

“BRAIN KNOWLEDGE FOR LEARNING” PROGRAM: DESIGN AND SHORT-TERM ASSESSMENT

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Abstract

Improvement of study habits in high school would prove beneficial for students at both present and future stages. This could be achieved through programs designed specifically for adolescents, which consider their greater impulsiveness, susceptibility to influence, and vulnerability to risky behaviors. The objective of the current work was to create and evaluate the effectiveness of the Brain Knowledge for Learning (BK4L) program, aimed at adolescents and focused on improving their study habits and decision-making through an understanding of the neural mechanisms involved. The BK4L-Program is based on neuroscience and designed as a voluntary out-of-class activity organized in four sessions (1h 30min each) plus a reinforcement session. The Wooclap platform was used for interactive activities. To assess the effectiveness of the program, a specific instrument (the BK4L-Questionnaire) was developed as a 5-point Likert scale (25 items), which was based on previously validated questionnaires for adolescents and adapted to the contents of the program. It was validated by 4 education experts. In addition, satisfaction with the program and knowledge acquisition were assessed. For implementation of the BK4L-Program, 104 students (15-17 years old) were recruited from two high schools and randomly assigned to control (46) or experimental (58) groups. Data from pre- and post-intervention measures were analyzed using descriptive and inferential statistics to examine changes over time. The BK4L-Program addressed topics related to neuroplasticity, attention and motivation, the reward system and addictions, study organization and planning, concept association and deep analysis, and brain health in adolescence. The validated BK4L-Questionnaire assessed three dimensions: (1) perception of study habits, including attention, motivation, and planning and deep learning; (2) perception of decision making, impulsivity, and emotional regulation; and (3) perception of brain-healthy habits. After the first stage of the program (4 sessions), the experimental group reported improvements across the three dimensions, particularly in attention and planning and deep learning indicators. Satisfaction with the program was high (4.4 ± 0.11 out of 5). The average knowledge acquisition score was 8.91 out of 10 (72.4% excellent and 20.7% very good). Overall, these findings suggest that, unlike previous interventions targeting isolated components, the BK4L-Program provides a well-accepted and effective integrative approach grounded in the mechanistic understanding of learning and decision-making, with its strongest short-term impact on students' perceived study habits and additional benefits for decision-making and brain-healthy habits.

Keywords: *Learning, neuroscience, adolescence, decision-making, Wooclap.*

1. Introduction

Recent studies have shown that university students exhibit study habits that could be improved (Vicente-Torres, 2025) and an improvement in these habits would be more beneficial if acquired before entering university. During adolescence, the activity of the brain's reward system stands out over executive functions, which leads to greater impulsivity, susceptibility to influence, and vulnerability to risky behaviors (Casey et al., 2008). A program designed to improve study habits in high school students should take these factors into account and address the multiple dimensions of learning, including those previously examined in university students: attention, motivation, planning and deep learning, and brain health (Vicente-Torres, 2025).

2. Objective

The objective of the current work was to design the Brain Knowledge for Learning (BK4L) neuroscience-informed program and its assessment instruments and to evaluate its effectiveness. This program aimed to bring scientific neurobiological mechanisms closer to adolescent students to raise awareness of the processes taking place in their brains during learning and decision-making, and to provide them with new tools to develop brain-healthy behaviors and to prevent risky behaviors such as the use of psychoactive substances or engaging in compulsive conduct.

3. Methodology

The BK4L-Program comprised four 90-minute sessions delivered over two consecutive weeks, with two sessions per week, followed by a reinforcement session approximately four months later. It was designed to be delivered in person outside regular class hours, in small groups of up to 20 students. The program used an interactive workshop format supported by the educational platform Wooclap and active learning methodologies, including question-based teaching adapted to adolescents' experiences.

To assess the short-term effectiveness of the program, three instruments were developed. First, students' perceptions of the topics addressed in the program were assessed using the BK4L-Questionnaire, a 25-item instrument based on a 5-point Likert scale and validated by four experts in education. Second, satisfaction with the program was evaluated using a separate questionnaire consisting of six items rated on a 5-point Likert scale and two open-ended questions. Third, knowledge acquisition was assessed by means of an objective test comprising 10 multiple-choice questions.

The program was implemented in two educational centers in the Community of Madrid, Spain: Francisco Ayala High School and SEI Concepción Charter School. The research protocol was reviewed and approved by the Ethics Committee of Universidad Complutense de Madrid. A total of 104 second- and third-year high school students aged 15 to 17 years were recruited on a voluntary basis and randomly assigned to either the control group ($n = 46$) or the experimental group ($n = 58$).

Baseline student perceptions prior to program implementation were assessed using the BK4L-Questionnaire, and differences between the control and experimental groups were analyzed using Student's *t*-tests for independent samples. The effect of the BK4L-Program on students' perceptions was then evaluated by comparing BK4L-Questionnaire responses in the experimental group before and after the intervention, using Student's *t*-tests for paired samples.

