Accounting Training in the Agricultural Sector from Neuroeducation: Impact on Cognitive Self-Regulation and Productive Awareness

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Abstract
Economic management is one of the main structural challenges of the agricultural sector, where weaknesses persist in accounting training and in productive decision-making. In this context, neuroeducation emerges as an innovative approach capable of optimizing learning processes through the activation of higher cognitive functions. The objective of this study was to analyze the impact of an accounting training program based on neuroeducation principles on cognitive self-regulation and productive awareness in actors in the agricultural sector. A quantitative approach with a quasi-experimental design was adopted, applying a pre-test and post-test to an experimental group (n = 60) and a control group (n = 60). The intervention was developed over 12 weeks and incorporated experiential learning strategies, productive contextualization and metacognition. The results showed statistically significant increases and with high effect sizes in cognitive self-regulation and productive awareness of the experimental group, compared to the control group. Likewise, a positive and significant correlation was identified between both variables. It is concluded that accounting training based on neuroeducation strengthens self-regulatory cognitive processes and promotes a more conscious and sustainable productive management in the agricultural sector, providing relevant implications for technical training, accounting education and rural development.
Keywords: neuroeducation; accounting training; agricultural sector; cognitive self-regulation; productive awareness; agricultural management.

1. INTRODUCTION

1.1 Context and problems

The agricultural sector is one of the strategic pillars for sustainable economic development, food security and social stability in emerging and developing countries. However, various international reports warn that one of the main structural limitations of the agricultural sector does not lie exclusively in technological or climatic factors, but in weaknesses associated with the economic, financial and accounting management of agricultural production units. Decision-making based on intuition, poor cost control,

limited financial planning, and the absence of systematic accounting records continue to affect the productivity, profitability, and sustainability of agricultural enterprises.

In this scenario, **accounting training** emerges as a key tool to strengthen the management capacity of agricultural producers, allowing them to understand the economic dynamics of their activity, optimize the use of resources and improve their insertion in increasingly competitive markets. However, traditional accounting teaching approaches, focused on the mechanical transmission of technical content, have shown limited effectiveness in rural and agro-productive contexts, where particular sociocultural, educational and cognitive factors converge.

At the same time, in the last two decades, advances in neuroscience have led to the emergence of **neuroeducation**, an interdisciplinary field that integrates knowledge from neuroscience, cognitive psychology and pedagogy, with the aim of designing training processes aligned with the functioning of the human brain. From this perspective, meaningful learning depends not only on the content taught, but also on the activation of higher cognitive processes such as attention, working memory, self-regulation and metacognition.

1.2 Accounting training and neuroeducation in the agricultural sector

The application of neuroeducational principles in accounting training in the agricultural sector represents an innovative opportunity to overcome the limitations of traditional instructional models. Strategies such as experiential learning, contextualization of content, positive emotional stimulation, the use of real problems in the productive environment, and the strengthening of cognitive self-regulation can facilitate a deeper and more functional understanding of accounting information.

Cognitive self-regulation, understood as the individual's ability to plan, monitor and evaluate their own learning and decision-making processes, is especially relevant in complex productive contexts such as agriculture. A producer with high levels of cognitive self-regulation is better able to analyze financial information, anticipate risks, adjust production strategies, and evaluate the results of their economic decisions.

Similarly, **productive awareness** is configured as a key construct that integrates the understanding of the economic, environmental and social impact of productive decisions. In the agricultural field, this awareness translates into a more responsible management of resources, a greater valuation of accounting information and a strategic orientation towards sustainability.

1.3 Background and research gap

Recent literature shows a sustained growth of research on neuroeducation applied to higher education and technical training, demonstrating positive effects on motivation, academic performance and self-regulation of learning. Likewise, studies in educational accounting have highlighted the need for active methodologies to improve the understanding and application of financial concepts.

However, **significant gaps** persist in empirical research related to the application of neuroeducation in accounting training specifically aimed at the agricultural sector. In particular, there are few quantitative studies that rigorously evaluate the impact of neuroeducational training programs on cognitive and productive variables in producers or students linked to the agricultural field. The relationship between cognitive self-regulation, accounting learning and productive awareness continues to be an insufficiently explored field, especially in rural and semi-rural contexts.

