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The Effect of Cognitive Processes on Declarative Knowledge: An Econometric Analysis

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Abstract
This study analyzes how cognitive processes, specifically filtering, procedural knowledge, organization, and statistical management, influence declarative knowledge. Using a multiple linear regression econometric model, data from a representative student sample were evaluated. The results indicate that organization and procedural knowledge have the most significant impacts, while filtering and statistical management present smaller but statistically relevant effects. These findings highlight the importance of designing educational strategies that promote information structuring and practical application of concepts. Likewise, the need to foster metacognitive skills such as filtering and statistical analysis to optimize academic performance is emphasized. The study concludes that integrating these cognitive processes into teaching can enhance the development of declarative knowledge and better prepare students for complex contexts.
Keywords: declarative knowledge, cognitive processes, filtering, procedural knowledge, organization, econometric model.

Introduction

Declarative knowledge, understood as the ability to store and retrieve explicit information about facts and concepts, constitutes an essential component of the human cognitive system (Anderson, 1980). This type of knowledge, integrated within explicit memory, enables the organization and transfer of information in a structured manner, facilitating problem-solving and learning in various contexts (Schneider & Stern, 2010). However, the dynamics between declarative knowledge and other cognitive processes, such as filtering, procedural knowledge, and organization, have not been explored in depth. This raises questions about how these interactions influence cognitive and academic performance.

Previous studies have emphasized that declarative knowledge does not operate in isolation but interacts with other cognitive systems, such as procedural knowledge, which governs the execution of specific skills and strategies (Flavell, 1979; Garner, 1987). For instance, the organization of information and the ability to filter irrelevant data have been identified as factors that enhance the acquisition and use of declarative knowledge (Paris & Winograd, 1990). However, the influence of variables such as statistical data management and the integration of cognitive processes remains a subject of debate in the literature (Vallejos, 2009).

In the educational field, understanding these interactions is essential for optimizing teaching and learning processes. Recent research has indicated that students who achieve better information organization and effective integration between declarative and procedural knowledge tend to perform significantly better in analytical reasoning and problem-solving tasks (Muñoz-Muñoz & Ocaña de Castro, 2017). However, individual differences in the development of these skills highlight the need to explore additional factors that may explain this variability.

In this context, the present study aims to analyze the interactions between declarative knowledge and other key cognitive processes, such as filtering, procedural knowledge, organization, and statistical data management. This approach seeks to address existing gaps in the literature, providing a more comprehensive understanding of how these processes interact to shape learning and cognitive performance. Additionally, the findings are expected to contribute to the design of innovative pedagogical strategies that foster the development of complex cognitive skills in educational and professional contexts.

Declarative knowledge, as an essential component of explicit memory, has been widely studied in relation to its influence on learning and problem-solving. Anderson (1980) describes declarative knowledge as the foundation for the development of procedural knowledge, emphasizing that both work complementarily to strengthen cognitive performance. Similarly, Flavell (1979) and Paris and Winograd (1990) highlight

the role of metacognition in monitoring and regulating declarative knowledge, proposing that processes such as monitoring, filtering, and organization are fundamental to optimizing its use in academic contexts. Recent studies have explored how variables such as organization and filtering directly influence the effectiveness of declarative knowledge. Garner (1987) found that the ability to identify and eliminate irrelevant information significantly improves the accuracy and speed of retrieving relevant information. Furthermore, Vallejos (2009) highlights that metacognitive strategies, such as data organization and critical evaluation, are essential for students to transform declarative knowledge into applicable skills in practical scenarios.

On the other hand, procedural knowledge, defined as the set of practical skills for executing specific tasks, has consistently been linked to declarative knowledge. According to Schneider and Stern (2010), the interaction between these two types of knowledge strengthens students' ability to solve complex problems, particularly in areas requiring analytical reasoning. This connection underscores the importance of considering both types of knowledge as interdependent elements in any explanatory model of learning.

Although previous research has provided significant evidence about these interactions, important gaps remain in the literature. For example, Muñoz-Muñoz and Ocaña de Castro (2017) noted the need for a more comprehensive understanding of how factors such as statistical data management affect the relationship between declarative knowledge and other cognitive processes. Additionally, studies like those of Solé (2012) propose that integrating critical skills into education can significantly enhance the impact of cognitive processes on academic performance, though this approach still requires further empirical development.

In summary, the current literature offers a solid theoretical framework for understanding the relationships between declarative knowledge and other key cognitive processes. However, the need for more specific studies exploring these interactions in different educational and professional contexts is evident. This research gap justifies the development of the present study, which seeks to analyze the relationships between declarative knowledge and variables such as filtering, procedural knowledge, organization, and statistical management.