4. Results and discussion

4.1. Design of the BK4L-Program topics and assessment tools

The BK4L-Program was designed to provide adolescent students with an integrative view of the mechanisms underlying learning and decision-making, based on dimensions previously described (Vicente-Torres et al., 2025). Therefore, it covered the following topics: 1) Neuroplasticity, 2) Attention, motivation, reward system, and addictions, 3) Organization and planning, 4) Concept association and deep analysis, 5) The adolescent brain and 6) Brain health (nutrition, exercise, stress, sleep, emotions).

The BK4L-Questionnaire was designed to assess students' perceptions about the previous topics. Thus, its 25 items were classified in three dimensions: (1) study habits (11 items), with three subdimensions -attention, motivation, and planning and deep learning-; (2) decision-making, impulsivity, and emotional regulation (DMIER) (9 items); and (3) brain-healthy habits (5 items) (Table 1). These items were based on and adapted from various previously validated questionnaires for adolescents (Tuinstra et al., 2000; Storfer-Isser et al., 2013; Melendez et al., 2017; Soemantri et al., 2018; Cesari et al., 2024 and Davoudpour et al., 2025), and sensitive questions were avoided.

*Table 1. Validated BK4L-Questionnaire. Items, dimensions, and subdimensions are presented. All items were assessed using a 5-point Likert scale ranging from 1 (complete disagreement) to 5 (strong agreement).
* Reverse-scored items.*

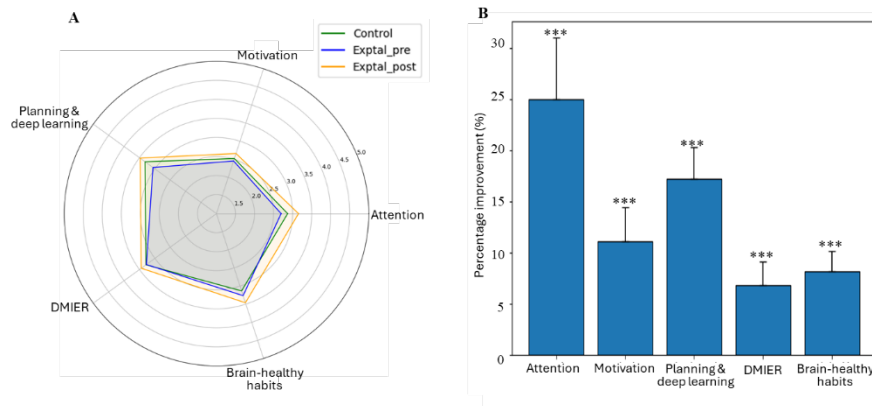
Dimension	Subdimension	Item
Study habits	Attention	1. I pay attention to what I am doing without getting easily distracted.
		2. I can easily concentrate on a single task when I study.
	Motivation	3. I study because I enjoy learning new things.
		4. I study mainly to get good grades rather than to learn.*
		5. I believe that what I learn at my high school will be useful for my future.
	Planning and deep learning	6. I try to keep up with class assignments.
		7. I relate what I learn in one subject to what I already know from others.
		8. Instead of memorizing, I try to understand how ideas connect to each other.
		9. I use outlines, concept maps, or summaries to organize the main ideas.
		10. Making outlines and explaining the material to a friend helps me learn.
		11. I like to think about how to explain to other people what I learn in class.
Decision-making, impulsivity, and emotional regulation (DMIER)		12. I find it difficult to finish what I start.*
		13. Sometimes I act without thinking about the consequences.*
		14. Sometimes, when I am with my friends, I find it hard to control my impulses.*
		15. Even if others have different opinions, I stick to my decisions without feeling bad.
		16. When I work in a group, I am able to contribute ideas and reach agreements without losing control.
		17. I make decisions thinking about how they may affect my study and life goals.
		18. I get overwhelmed easily.*
		19. I have sudden outbursts of anger.*
		20. When something goes wrong for me, I manage to calm down in a short time.
Brain-healthy habits		21. I get enough sleep and feel rested in the morning.
		22. I do physical activity for one hour or more a day (sports, brisk walking, dancing, etc.).
		23. I eat a healthy breakfast before going to high school.
		24. I eat fruits and vegetables several times a day.
		25. I usually consume fast food or pastries several times a week.*

4.2. Assessment of the BK4L-Program short-term effectiveness

The initial perceptions (prior to receiving the BK4L-Program) of the students regarding their study habits, decision-making, and brain-healthy habits were similar between control and experimental groups, given that no statistical difference was detected in any of the five indicators analyzed (attention, motivation, planning and deep learning, DMIER and brain-healthy habits) (Figure 1A). Mean scores for each indicator were at mid-range levels within the five-point scale used; the lowest perception values observed were for attention and motivation, which may represent an opportunity for improvement in aspects related to student engagement.