1.4 Justification of the study

From the theoretical point of view, the research contributes to the conceptual integration between neuroeducation, accounting education and agroproductive development, expanding the explanatory framework on how cognitive processes influence the economic management of the agricultural sector.

On the **methodological level**, the study proposes a quasi-experimental design with pre-test and post-test measurements, providing quantifiable empirical evidence on the effects of a neuroeducational intervention, which strengthens the scientific validity of the field.

In **practical** terms, the results will allow the design of more effective accounting training programs for agricultural producers, technical training institutions and rural development agencies, contributing to improving productivity, sustainability and economic decision-making in the sector.

Finally, from a **social and economic** perspective, strengthening the productive awareness and cognitive self-regulation of actors in the agricultural sector has a positive impact on food security, rural poverty reduction and sustainable territorial development.

1.5 Research objectives

General objective

To analyze the impact of an accounting training program based on neuroeducation principles on cognitive self-regulation and productive awareness in actors in the agricultural sector.

Specific objectives

- To evaluate the levels of cognitive self-regulation before and after the implementation of a neuroeducational accounting training program.
- To determine the effect of the training program on the development of productive awareness in the agricultural sector.
- To analyze the relationship between cognitive self-regulation and productive awareness after neuroeducational intervention.
- To compare the results obtained between an experimental group and a control group with traditional accounting training.

1.6 Research hypothesis

- **H1:** Accounting training based on neuroeducation significantly increases the levels of cognitive self-regulation in participants in the agricultural sector.
- **H2:** Accounting training based on neuroeducation significantly improves productive awareness compared to traditional methods.
- **H3:** There is a positive and significant relationship between cognitive self-regulation and productive awareness after neuroeducational intervention.

2. THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.1 Neuroeducation: conceptual and neurocognitive foundations

Neuroeducation emerges as an interdisciplinary field that integrates contributions from neuroscience, cognitive psychology and pedagogy, with the purpose of optimizing teaching-learning processes based on knowledge of brain functioning. From this perspective, learning is conceived as a dynamic process that involves the interaction between neural structures, emotions, motivation, memory, and cognitive self-regulation.

Studies have shown that meaningful learning is enhanced when educational experiences activate the prefrontal cortex, limbic system, and executive networks of the brain, responsible for planning, inhibitory control, and decision-making. In formative contexts, the stimulation of these systems is achieved through strategies such as authentic problem solving, contextualization of content, constant feedback, and emotional involvement of the student.

Neuroeducation emphasizes that the brain learns best when it perceives practical relevance and contextual sense, which is especially relevant for accounting training in the agricultural sector, where knowledge must be immediately transferred to real productive situations. In this sense, neuroeducational principles favor the consolidation of lasting and functional learning, overcoming the mechanical memorization of accounting concepts.

2.2 Cognitive self-regulation and meaningful learning

Cognitive **self-regulation** is one of the fundamental pillars of autonomous and effective learning. It is defined as the individual's ability to plan, monitor, and evaluate their own cognitive, behavioral, and motivational processes during learning and decision-making. This construct is closely linked to executive functions, particularly working memory, cognitive flexibility, and inhibitory control.

Widely accepted theoretical models conceptualize self-regulation as a cyclical process that includes phases of planning, execution, and self-evaluation. During planning, the individual sets goals and selects strategies; in execution, it monitors their performance; and in the self-evaluation, reflect on the results obtained to adjust future actions. Neuroeducation enhances this process by designing learning environments that stimulate metacognition and conscious reflection.

In the field of accounting education, cognitive self-regulation acquires particular relevance, since the understanding of financial statements, production costs and cash flows requires analytical skills, critical thinking and the ability to integrate diverse information. Recent research shows that students with higher levels of self-regulation have better performance in complex accounting tasks and a greater transfer of knowledge to real contexts.

2.3 Accounting training in agro-productive contexts

Accounting training in the agricultural sector has different characteristics with respect to other productive areas. Agricultural and livestock activities are subject to high climatic uncertainty, price variability, long production cycles and a strong dependence on natural resources. These conditions demand flexible accounting management, oriented towards strategic decision-making and risk analysis.

However, numerous studies agree that agricultural producers face limitations in their accounting and financial literacy, which restricts their ability to interpret economic information and adopt efficient management practices. Traditional training programs tend to focus on normative or technical aspects, without considering the cognitive processes involved in adult learning or the socio-productive context of agriculture.