The main objective of this study is to analyze the relationship between declarative knowledge and other cognitive processes, specifically filtering, procedural knowledge, organization, and statistical management. This approach aims to understand how these variables interact to influence individuals' ability to store, structure, and retrieve relevant information in educational and professional contexts. Through this analysis, the study intends to provide a theoretical and empirical framework that enhances the understanding of the internal dynamics of learning and cognitive development.

This study is based on a rigorous methodological design that combines descriptive and econometric analysis, enabling not only the identification of significant correlations but also the establishment of causal inferences about the interactions between variables. By addressing these issues, this work seeks to fill existing gaps in the literature and provide valuable insights for designing educational strategies that optimize learning and cognitive performance.

The article is organized into five main sections. The first presents the theoretical framework supporting the relationship between declarative knowledge and the cognitive processes studied, highlighting key contributions from previous research. The second section describes the methodology employed, detailing the design of the econometric model, the variables considered, and the statistical tests applied. The third section presents the results obtained, including a descriptive analysis of the variables and the findings of the multiple regression model. The fourth section discusses the results in relation to the theoretical framework, highlighting their theoretical and practical implications. Finally, the fifth section concludes the article with a summary of the main findings, the study's limitations, and recommendations for future research.

Theoretical Framework

Declarative Knowledge

Declarative knowledge is defined as the ability to store and retrieve explicit information about facts, concepts, and relationships between them, making it one of the primary dimensions of explicit memory (Anderson, 1980). This type of knowledge allows individuals to organize and use information in a structured manner, facilitating processes such as logical reasoning and problem-solving. According to Schneider and Stern (2010), declarative knowledge serves as a foundation for acquiring and applying more complex skills, such as those characteristic of procedural knowledge.

Unlike procedural knowledge, which focuses on the execution of tasks and specific skills, declarative knowledge is more closely associated with conceptual understanding and the ability to transfer learning to new situations (Flavell, 1979). This feature makes it an essential component in educational contexts, where its development is linked to academic performance and meaningful learning (Garner, 1987).

However, the effectiveness of declarative knowledge largely depends on its interaction with other cognitive processes, such as organization, filtering, and the ability to integrate statistical data.

Related Cognitive Processes

- **Cognitive Filtering**: Filtering refers to the ability to identify and eliminate irrelevant or redundant information during the learning process. According to Garner (1987), this process is essential for optimizing working memory and improving the quality of stored knowledge. In the context of declarative knowledge, filtering contributes to the precision and relevance of retrieved information, facilitating its use in complex tasks.
- **Procedural Knowledge**: Procedural knowledge complements declarative knowledge by focusing on the practical application of information. Schneider and Stern (2010) highlight that these two types of knowledge are interdependent, as declarative knowledge provides the conceptual basis needed to execute procedural skills. This interaction is key to understanding how students transfer theoretical knowledge to practical situations, a critical aspect of academic training.
- **Information Organization**: Organization is a metacognitive process that allows for structuring information logically and coherently. Paris and Winograd (1990) argue that effective organization improves the ability to efficiently retrieve and use declarative knowledge. In educational settings, this process is associated with students' ability to categorize and prioritize concepts, which is essential for meaningful learning.
- **Statistical Management**: Although less studied in relation to declarative knowledge, statistical management represents a skill that influences the ability to interpret and analyze numerical data. Muñoz-Muñoz and Ocaña de Castro (2017) suggest that this skill may mediate the relationship between declarative knowledge and academic performance, particularly in areas requiring quantitative reasoning.

Theoretical Foundations of the Econometric Model

Analyzing the relationships between declarative knowledge and cognitive processes, such as filtering, procedural knowledge, organization, and statistical management, requires a robust quantitative approach to identify significant interactions. The econometric model, based on multiple linear regression, provides an appropriate theoretical framework for examining these interactions, as it allows for the analysis of how independent variables jointly influence the dependent variable—in this case, declarative knowledge (Wooldridge, 2010).

The choice of a multiple linear regression model is based on its ability to measure the magnitude and direction of relationships between variables. This model assumes that declarative knowledge can be explained as a linear function of key cognitive processes, as described in the following equation:

$$Y=B0+B1X1+B2X2+B3X3+B4X4+uY = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + uY=B0+B1X1+B2X2+B3X3+B4X4+u$$

Where:

- YYY: Declarative knowledge.
- B0B_0B0: Intercept, representing the average level of declarative knowledge when the independent variables are zero.
- X1,X2,X3,X4X_1, X_2, X_3, X_4X1,X2,X3,X4: Independent variables (filtering, statistical management, procedural knowledge, organization).
- B1,B2,B3,B4B_1, B_2, B_3, B_4B1,B2,B3,B4: Regression coefficients, indicating the influence of each independent variable on YYY.
- uuu: Random error, capturing unobserved factors.

