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DISCUSSION. RESEARCH SKILLS: A CLOSELY CONNECTED TRIPLET OF RESEARCH AREA, RESEARCH METHODOLOGY AND STATISTICS

In the discussion document of the theme of the *IASE Round Table Conference* it is stated that: 'Statistics is an important component in the training of new researchers within masters and doctorate courses'. Indeed within many of these programs in non-statistical disciplines courses such as statistics and research methodology are included.

Winer's book (1962) is an old standard book in the biosciences, which focuses on statistical manipulation of experimental data. This book belongs to the Fisher tradition (Fisher, 1925). The book of Cook and Campbell (1979) is another old standard book well known in psychology and social sciences. Here the focus is on general methodological issues and statistical techniques are described in terms of different research designs. This book belongs to the McCall (1923) tradition with focus on the methods of securing adequate and proper data to which to apply statistical procedure.

At the end of those programs students are supposed to possess adequate research skills. It is often heard that they master these skills in an insufficient way. In addition to this lack of mastery of statistical skills by the end of programs, researchers need to update their statistics knowledge in order to keep in touch with recent developments in statistics. This line of thought leads us to consider different types of researchers and the methodological and statistical thinking skills required in the research process. The intertwining of general research methodology and statistics is illustrated in Section 4 by the different treatment of the key concept 'error'. Finally, some considerations are given concerning the place of statistics and/or general research methodology courses in student programs and instruction type used.

1. OVERVIEW OF PAPERS

Table 1 summarises the type of researchers addressed by the papers of Bishop and Talbot, Harraway, Manly, Sutherland and McRae, and Saville.

Table 1 Overview of Papers

	Bishop	Harraway	Saville
Target Populations	Students; Postgraduates	Students; Postgraduates; Professionals	Professionals
Statistics & Methodological Components	Methodological components are emphasised	Relation between statistics methods & scientific inference	Both components are stressed
Training	When required Web delivered	Special short courses Workshops Formal lectures	Workshops Projects Essential ingredients

The attention given to statistical and methodological competencies and the way the training is organised.

Bishop discusses the training of master's and doctoral level students and emphasises the methodological component; the training is web delivered and done as required. The basics of statistics are included in the background materials.

Harraway trains the three types of researchers. He organises the training in different ways: specialised short courses, workshops and formal lectures. He stresses the relationship between statistical methods and scientific inference.

Saville trains the professional researcher and organises his training in workshops and projects.

The papers by Harraway and his colleagues, Saville and Bishop and Talbot all reflect the intertwining between research area, general research methodology and statistics and discus how the training of research skills can be organised.

My comments below are organised into four topics: 1) the researcher type, 2) research skills, statistical and methodological competencies and the research process, 3) concept of 'error' in research methodology and statistics, and 4) training in research skills.

2. RESEARCHER TYPE

Three types of researchers are considered in the three papers: (1) the students, other than a doctoral student as researchers, (2) the doctoral student as researcher, and (3) the professional researcher.

The dimensions for assessment of mastering research skills are not really different for the master and doctoral students but the expectations or standards for a doctoral student are higher. Both have to deliver a research project: The first to obtain a masters degree, the second to obtain a Ph.D.. Master's students are required to activate and apply their statistical and methodological knowledge. The needs of professional researchers working at research institutes are of a different kind; here updating of their research methodology and statistical techniques are the core matter. Doctoral students are between the two, as they are required to activate and apply their knowledge and to acquire new developments in statistics as imposed by the research questions. Activating, applying and updating of statistical and methodological knowledge are core activities involved in a research process.

3. RESEARCH SKILLS

Research skills can be broadly categorised into two types (Schuyten, 1991):

1. Skills needed to read and evaluate surveys, experiments and other studies dealing with substantive problems in the research area;
2. Skills needed to do research while planning a study, analysing the data, interpreting and generalising the results. To this second category 'reporting the results' can be added (see in the different papers included in this book). Both categories of skills rely on statistical and methodological competencies.

