. Metacognitive intelligence, which involves controlling and guiding one's thinking, typically improves through long-term analytical tasks rather than high-speed activities that emphasize cognitive processing speed (Angelov et al., 2021). Practical intelligence is also fostered through skill application, which is not included in Lumosity's tasks (Mam Khazari Azad & Farzaneh, 2021; Mendoza et al., 2022). Thus, Lumosity-based cognitive empowerment has not enhanced the underlying components of happiness intelligence and has no significant effect on its main or sub-components.

Lastly, the findings do not confirm that cognitive empowerment based on the Lumosity program influences crystallized intelligence in elementary school boys, indicating no significant effect. This result contradicts Shah Mohammadi et al. (2019), who examined verbal intelligence with different measurement tools and a sample of students with learning disabilities (Shah Mohammadi et al., 2019). Crystallized intelligence is rooted in experience and reflects accumulated knowledge and skills acquired over a lifetime. While not the same as memory, it relies on long-term memory for information processing (Speer et al., 2019). It is associated with general knowledge, vocabulary, and reasoning skills using words and numbers (Roberts, 2022). Crystallized intelligence develops through educational and cultural experiences in interaction with fluid intelligence and involves secondary relational reasoning based on primary learned abstractions (Mayer, 2021). Expanding knowledge and information that supports reasoning is essential for enhancing crystallized intelligence (Lawlor-Savage et al., 2021). The lack of a significant impact of Lumosity-based cognitive empowerment on crystallized intelligence may be attributed to several factors. As noted, the empowerment program showed no meaningful effects on sub-components of crystallized intelligence, such as social-cultural intelligence, personality-emotional intelligence, bodily-kinesthetic intelligence, and happiness intelligence, which may have affected overall crystallized intelligence. Additionally, the tasks in Lumosity-based cognitive empowerment focus on processing speed rather than knowledge acquisition, which is crucial for crystallized intelligence. Furthermore, cognitive empowerment improves cognitive processing speed and attention, which did not significantly enhance crystallized intelligence.

Authors' Contributions

All authors significantly contributed to this study.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

In this study, to observe ethical considerations, participants were informed about the goals and importance of the research before the start of the interview and participated in the research with informed consent.

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