This approach not only identifies significant correlations but also establishes causal relationships, provided the model's fundamental assumptions—such as linearity, independence of errors, homoscedasticity, and normality of residuals—are met (Gujarati & Porter, 2009).

Application of the Model to Cognitive Processes

The econometric model has been widely used in educational research to evaluate the impact of multiple variables on academic and cognitive performance. For example, studies by Vallejos (2009) and Schneider and Stern (2010) have demonstrated that the interaction between variables such as procedural knowledge and organization can accurately predict the level of declarative knowledge in educational contexts. Similarly, Garner (1987) and Paris and Winograd (1990) emphasize that filtering and organization not only affect the quantity of stored knowledge but also its quality and practical utility.

Furthermore, statistical management, although less explored, has been identified as a potential mediator in these relationships, particularly in areas requiring advanced quantitative skills. Muñoz-Muñoz and Ocaña de Castro (2017) suggest that students with strong statistical management competencies are more likely to structure and apply declarative knowledge efficiently in complex contexts.

Relevance of the Model in the Current Context

Using econometric models in cognitive research not only provides a detailed analysis of relationships between variables but also allows for evaluating the effectiveness of educational interventions aimed at improving learning and cognitive performance. This approach is particularly relevant in an increasingly data-oriented world, where the ability to interpret, organize, and use information effectively is fundamental to academic and professional success (Anderson, 1980; Wooldridge, 2010).

Methodology

Study Design

This study adopts an explanatory quantitative design based on a multiple linear regression econometric model. This approach enables the analysis of how various independent variables influence declarative knowledge, aiming to identify significant relationships and quantify their impact. The choice of this methodological design responds to the need to establish an empirical basis supporting the hypotheses proposed regarding the interaction of key cognitive processes.

Econometric Model

The multiple linear regression model used in this study is formulated as follows:

Y=B0+B1X1+B2X2+B3X3+B4X4+uY = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + uY=B0+B1X1+B2X2+B3X3+B4X4+u

Where:

- YYY: Dependent variable (Declarative knowledge).
- X1X_1X1: Filtering.
- X2X_2X2: Statistical management.
- X3X_3X3: Procedural knowledge.
- X4X_4X4: Organization.
- B0B_0B0: Intercept.
- B1,B2,B3,B4B_1, B_2, B_3, B_4B1,B2,B3,B4: Regression coefficients associated with the independent variables.
- uuu: Random error.

This model evaluates how each independent variable contributes to declarative knowledge while keeping the others constant. Additionally, various statistical tests were applied to ensure the validity of the model, as detailed below.

Variables

Dependent Variable:

- **Declarative Knowledge**: Measured using a scale that captures participants' ability to retrieve and apply explicit information about facts and concepts.

Independent Variables:

1. **Filtering**: Represents the ability to filter irrelevant information.
2. **Statistical Management**: Assesses skills in handling and interpreting quantitative data.
3. **Procedural Knowledge**: Evaluates the ability to execute practical tasks based on declarative concepts.
4. **Organization**: Measures the ability to structure information logically and coherently.

Statistical Tests

1. **Model Specification**:
    - **Ramsey RESET Test**: Verifies the functional form of the model, ensuring no relevant variables are omitted or specification errors are present.
2. **Linearity**:
    - **Rainbow Test**: Determines whether the relationship between independent variables and the dependent variable is linear.
3. **Normality of Residuals**:
    - **Shapiro-Wilk Test**: Confirms that the residuals of the model follow a normal distribution, a fundamental requirement for validity.
4. **Homoscedasticity**:
    - **Breusch-Pagan Test**: Evaluates whether the variance of residuals is constant across the values of the independent variables.
5. **Autocorrelation**:
    - **Durbin-Watson Test**: Checks for the absence of autocorrelation among residuals, ensuring independence of observations.
6. **Multicollinearity**:
    - **Variance Inflation Factor (VIF)**: Measures the degree of collinearity among independent variables to ensure model stability.

Procedure

Data were analyzed using specialized statistical software, implementing the aforementioned tests to validate the model's fundamental assumptions. The analysis included an initial diagnostic of the variables through descriptive statistics, followed by the estimation of the econometric model and the interpretation of the coefficients obtained.