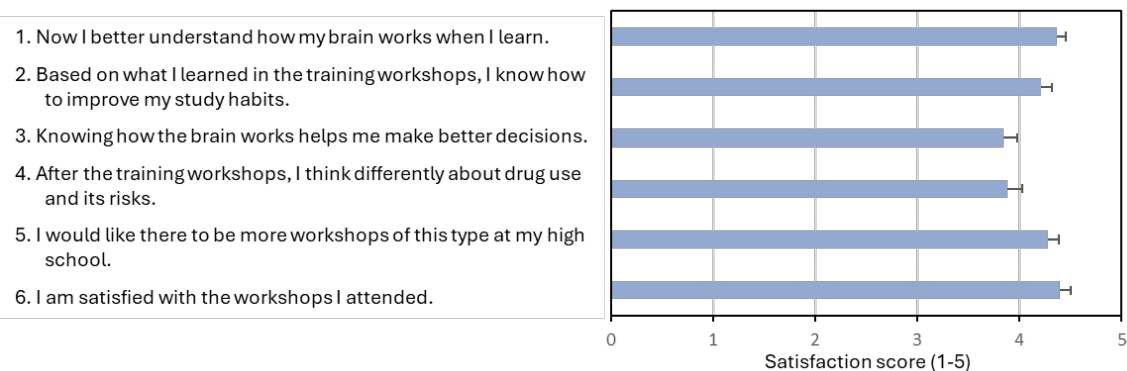
After the first stage of the program (4 sessions), the experimental group reported moderate but statistically significant improvements across all the dimensions analyzed, particularly in attention ($25.01 \pm 6.04\%$), planning and deep learning ($17.17 \pm 3.08\%$), and motivation ($11.06 \pm 3.34\%$), although motivation was the only indicator that remained below the mid-range level (Figure 1A, B). These indicators are directly related to key cognitive processes involved in learning, suggesting that the intervention had a particularly positive impact on students' perception of their study habits. Additionally, it also positively influenced variables related to decision-making and brain-healthy habits.

Figure 1. Impact of the BK4L-Program on students' perceptions of their study habits, DMIER and brain-healthy habits. (A) Radar plot showing the three conditions: control, experimental pre-program, and experimental post-program. (B) Bar graph showing percentage improvement after the intervention in the experimental group (mean $\pm$ SEM). The short-term impact of the BK4L-Program, assessed by comparing pre- and post-program values, was significant across all dimensions analyzed ($***P < 0.001$, Student's *t*-test).



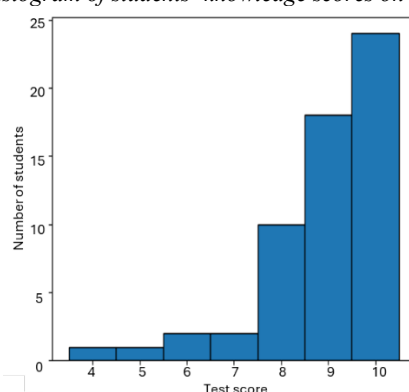
Overall satisfaction with the program was high (4.4 ± 0.11 out of 5; item 6 of the satisfaction questionnaire) (Figure 2). All aspects evaluated received positive ratings. Students rated highly the workshops and their contribution to understanding brain functioning, and reported that the program helped them improve their study habits and reflect on their decision-making, indicating its relevance from both academic and personal perspectives.

Figure 2. Student satisfaction scores for the six BK4L-Program items (mean $\pm$ SEM). Ratings were obtained using a 5-point Likert scale ranging from 1 (complete disagreement) to 5 (strong agreement).



Furthermore, the mean score on the objective knowledge test was 8.91 ± 0.19 out of 10, with 72.4% of students rating it as excellent and 20.7% as very good, indicating effective knowledge acquisition in most participants. Overall, the results suggest a high and relatively homogeneous level of learning, with only a few isolated cases of lower performance. Together with the high satisfaction ratings, these findings indicate that the program was both well received and effective in terms of learning outcomes.

Figure 3. Histogram of students' knowledge scores on an objective test.



5. Originality, relevance and conclusions

The BK4L-Program differs from previous neuroscience-based educational interventions, which have generally focused on specific learning-related components, such as motivation, executive functions, emotion regulation, or brain health, or have been developed from predominantly psychological perspectives (Thomas et al., 2019; De Pablo et al., 2020; Debenham et al., 2024). In contrast, the BK4L-Program provides adolescents with an integrative, mechanistic view of how the brain operates during learning, translating neuroscience knowledge into a format aimed at improving learning and decision-making. This approach is consistent with adolescents' search for self-understanding and their natural curiosity. Notably, short-term assessment revealed integrated positive effects across the three dimensions analyzed, most notably in the perception of study habits, but also in decision-making and brain-healthy habits. Together with the high satisfaction and knowledge acquisition scores, these findings suggest that the program may have benefits extending beyond students to their schools, families, and the broader community.

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