From a neuroeducational perspective, accounting training in the agricultural sector must incorporate active methodologies, learning based on real problems, financial simulations and analysis of productive cases typical of the rural environment. These strategies facilitate the activation of neural networks associated with experiential learning and strengthen the internalization of accounting concepts applied to productive reality.

2.4 Productive awareness and decision-making in the agricultural sector

Productive awareness is defined as the individual's ability to comprehensively understand the economic, productive, and sustainable implications of their decisions in the production process. This construct integrates cognitive, attitudinal and behavioral dimensions, linked to productive efficiency, responsible use of resources and long-term planning.

In the agricultural sector, productive awareness is manifested in practices such as the systematic recording of costs, the evaluation of profitability per productive unit, the adoption of appropriate technologies and the consideration of environmental and social impacts. Empirical studies suggest that greater productive awareness is associated with higher levels of productivity, economic resilience, and sustainability.

Recent literature highlights that productive awareness is not developed only through the transmission of information, but through reflective processes that connect accounting knowledge with everyday productive experience. In this sense, neuroeducation offers an ideal framework to stimulate reflection, perspective-taking and the internalization of responsible productive values.

2.5 Neuroeducation, self-regulation and productive awareness: empirical evidence

International research has reported positive effects of neuroeducational interventions on cognitive self-regulation, intrinsic motivation, and deep learning at various educational levels. In the field of technical and vocational education, these approaches have been shown to improve the transfer of knowledge to real work contexts.

In studies related to accounting education, it has been observed that active methodologies based on problem solving and contextualized learning increase conceptual understanding and financial analysis capacity. However, most of this research focuses on urban university contexts, leaving aside productive sectors such as agriculture.

Empirical evidence on the relationship between cognitive self-regulation and productive awareness is still incipient. Some studies suggest that individuals with greater self-regulatory skills have a greater capacity to evaluate the impact of their productive decisions and adjust their strategies based on economic results. However, quantitative studies with robust designs are required to confirm these relationships in agricultural contexts.

2.6 Conceptual model of the study

Based on the theoretical review, the present study proposes a conceptual model in which **accounting training based on neuroeducation** acts as an independent variable, directly influencing **cognitive self-regulation** and **productive awareness** as dependent variables. Likewise, a positive relationship between cognitive self-regulation and productive awareness is proposed, suggesting a partial mediating effect of self-regulation in the development of conscious productive management.

This model guides the methodological design and statistical analysis of the study, allowing the evaluation of both the direct effects of the intervention and the relationships between the constructs analyzed.

3. METHODOLOGY

3.1 Approach and type of research

The study was developed under a **quantitative approach**, since it is oriented to the objective measurement of variables and the statistical analysis of the effects of a training intervention. The scope of the research is **explanatory**, as it seeks to determine the causal relationship between accounting training based on neuroeducation and its effects on cognitive self-regulation and productive awareness in the agricultural sector.

Likewise, a correlational component was incorporated, in order to analyze the relationship between the dependent variables once the intervention was completed.

3.2 Research design

A quasi-experimental design **was used**, with a non-equivalent experimental group and control group, using **pre-test and post-test** measurements. This design is appropriate in educational and productive contexts where strict random assignment of participants is not possible, but it is necessary to evaluate the impact of a specific intervention.

The experimental group participated in an accounting training program designed under neuroeducation principles, while the control group received traditional accounting training, based on conventional expository methods. Both groups were assessed before and after the intervention using standardized instruments.

3.3 Population and sample

The study population was made up of actors linked to the agricultural sector, specifically small and medium-sized agricultural producers and agro-productive technicians who participate in accounting and management training programs.

The sample consisted of **120 participants**, distributed in two groups:

- **Experimental group:** 60 participants
- **Control group:** 60 participants

The sampling was **non-probabilistic for convenience**, considering criteria of accessibility, willingness to participate and permanence throughout the training process. However, the initial homogeneity of the groups was verified by means of descriptive statistical analyses and comparison tests in the pretest.

3.4 Study and operationalization variables

The study considered the following variables:

- **Independent variable:**Accounting training based on neuroeducation.
- **Dependent variables:**
  - Cognitive self-regulation
  - Productive awareness

The neuroeducational accounting training was operationalized as a structured program that integrates experiential learning strategies, real problem solving in the agricultural sector, positive emotional stimulation, continuous feedback and metacognitive activities.