Empirical research is generally characterised by an empirical cycle with five phases: Describing phenomena, constructing a theory, formulating hypotheses, testing hypotheses and adapting the theory. In this cycle researchers start in the real world by

collecting data, move to the theoretical world of the specific discipline and confront their findings in the theoretical world again with the data collected in the real world. In bridging the gap between the two worlds general research methodology and statistics play an important role.

Let us focus on the research process while moving from the theoretical towards the real world. Here the researcher goes from formulating (phase 3) to testing hypotheses (phase 4); the interplay between general methodological competence and statistical competence is crucial. First a conceptual framework, which results from answering the methodological questions 'why' and 'what', has to be worked out. Here there is a strong interplay of specific discipline and general research methodology. From this conceptual framework the hypotheses have to be operationalised such that the collection of data can start and the answers to the methodological questions 'where' and 'how' are given by the design. In answering the 'where' and 'how' questions researchers need knowledge about the connections between design and the forthcoming statistical analyses. The choice of statistical techniques is induced by the design.

Once the statistical analysis and interpretation of the results is done, the researcher moves again from the real world to the theoretical world by generalising the results and/or collecting new data. This generalising depends again on the design. In this description conceptual framework and design are important components in the research process. The conceptual framework links the specific discipline with general research methodology; the design links general research methodology with statistics. The conceptual framework induces the choice of the design and the design induces the choice of the statistical techniques. In this description of the research process, research methodology is strongly emphasised and statistics is seen as the servant. Nevertheless both are strongly connected. We will discuss one important key concept 'error' to illustrate this.

4. THE CONCEPT OF ERROR IN RESEARCH METHODOLOGY AND STATISTICS

Variation in the real world makes research a challenging endeavour. In danger of oversimplification we consider two types of sources of variation: an intended one -the true variation we want to study- and the non-intended one which can be split again into systematic and random error. Statistics deals with random error. The non-intended systematic variation can be reduced by more adequate operationalisation, which means appropriate instrumentation, sampling and appropriate design. Research methodology helps in avoiding systematic error; statistics helps in handling random error.

The following illustration clarifies this non-intended error in the case of the statistical technique of 'analysis of variance' applied with two different designs: a random and a block design. Suppose that we have three treatments and one dependent variable. The within variance is taken as the error variance in the calculation of the F-value. This error variance can contain a lot of unknown non-intended systematic error variance that can be taken out by using a block design. In general using more appropriate designs reduces the non-intended systematic variation. Researchers are not always fully aware of the consequences of choosing a specific design. In statistics classes the focus is on techniques and the design is subordinated. Why a particular design has been chosen is often not fully addressed. In methodology classes the focus is on the design and the appropriate statistical technique is subordinated. This brings us to the question 'how should we train people in these research skills?' such that integration of methodological and statistical competencies can be done.

5. TRAINING IN RESEARCH SKILLS

Nowadays a lot of discussion is going on in the health sciences and the social sciences about the problem-based, inductive and deductive approach of training research skills. By the inductive approach we generally mean a problem-based approach based on project-like work and co-operative work

I would like to call this 'the triplet approach' where substantive theory, research methodology issues and statistics are all three emphasised and linked. In a research problem dealing with correlation, for instance, focus is not on the statistical theory of correlation but on the consequences of using a specific instrumentation on the choice of appropriate statistical technique. A functional procedural knowledge of statistics is needed rather than an analytical, conceptual one. This approach is mainly problem driven.

By a deductive approach we mean a theoretical approach with examples and applications. This approach is driven either by statistics or by research methodology. In this approach there are usually two courses, one statistics course and one methodology course. Starting training with a triplet approach may cause a lot of problems. A deductive generic course dealing with the 'old standards' of statistics, as well as a deductive generic course dealing with the 'old standards' of research methodology provided with sufficient bridges between both is needed. Building on these two generic courses where the basics of statistics and research methodology are dealt with, research skills can be practised in a problem driven course; it is only by doing research that research skills can function in an integrated way.

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