METACOGNITION AS A DIDACTIC STRATEGY IN STATISTICS TEACHING

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SUMMARY

Statistical inference is one of the main branches of Statistics and a fundamental methodological tool in empiric sciences, in particular, it allows us to quantify the reliability of results of aleatory samples, and therefore to verify our impressions by means of calculations (Batanero, 2001). This fact highlights the importance of an up-to-date teaching of the subject.

This work is part of a research project which aims to investigate what the concept of Confidence Intervals means to students of a first course in Statistics at Rosario's National University.

In the frame of the Godino's (1999) theory we attempt to determine, by means of an opinion survey and a test given to students, the relationship between their own perceptions about their knowledge of the subject and the grades obtained in the test through the study of different elements of meaning: extensive, ostensive, actuative, intensive and validative which reveal the comprehension of the topic: Confidence Intervals.

1. Introduction

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We incorporate some theoretical reflections on metacognition to be able to carry out a more exact interpretation of the relationship between the opinion of the students about difficulties in the learning of Confidence Intervals and the results of a test on this topic.

When we speak of metacognition we speak of conscience and control that individuals have on their cognitive processes. Garner (1987) maintains that, during the last decade, a considerable quantity of studies has demonstrated that metacognition plays an important role in effective comprehension.

The term metacognition, according to a majority of authors, refers to two basic components: knowledge about cognition and the regulation of cognition. The first component is related to the capacity to reflect on our own cognitive processes, and the metacognitive regulation implies the use of strategies that allow us to control cognitive efforts.

According to Baker (1994), the distinction between metacognitive and cognitive strategies is not clear. Many cognition strategies or study strategies traditionally considered as metacognitive are useful, not only because they improve learning or comprehension, but also because they contribute to giving students a means of gauging the success of their efforts to learn and to understand.

For practical purposes, so long as a strategy is effective, it doesn't matter if it is labelled as cognitive or metacognitive. The fundamental aim when we teach the mechanisms of metacognition to students is to enable them to take over responsibility for their own activities of learning and comprehension.

The psychologists based on Vygotsky's theory consider that the best way of achieving this objective is to transfer the responsibility of regulation gradually to young people.

Watson (1983) claims that an essential objective of education in science is to encourage students to transform themselves into autonomous learners, able to acquire information from many sources, of considering alternatives, and of arriving to defensible conclusions.

Specialists in scientific education such as Carin and Sand (1985); Carter and Simpson (1978); Esler and Esler (1985); Peterson and others (1985), have identified a basic core of abilities that the students of science resources should acquire, among them: observation, classification, comparison, description, organization of information, prediction, inference, hypothesis formulation, data interpretation, communication, experimentation and conclusion drawing.

It should be stressed that many of the abilities involved in scientific procedure can also be considered as metacognitive abilities; for example, the formulation of conclusions. Carter and Simpson (1978) claim that such abilities are in direct correspondence with a reader's ability to critically analyze, to evaluate information, to recognize ideas and main concepts, to establish relationships and to apply the information to other situations. These operations are undoubtedly similar to evaluation criteria. Also, they claim that the scientific ability to interpret data belongs together with the operation of summarizing new information and of modifying the reading rhythm according to text needs, and highlight that both abilities can be considered as metacognitive.

Fischer and Lipson (1986); Johnson (1985); Osborne and Wittrock (1983); Pope and Gilbert (1983), have come in similar ways to recognize the necessity for students to assume an active role in the acquisition of new knowledge. To Pope and Gilbert, knowledge is seen as product of transactions between a person and the context. They point out, also, that currently the emphasis is put on the activity of a person who tries to extract sense out of facts by the construction and interpretation of individual experiences.

Osborne and Wittrock (1983) describe a constructivist model adapted to the learning of science, according to which to understand things that we are taught verbally or those that we read or discover when observing a demonstration or when carrying out an experiment, we should devise a model or explanation that organizes the information collected from that experience in a way that is significant and appropriate to our logic, to our experiences in the real world, or to both.

The construction of these kinds of models requires certain metacognitive abilities such as evaluating the model's factibility and revising its hypotheses, as necessary.

Hawkins and Pea (1987), explicitly based on Vygotsky's work, support a learning approach that encourages a transition from heteroregulation (being regulated by others) to self-regulation. Johnson (1985) also comments on the importance that students take over control of their own scientific learning, and maintains that when students learn that they have a certain control about the information they access, they can look to themselves as agents responsible for their own learning rather than as inert holders of information that others dump on them.

Maehr (1983) criticizes great part of science teaching, objecting that it is being too much directed by teachers and outlines that insofar as directed learning restricts the students' participation in the learning process, it will end up diminishing their achievements. According to this author, problems derived from directed learning are probably more severe in the area of science education, where the main interest is to create a person who behaves autonomously.