Table 1 presents the operationalization of the variables, dimensions and instruments used.

Table 1Operationalization of study variables

Variable	Dimensions	Instrument	Scale Type
Neuroeducational accounting training	Neuroeducational strategies, contextualization, metacognition	Structured training programme	Dichotomous application

Cognitive self-regulation	Planning, monitoring, self-assessment	Cognitive Self-Regulation Questionnaire	Likert (1–5)
Productive awareness	Economic management, resource use, sustainability	Scale of agricultural productive awareness	Likert (1–5)

3.5 Data collection instruments

To measure the dependent variables, instruments validated in previous studies and adapted to the agricultural context were used:

- **Cognitive self-regulation questionnaire**, composed of 24 items distributed in three dimensions: planning, monitoring and self-evaluation. Responses were recorded on a five-point Likert-like scale, from "never" to "always."
- **Scale of productive awareness**, made up of 20 items that evaluate the understanding and application of principles of productive, economic and sustainable management in the agricultural sector.

Both instruments were subjected to a **process of content validation through expert judgment** and an internal **reliability** analysis, obtaining Cronbach's alpha coefficient values greater than 0.85, considered suitable for explanatory research.

3.6 Procedure

The research procedure was carried out in four phases:

1. **Diagnostic phase:** Application of the pre-test to both groups to establish initial levels of cognitive self-regulation and productive awareness.
2. **Intervention phase:** Implementation of the neuroeducational accounting training program for 12 weeks, with weekly theoretical-practical sessions in the experimental group.
3. **Control phase:** Simultaneous development of a traditional accounting training program in the control group.
4. **Evaluation phase:** Application of the post-test to both groups and data collection for statistical analysis.

3.7 Data analysis techniques

Data analysis was performed using specialized statistical software. The following techniques were used:

- Descriptive statistics: means, standard deviation and frequency distribution.
- Normality tests to verify the distribution of the data.
- Inferential Tests:
  - **Student's t for related samples** (pretest–posttest).
  - **Student's t test for independent samples** (experimental group vs. control group).
  - **ANOVA** to analyze global differences.
  - **Pearson's correlation** to examine the relationship between cognitive self-regulation and productive awareness.
- Effect size analysis (Cohen's d) to estimate the magnitude of the impact of the intervention.

3.8 Ethical considerations

The research complied with the ethical principles established for studies with human beings. All participants signed an informed consent, guaranteeing the confidentiality of

the information, the anonymity of the data and voluntary participation. It was also ensured that the results were used exclusively for academic and scientific purposes.

4. RESULTS

4.1 Initial descriptive analysis (pre-test)

Before the intervention, the initial levels of **cognitive self-regulation** and **productive awareness** in both groups were analyzed in order to check the homogeneity of the sample. Descriptive statistics show similar mean values between the experimental group and the control group, which allowed us to assume comparable initial conditions.

Table 2Descriptive statistics of the pre-test in both groups

Variable	Group	Media	Standard deviation
Cognitive self-regulation	Experimental	3.12	0.41
Cognitive self-regulation	Control	3.09	0.44
Productive awareness	Experimental	3.05	0.38
Productive awareness	Control	3.02	0.40

The t-tests for independent samples applied to the pretest showed no statistically significant differences ($p > 0.05$), confirming the initial equivalence of the groups.

4.2 Impact of neuroeducational training on cognitive self-regulation

After the intervention, significant changes were observed in the levels of cognitive self-regulation of the experimental group. The pretest-posttest comparison using Student's t for related samples showed a statistically significant increase in all the dimensions evaluated.

Table 3Pretest–posttest comparison of cognitive self-regulation in the experimental group

Dimension	Pretest (M ± DE)	Postest (M ± DE)	t	p	Cohen's d
Planning	3.15 ± 0.43	4.01 ± 0.39	9.84	< 0.001	1.27
Monitoring	3.10 ± 0.40	4.08 ± 0.36	10.21	< 0.001	1.34
Self-assessment	3.11 ± 0.42	4.12 ± 0.35	10.67	< 0.001	1.41
Global self-regulation	3.12 ± 0.41	4.07 ± 0.33	11.02	< 0.001	1.46

The effect size was high across all dimensions, indicating that accounting training based on neuroeducation principles had a substantial impact on cognitive self-regulation.

