Facilitating the Development of Cognitive Schemata Relating to Statistics

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1. Introduction

In recent years research on the assessment of statistical knowledge has made clear that a distinction should be made between such terms as conceptual or connected understanding of statistics (Huberty et al, 1993; Schau & Mattern, 1997), statistical reasoning ability (Chervany et al, 1977) and a general propensity to think statistically, characteristic of expert statisticians (Wild & Pfannkuch, 1999). Of these three, conceptual understanding is the most basic aspect of statistical knowledge. It concerns the ability of a student to integrate his knowledge of statistical concepts, facts and principles into a network of interrelated propositions (Huberty et al, 1993; Schau & Mattern, 1997).

From cognitive psychology, it is known that the development of such an integrated knowledge structure starts with simple propositions like definitions of concepts (e.g. 'r_{xy} is a measure of linear correlation') or principles like 'r_{xy}^2 gives the proportion of variation explained'. Such propositions are related to each other to form simple cognitive schemata – the term 'schema' denoting a meaningful organization of related knowledge items (Sternberg, 1996). At a higher level of organization these simple schemata function as cognitive units that in their turn are related into meaningful clusters of complex cognitive schemata.

As the maturation process of a student from novice to expert involves the formation of gradually more complex schemata of ever increasing generality and abstraction, various instruction technologies have been developed to stimulate the formation of such schemata (Van Merrienboer, 1997; Novak, 1998). A technique that we have been working on attempts at parcelling out the statistical theory to be taught into a finite number of constituent propositions. The students are instructed to manipulate these propositions in the course of statistical problem solving. It is thought that this manipulative activity will stimulate the development of cognitive schemata. An experiment was conducted to test this hypothesis.

2. Procedure

Based on a pilot study, a list was compiled of 90 basic propositions pertaining to descriptive statistics as taught to psychology undergraduates in Maastricht. In a subsequent experiment, 100 psychology undergraduates following the course on descriptive statistics were randomly assigned to one of four groups. The first group was a control group that received no treatment during the experiment. The other groups each attended four different sessions. Preceding each session, the students were instructed to learn a subset of the total collection of propositions. During each session, the first group received a number of statistical tasks requiring the use of the studied propositions for their solution. The second group received the same tasks, but afterwards were given a complete exposé of the way the propositions should have been used to solve the tasks. The third group likewise received the tasks, but afterwards were given a list of the propositions relating to each of the tasks, with the request of constructing an argument leading up to the solution of the different tasks. The experiment was concluded with an exam containing tasks covering the complete list of propositions.

3. Discussion

Prior to the first session of the experiment, a sizeable proportion of students withdrew from participation in the experiment. This left us with 15 subjects in the control group, and respectively 13, 13 and 10 subjects in the experimental groups. After the experiment, students in each of the experimental groups proclaimed that their participation had greatly enhanced their understanding of the material. Analysis of the data suggested that the experimental groups did better on a test requiring conceptual understanding of the material. There was no noticeable difference in performance between the groups on a test for the assessment of purely propositional knowledge.

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RESUME

La psychologie cognitive a montré que le developpement graduel d' un novice en un expert statisticien entraî ne le developpement de schemes cognitifs de plus en plus generaux et abstracts. Nous avons testé une technique didactique dont le but est la formation de tels schemes cognitifs. Le fond theoretique de cette technique et les résultats d' une expérience testant son potentiel seront traités.