Fischer and Lipson (1986) express that one of the objectives of science teaching at the university is for the students to learn how to recognize and correct their own errors. They maintain that the students themselves should acquire the ability of dealing with errors and be able to disassemble their own "programs."

Based on this point, we can consider that the recognition and the correction of one's own errors are fundamental metacognitive operations.

The problem of erroneous preconceptions is of metacognitive order. If students don't become aware that they don't possess the correct knowledge, they cannot clarify their understanding. In this sense, opinion surveys constitute a strategy for creating that awareness.

2. Problem investigated

What knowledge do students have about their own comprehension of a concept?

What relation exists between the knowledge that students believe they have about the topic of Confidence Intervals and the comprehension of the concept as revealed by the possession of the different types of elements of meaning?

3. Methodology

Metacognition of students on the topic of Confidence Intervals: opinion survey

We carry out a survey which objective is to know the opinion of students about difficulties in the process of learning this topic, and through that opinion, to know the awareness and the control that students have on their own cognitive processes.

This survey is shown up next.

Opinion survey to students

1. Having taken a Course in Statistics, do you recognize that you had difficulties with the topic of Confidence Intervals? (Indicate your answer with a cross). Yes No
2. If yes: Do you have difficulties with: (indicate your answers with a cross)
    - Understanding theory.
    - Understanding simbology.
    - Understanding the instructions.

- The approach to solving the problem.
- Numerical calculation.
- Specification of the solution using appropriate simbology and graphics.
- Interpretation of conclusions.

Career: Age: Origin place:
Type of high school attended: Computation knowledge:

4. Results

In the following box the didactic variables which characterize the knowledge process are related to the different elements of meaning:

Relationship between difficulties evidenced by students and the possession of elements of meaning - Table 1

Items: difficulties evidenced	Types of elements				
	Extensive	Ostensive	Actuative	Intensive	Validative
Understanding of theory	X			X	
Understanding of simbology		X			
Understanding of instructions	X			X	
Approach to solving the problem	X			X	
Numerical calculation			X		
Specification of the solution using appropriate simbology and graphs		X		X	
Interpretation of conclusions					X

Taking into account the relationship between the type of element of meaning and each of the questions asked in the survey, we analyzed the difficulties most frequently observed by the students themselves and the items they claim not to have problems with in relation to the skills evaluated. To that effect, descriptive tables were created for each element of meaning.

The proportion of students who claim not to have problems with the different items that include the most commonly observed difficulties (elements of meaning) was compared with the grades obtained for each one of these items in a test. This relationship gave origin to charts that reflect clearly that students have bigger difficulties in the topic Confidence Intervals than they declare in their statements. Following is presented one of these charts:

Relationship between the students' perception about the difficulties they experienced with the topic of Confidence Intervals and the results obtained by them in the test - Table 2

Validative elements

	Have you problems		
Pass	No	Yes	Total
Yes	5	2	7
No	42	48	90
Total	47	50	97

$\chi_1^2 = 1{,}59$

C.A.= 0,093

For example, although 48% of the students claim not to have difficulty in the application of validative elements, only 8% of the total passes the item corresponding to this element of meaning.

In the analysis of the actuative elements 71% of the students consider that they don't have difficulties with the numerical calculation, but 32% only approve the items where actuative elements are evaluated.

Similar results can be observed in the study of the ostensive and extensive elements. As for the intensive elements differences are not observed between what the students say and the test results.

These conclusions are reinforced by the association coefficients (AC) and the χ^2 tests that determine the consistency between the students' perception about the difficulties they experienced with the topic of Confidence Intervals and the results obtained by them in the test, which are summarized next:

Statistical analysis - Table 3

Type of meaning Element	χ^2_{obs}	$\chi^2_{1;0,05}$	Association Coefficient	Conclusion
Actuative Elements	0,206	3,84	-0,072	Association doesn't exist
Intensive Elements	21,58	3,84	0,485	Association exists
Ostensive Elements	4,012	3,84	0,237	Association exists
Extensive Elements	6,76	3,84	0,278	Association exists
Validative Elements	1,59	3,84	0,093	Association doesn't exist

5. Conclusion

From an analysis of the box above we conclude that although there is a consistency between the students' perception of what the test results were and the actual results when the student refers to the Understanding of Theory, Understanding of Instructions, Understanding of Simbology and the Approach to Solving the Problem, which in turn are in correspondence with Intensive, Ostensive and Extensive Elements of Meaning, they don't seem to be aware of their failings as regards actuative and validative elements.

This would indicate a lack of reflection capacity linked with the prevalence of a mechanical approach to problem solving. We observed that students don't validate either the statistical concepts or their own performance. They believe they possess knowledge, but they have not apprehended its meaning.

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