In contrast, the control group showed slight and non-significant increases ($p > 0.05$), associated with traditional learning.

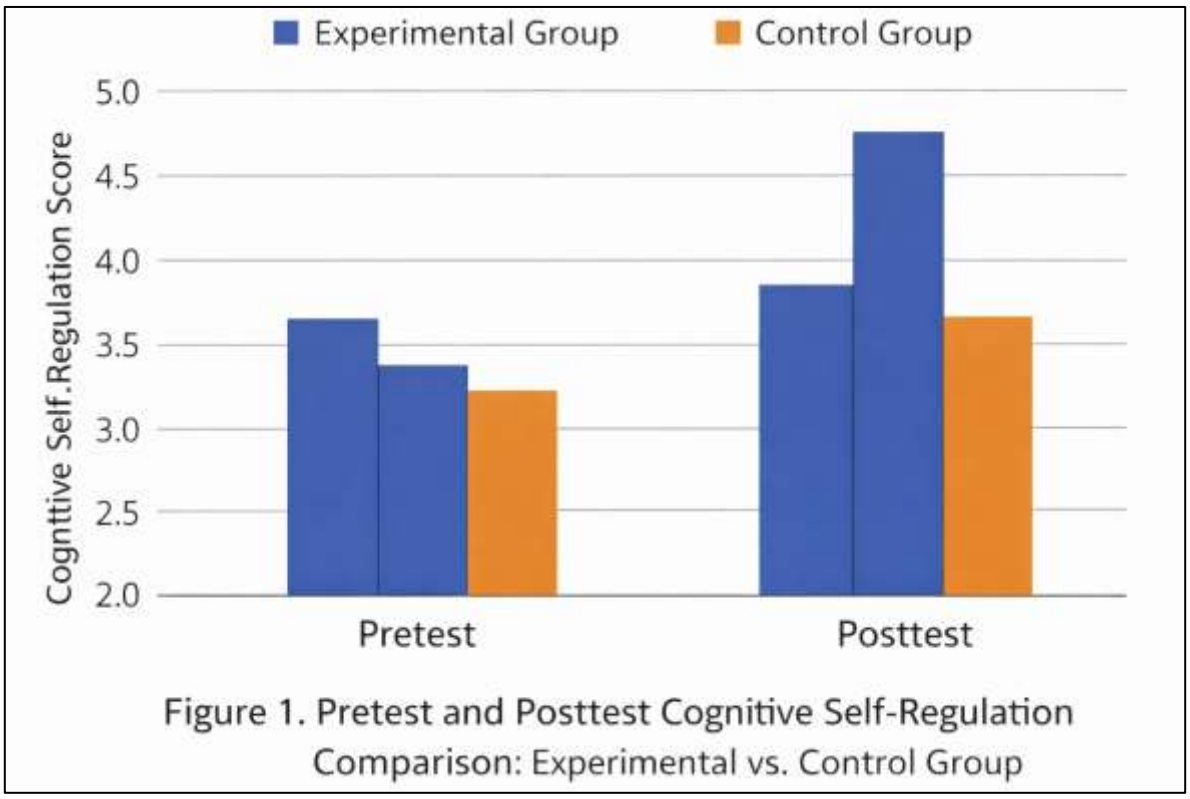

Figure 1. Pretest and Posttest Cognitive Self-Regulation Comparison: Experimental vs. Control Group

(Bar graph showing a marked increase in the experimental group versus minimal variation in the control group.)

4.3 Impact of neuroeducational training on productive awareness

The post-test results show significant improvements in the productive awareness of the experimental group, especially in the dimensions related to economic management and productive planning.

Table 4Pretest-posttest comparison of productive consciousness in the experimental group

Dimension	Pretest (M ± DE)	Postest (M ± DE)	t	p	Cohen's d
Economic management	3.08 ± 0.37	4.15 ± 0.34	11.45	< 0.001	1.52
Efficient use of resources	3.04 ± 0.39	4.09 ± 0.36	10.88	< 0.001	1.39
Sustainable approach	3.03 ± 0.38	4.02 ± 0.35	9.97	< 0.001	1.28
Global productive awareness	3.05 ± 0.38	4.09 ± 0.33	11.12	< 0.001	1.44

These results confirm that participants who received neuroeducational accounting training developed a deeper understanding of the impact of their productive and economic decisions in the agricultural context.