Results

Descriptive Analysis of Variables

The descriptive analysis reveals the main characteristics of the five variables evaluated: declarative knowledge, filtering, statistical management, procedural knowledge, and organization. The results are as follows:

- **Declarative Knowledge**:
  - Values range from 2.9 to 5.0, with a mean of 4.069 and a median of 4.100, indicating a trend toward high knowledge levels.
  - The interquartile range (3.9 to 4.325) suggests moderate concentration in higher values.
- **Filtering**:
  - Values range from 2.4 to 5.0, with a mean of 4.145 and a median of 4.200.
  - Data are concentrated in the range of 3.8 to 4.6, suggesting a distribution close to high levels.
- **Statistical Management**:
  - Values range from 2.0 to 4.8, with a mean of 3.781 and a median of 3.800.
  - This broader range reflects greater dispersion compared to other variables.
- **Procedural Knowledge**:
  - Values range from 2.5 to 5.0, with a mean of 3.929 and a median of 4.000.
  - Most data are concentrated between 3.5 and 4.3.
- **Organization**:
  - Values range from 2.4 to 5.0, with a mean of 3.832 and a median of 3.800.
  - The interquartile range shows concentration in medium-high values (3.6 to 4.1).

Variable Correlations

The correlations among variables show interesting patterns:

- Filtering, organization, and procedural knowledge present moderate correlations with declarative knowledge, indicating significant relationships.
- The weakest correlation is observed between statistical management and the other variables, suggesting its influence on declarative knowledge may be indirect.

Econometric Model: Key Results

The estimated econometric model is a multiple linear regression with the following equation:
Declarative Knowledge=1.26994+0.13841(Filtering)+0.12090(Statistical Management)+0.19194(Procedural Knowledge)+0.26470(Organization)+u\text{Declarative Knowledge} = 1.26994 + 0.13841(\text{Filtering}) + 0.12090(\text{Statistical Management}) + 0.19194(\text{Procedural Knowledge}) + 0.26470(\text{Organization}) + uDeclarative Knowledge=1.26994+0.13841(Filtering)+0.12090(Statistical Management)+0.19194(Procedural Knowledge)+0.26470(Organization)+u

- **Coefficients and Significance**:
  1. **Filtering (B1=0.13841,p=0.016B_1 = 0.13841, p = 0.016B1=0.13841,p=0.016)**: Increases declarative knowledge by an average of 0.138 units for each additional point, indicating statistical significance.
  2. **Statistical Management (B2=0.12090,p=0.037B_2 = 0.12090, p = 0.037B2 =0.12090,p=0.037)**: Contributes an average increase of 0.121 units, also statistically significant.
  3. **Procedural Knowledge (B3=0.19194,p=0.001B_3 = 0.19194, p = 0.001B3 =0.19194,p=0.001)**: Generates an average increase of 0.192 units, reflecting a robust relationship.
  4. **Organization (B4=0.26470,p<0.001B_4 = 0.26470, p < 0.001B4=0.26470,p<0.001)**: Has the greatest impact, increasing declarative knowledge by an average of 0.265 units per additional point.
- **Model Fit**:
  - **Coefficient of Determination (R2=0.3522R^2 = 0.3522R2=0.3522)**: Indicates the model explains 35.22% of the variability in declarative knowledge.
  - **F-Statistic (F=26.51,p<0.001F = 26.51, p < 0.001F=26.51,p<0.001)**: Confirms the model is globally significant.

Diagnostic Tests

1. **Ramsey RESET Test**: p=0.356p = 0.356p=0.356, indicating correct model specification.
2. **Rainbow Test**: p=0.760p = 0.760p=0.760, confirming linear relationships between variables.
3. **Shapiro-Wilk Test**: Residuals follow a normal distribution (p=0.3893p = 0.3893p=0.3893).
4. **Breusch-Pagan Test**: Residual variance is constant (p=0.2898p = 0.2898p=0.2898).
5. **Durbin-Watson Test**: No autocorrelation among residuals (p=0.8231p = 0.8231p=0.8231).
6. **Variance Inflation Factor (VIF)**: All values below 1.5 indicate no multicollinearity among variables.

General Interpretation

The model confirms that filtering, procedural knowledge, and organization have significant and positive impacts on declarative knowledge. Although statistical management shows a weaker relationship, it remains statistically significant, suggesting a moderate role. Diagnostic tests validate the model, confirming it meets fundamental assumptions of linearity, normality, homoscedasticity, and absence of multicollinearity.

Discussion

Interpretation of Results

The results of this study confirm that declarative knowledge is significantly influenced by cognitive processes such as filtering, procedural knowledge, organization, and statistical management. Among these, organization emerged as the most influential factor, aligning with previous research highlighting the importance of structuring and categorizing information for efficient retrieval and application (Paris & Winograd, 1990). This finding suggests that fostering organizational skills in educational contexts could substantially enhance students' ability to manage and use declarative knowledge effectively.