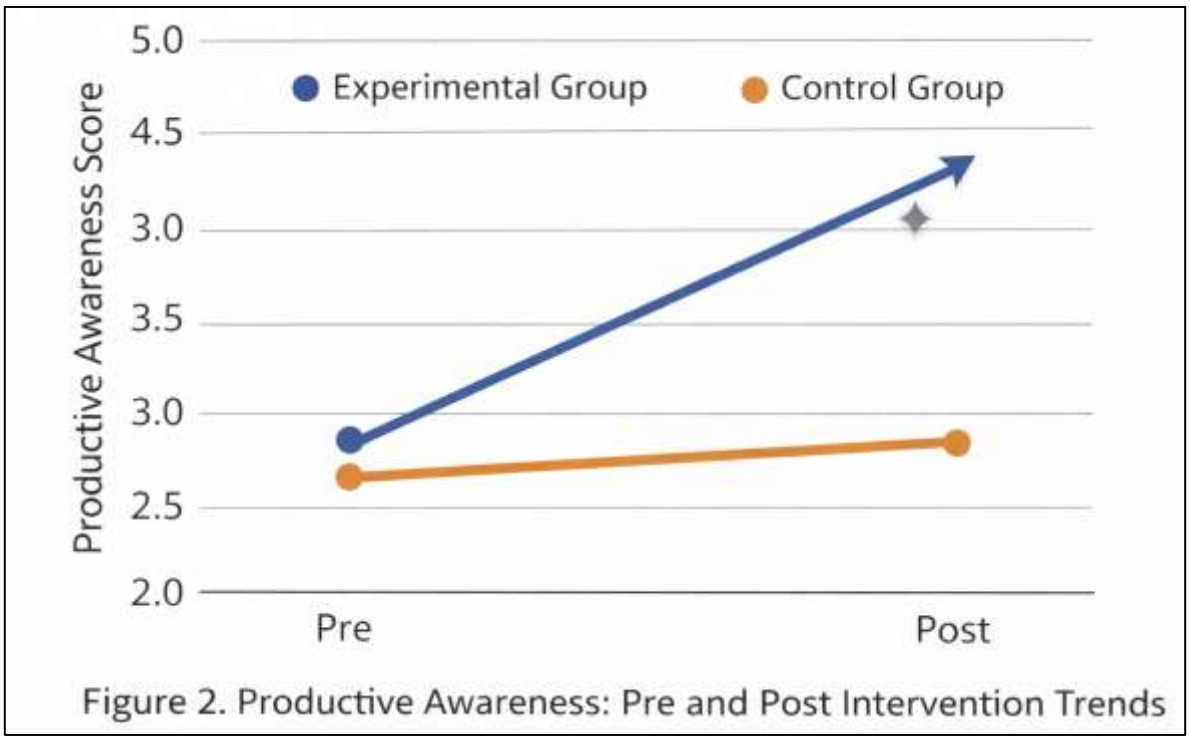

Figure 2. Productive Awareness: Pre and Post Intervention Trends

(Line graph reflecting sustained growth of the experimental group versus relative stability of the control group.)

4.4 Post-test comparison between experimental and control groups

To contrast the effects of both training approaches, a post-test comparison was made between the groups. The results show statistically significant differences in favor of the experimental group in all the variables analyzed.

Table 5Post-test comparison between experimental and control groups

Variable	Experimental group (M ± SD)	Control group (M ± SD)	t	p
Cognitive self-regulation	4.07 ± 0.33	3.28 ± 0.42	9.36	< 0.001
Productive awareness	4.09 ± 0.33	3.31 ± 0.40	8.97	< 0.001

These results empirically support the superiority of the neuroeducational approach over traditional accounting training in the agricultural sector.

4.5 Relationship between cognitive self-regulation and productive awareness

A Pearson correlation analysis was applied to examine the relationship between cognitive self-regulation and productive awareness in the post-test of the experimental group. The results show a **positive and significant correlation**.

- $r = 0.68$
- $p < 0.001$

This finding indicates that higher levels of cognitive self-regulation are associated with greater productive awareness, reinforcing the proposed conceptual model.

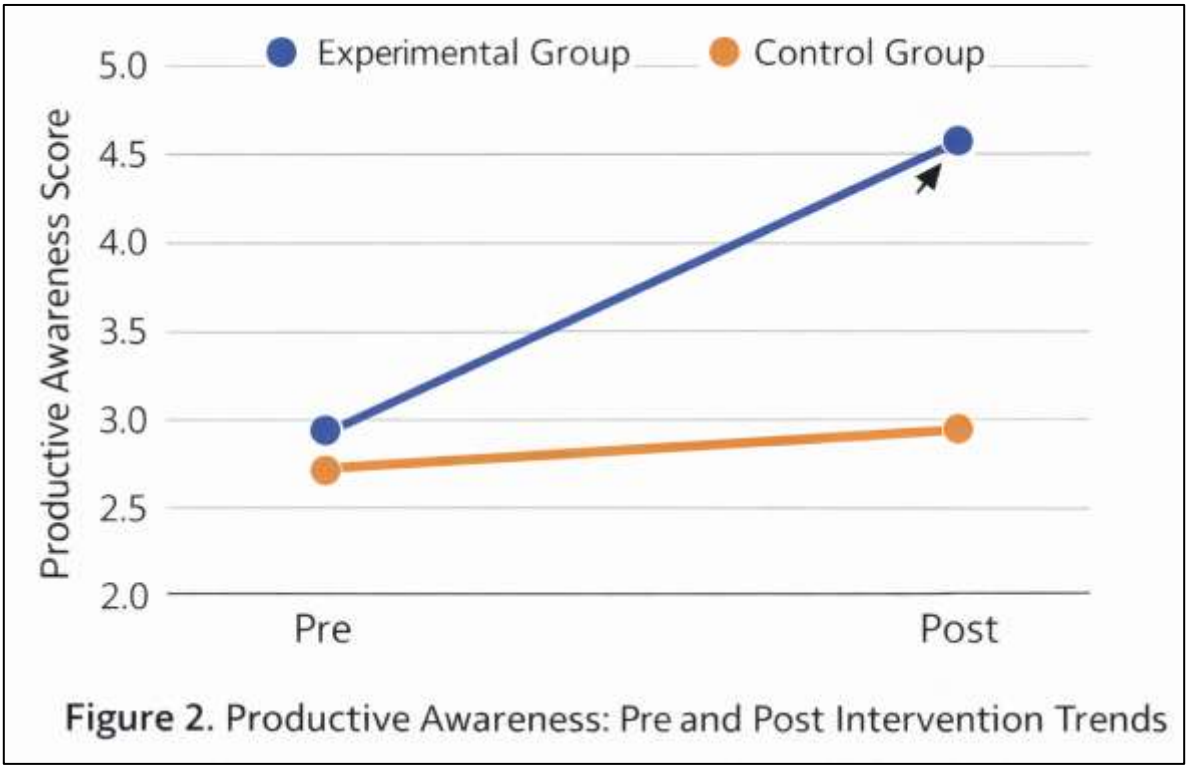

Figure 2. Productive Awareness: Pre and Post Intervention Trends

(A positive linear trend is observed with a high concentration of cases in high values).

5. DISCUSSION

The results of this study show that **accounting training based on neuroeducation principles generates positive, statistically significant and large-scale effects on cognitive self-regulation** and **productive awareness** in actors in the agricultural sector. These findings confirm the hypotheses raised and provide solid empirical evidence to a still incipient field of research.

First, the significant increase observed in the cognitive self-regulation of the experimental group reinforces the neuroeducational postulates that support that learning is optimized when the executive functions of the brain are activated, especially those related to planning, monitoring and self-evaluation. Cross-cutting improvement across all dimensions of self-regulation suggests that the intervention not only strengthened specific cognitive skills, but promoted a structural change in the way participants manage their own learning and decision-making.

These results are consistent with previous research that has shown that learning environments based on authentic problem-solving, metacognitive reflection, and constant feedback support the development of cognitive self-regulation in educational and professional contexts. However, unlike studies focused on university or urban technical education, the present work extends this evidence to the **agricultural sector**, characterized by complex productive dynamics and heterogeneous educational conditions.

In relation to **productive awareness**, the findings show significant improvements in the understanding of economic management, efficient use of resources and the sustainable approach to agricultural production. This result suggests that neuroeducational

accounting training not only improves technical knowledge, but also transforms the way participants interpret the impact of their productive decisions. The integration of accounting content with real situations in the agricultural environment allowed participants to internalize the practical usefulness of accounting records, cost analysis and financial planning.