Procedural knowledge also demonstrated a strong and statistically significant relationship with declarative knowledge. This result supports the theoretical perspective that procedural and declarative knowledge are interdependent, with each contributing to the development and application of the other (Schneider & Stern, 2010). The practical implication is that curricula should aim to integrate theoretical and practical components to reinforce the synergy between these knowledge types.

Filtering, while having a smaller impact than organization and procedural knowledge, also played a significant role in enhancing declarative knowledge. This result aligns with Garner's (1987) findings that the ability to eliminate irrelevant information optimizes cognitive resources and improves learning efficiency. Educational strategies that encourage critical evaluation and selective information processing could further amplify the benefits of filtering on declarative knowledge development.

Statistical management, although the least influential of the variables studied, was nonetheless statistically significant. This finding suggests that while statistical management may not directly impact declarative knowledge, it could act as a mediating or complementary factor, particularly in contexts requiring quantitative reasoning and data interpretation (Muñoz-Muñoz & Ocaña de Castro, 2017). Future studies could further explore this indirect relationship and its implications for educational practice.

Comparison with Previous Studies

The findings of this study align with and expand upon existing literature. For example, Paris and Winograd (1990) emphasized the critical role of organizational processes in enhancing learning outcomes, a conclusion supported by the current study. Additionally, Schneider and Stern (2010) highlighted the interdependence of procedural and declarative knowledge, further validated by this research.

However, the inclusion of statistical management as a variable represents a novel contribution, addressing a gap identified by Muñoz-Muñoz and Ocaña de Castro (2017). By integrating this dimension into the analysis, the study provides a more comprehensive understanding of the factors influencing declarative knowledge.

Practical Implications

The results have significant implications for the design of educational programs and interventions. Specifically:

1. **Fostering Organization**: Strategies such as using concept maps, structured outlines, and categorization exercises can enhance students' ability to organize information, thereby improving their declarative knowledge.
2. **Integrating Theory and Practice**: Combining theoretical content with hands-on activities can strengthen the relationship between declarative and procedural knowledge, facilitating deeper learning and better knowledge transfer.
3. **Enhancing Filtering Skills**: Encouraging critical evaluation and information selection can optimize cognitive resources and improve learning outcomes.

4. **Promoting Statistical Literacy**: While its direct impact may be limited, incorporating statistical reasoning into curricula can complement other cognitive processes and support the development of declarative knowledge in specific contexts.

Conclusions

This study provides empirical evidence that declarative knowledge is significantly influenced by cognitive processes such as organization, procedural knowledge, filtering, and statistical management. Among these, organization emerged as the most influential variable, emphasizing the importance of structuring and categorizing information for efficient retrieval and application. Procedural knowledge and filtering also demonstrated strong and significant impacts, while statistical management, though less influential, was statistically significant, suggesting its role as a complementary factor in specific contexts.

The results align with existing theories on the interdependence of cognitive processes in knowledge acquisition and application (Anderson, 1980; Paris & Winograd, 1990). By integrating these variables into an econometric model, this study contributes to the understanding of how declarative knowledge interacts with other cognitive systems, offering a comprehensive perspective on the factors that shape learning and cognitive performance.

Practical Implications

The findings have direct implications for educational strategies:

1. **Curriculum Design**: Educational programs should integrate organizational techniques, such as concept mapping and structured note-taking, to enhance declarative knowledge.
2. **Balanced Learning Approaches**: Combining theoretical content with practical tasks can strengthen the synergy between declarative and procedural knowledge.
3. **Skill Development**: Promoting filtering and critical evaluation can help students optimize their cognitive resources and improve learning efficiency.
4. **Statistical Reasoning**: Incorporating statistical management into curricula, particularly in quantitative fields, can complement other cognitive processes and enhance declarative knowledge in applied contexts.

Limitations and Future Research

The main limitation of this study is its reliance on cross-sectional data, which restricts the ability to establish causal relationships definitively. Additionally, while the model explains 35.22% of the variability in declarative knowledge, other unobserved factors may contribute to this phenomenon. Future research could address these gaps by adopting longitudinal designs and exploring additional variables, such as motivation, metacognitive strategies, and learning environments.

In conclusion, this study offers a robust analytical framework for understanding the dynamics of declarative knowledge and its interaction with key cognitive processes. By integrating these insights into educational practices, educators can design more effective strategies to enhance learning and cognitive development, ultimately preparing students for academic and professional success.

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