From a theoretical perspective, these results support approaches that conceive productive consciousness as a dynamic construct, influenced by higher cognitive processes and not only by the acquisition of information. Neuroeducation, by incorporating the emotional and contextual dimension of learning, seems to facilitate the connection between accounting knowledge and everyday productive reality, strengthening conscious and strategic decision-making.

A particularly relevant finding is the **positive and significant correlation** between cognitive self-regulation and productive awareness. This relationship suggests that individuals with greater self-regulation capacities are more likely to develop a comprehensive view of their productive activity, evaluate economic consequences, and adjust their strategies based on results. This result supports the proposed conceptual model, in which cognitive self-regulation acts as a key mechanism that enhances the development of productive consciousness.

In methodological terms, the quasi-experimental design allowed establishing clear differences between the neuroeducational approach and traditional accounting training. The size of the high effect observed in the dependent variables indicates that the changes are not attributable only to the passage of time or exposure to accounting content, but also to the pedagogical approach used. This aspect is particularly relevant for agricultural training institutions that seek to maximize the impact of their training programs.

However, it is necessary to recognize certain limitations of the study. Non-probability sampling and concentration of the sample in a specific geographic context may limit the generalizability of results. The study also focused on short-term effects, so future research could incorporate longitudinal designs to assess the sustainability of the changes observed in cognitive self-regulation and productive awareness.

Despite these limitations, the study provides robust empirical evidence that contributes to closing the existing gap in the literature on the application of neuroeducation in accounting training in the agricultural sector. The results obtained reinforce the need to rethink traditional models of agricultural training, incorporating pedagogical approaches that consider the cognitive and emotional functioning of learners.

6. CONCLUSIONS AND IMPLICATIONS

The objective of this study was to analyze the impact of an **accounting training program based on neuroeducation principles** on cognitive self-regulation and productive awareness in actors in the agricultural sector. From the results obtained, relevant conclusions are derived that contribute to the theoretical, methodological and practical progress in the field of accounting education and agro-productive development.

First, it is concluded that the incorporation of neuroeducational strategies in accounting training generates a **significant and sustained increase in cognitive self-regulation**. The participants of the experimental group demonstrated greater capacities to plan, monitor and evaluate their learning processes and economic decision-making. This

finding confirms that cognitive self-regulation can be strengthened through pedagogical interventions designed from knowledge of brain functioning, even in productive contexts traditionally far from innovative educational approaches.

Secondly, the results allow us to affirm that neuroeducational accounting training contributes significantly to the development of **productive awareness**. Participants showed a deeper understanding of the relationship between accounting records, cost management, efficient use of resources and the sustainability of agricultural activity. This strengthened productive awareness translates into a greater capacity to make informed and strategic economic decisions, with direct implications for the productivity and sustainability of the sector.

Likewise, the positive relationship identified between cognitive self-regulation and productive awareness allows us to conclude that both variables are closely interconnected. Cognitive self-regulation acts as a facilitating mechanism that enhances the internalization of accounting knowledge and its conscious application in the productive field. This relationship reinforces the validity of the proposed conceptual model and provides empirical evidence on the importance of cognitive processes in agroproductive management.

From a **theoretical** perspective, the study expands the conceptual framework of neuroeducation by integrating it with accounting education and agricultural development, fields that have traditionally been approached in a fragmented manner. The research shows that neuroeducational principles are not only applicable to school or university contexts, but also to complex productive environments such as the agricultural sector.

On the **methodological** level, the use of a quasi-experimental design with robust statistical analyses allowed the identification of clear effects attributable to neuroeducational intervention. This approach offers a methodological reference for future research interested in evaluating innovative training programs in rural and productive contexts.

In **practical** terms, the results have direct implications for agricultural training institutions, universities, rural development agencies and public policy makers. The adoption of accounting training programs based on neuroeducation can contribute to improving productive efficiency, strengthening the economic sustainability of agricultural enterprises and promoting a management culture based on reflection and analysis.

Finally, it is recommended that future research expand the geographic scope of the study, incorporate probabilistic samples and longitudinal designs, as well as additional variables such as real economic performance, productive resilience, or technology adoption. These lines of research will allow us to deepen the understanding of the impact of neuroeducation on the integral development of the agricultural sector.

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