MAKING STATISTICS MEANINGFUL: THE MERITS OF A COMPETENCE-BASED APPROACH

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The rather poor students' performances and the reluctance of students to attend courses were the motives for a project that entails the redesign of conventional statistics courses, into courses designed according to the characteristics of a competence-based approach that integrates research methods, statistics and psychology subjects into holistic authentic tasks throughout the psychology curriculum. This paper presents the findings of the first redesigned course. The competence-based course resulted, compared to the conventional course, into higher students' performance and higher scores on learning competences, attitudes and motivation.

INTRODUCTION

Traditionally the research training in the academic psychology curricula consists of a number of courses in research methods and statistics which are delivered separately and independently from each other by specialists who are not interested in clinical research applications or are indifferent to students' needs and feelings about the subject matter. Such a conventional research training practice has some profound deficiencies (Gelso, 2006). It reduces students' interests, study efforts and finally also their performance in conducting research (Garfield & Ben-Zvi, 2007).

A rather contrasting approach is advocated by educational design researchers, like Van Merriënboer (1997) who proposed the Four Component / Instructional Design (4C/ID) model for complex learning, and Lovett and Greenhouse (2000). They all stress the importance of an approach that emphasises the coordination and integration of the constituent skills from the very beginning, and stresses that students should quickly develop a holistic view of the whole task that is gradually embellished and detailed during the course of instruction. The holistic view implies that students have to grasp the necessity to align the successive steps systematically. Students should be stimulated to develop awareness of the inextricable connectedness of the subsequent steps in the process of research. So students have to be stimulated to experience and learn all the steps in the entire complete research process with all relations and connections between the theoretical, methodological, and statistical aspects.

Despite growing evidence in favour of what we label as a more competence-based approach, so far research was primarily restricted to small-scale experiments investigating limited components of this approach. This paper presents the findings of a substantial study among a large group of students attending a research course that was redesigned according to the main principles of the competence-based approach and compare the students' outcomes to the outcomes of students attending the conventional statistics course.

CHARACTERISTICS OF THE REDESIGNED RESEARCH COURSES

Table 1 provides an overview of the main characteristics of the conventional and the redesigned competence-based course, respectively. It concerns an introduction course on bachelor level that is part of the psychology curriculum of the Open University of the Netherlands that offers distance university education programs in various domains.

Table 1: Key characteristics of conventional and competence-based course

	Conventional course	Competence-based course
Number of study hours	Two service courses of each 120 hours	One research practical of 120 hours
Content in the domain of statistics	Parametric and non-parametric measures and tests	Parametric measures and tests
Learning activities	Learning texts, doing text-related sums and exercising text-related problems	Conducting surveys in ascending degree of complexity, while successively learning and applying statistical measures and tests
Materials	Text book with (at the end of each chapter) text-related sums and problems	Assignments in the domain of psychology, just-in-time information, textbook, statistical program SPSS
Environment	Traditional correspondence course	Electronic environment that offers (additional) learning materials, communication with peer students and interaction with teacher

The redesigned course combines the subjects of research methods and statistics respectively and show much more features of a real practical that allow students to work on a series of authentic research assignments. The first assignment is a worked-out example in order to reduce the 'mental' or cognitive load (Lovett & Greenhouse, 2000); the second a less worked-out assignment (fill-in) where students have to contribute more, and the final assignment is the task where students have to carry out their own research in accordance with the learning goals. The intensity of the coaching decreases and the contribution of the individual student increases (scaffolding), according to the principles of the 4C/ID) model (Van Merriënboer, 1997). Not all elements of the research process are emphasized equally in all redesigned courses. In the above course that introduce students into parametric data-analysis, the results stage of the research process is emphasized, which means that although examples and cases of the entire research processes are given, most attention is given to the data analysis. In the next course, positioned further on in the curriculum, the attention shifts to the second stage of the research process (Methods).

Our research question is*:* Does a competence-based statistics course, compared to a conventional statistics course, result into:

- more positive attitudes of students toward conducting research?
- an increase in students' motivation for research?
- higher levels of deep learning strategies and lower levels of surface learning?
- an increase in students' learning outcomes?

METHODS

Participants

Data were collected from 468 bachelor students attending the psychology bachelor at the Dutch Open University. 340 students who participated in the traditional statistics service course, and 128 students who attended the competency-based course.

Instruments

A questionnaire was administered to students, consisting primarily of Dutch translations of the SATS (Schau et al., 1995) and the MSLQ (Pintrich et al., 1991, 1993). Four aspects of *Attitude* were included: *Affects*, which reflects affective evaluations of statistics; *Cognitive Competence*, representing opinions about the cognitive skills needed to master statistics; *Value*

(statistics), which is an evaluation of the usefulness and importance of statistics and *Difficulty*, reflecting beliefs about the problems that will be met in studying statistics.

Four aspects of *Motivation*, the process whereby goal-directed activity is instigated and sustained, reflecting a dynamic process between individual and context, were included in the questionnaire. *Intrinsic Value*, the cognitive and affective reasons for being engaged in a task. *Task Value Research:* student's evaluation of the importance and usefulness of the research task, related to more distant or instrumental goals like e.g. the future profession. *Self-Efficacy*, which has been defined as 'people's judgement of their capabilities to organize and execute courses of action required to attain designated types of performance, and *Test Anxiety*, a set of phenomenological, physiological and behavioural responses that accompanies concerns about possible negative consequences or failure on an exam or similar evaluative situation.

Four *learning strategies* were included in the questionnaire. *Rehearsal*, a surface level strategy, where students focus on memorizing and recall of facts. *Elaboration*, a deeper processing strategy, where students focus on extracting meaning, summarizing, or paraphrasing. *Critical thinking*, another deeper processing strategy where students apply knowledge and domain-related criteria in a variety of situations in which problem solving, decision-making and critical evaluations are required. *Self-Regulation* is a meta-cognitive strategy, activating prior knowledge and monitoring, planning and regulating the cognitive learning strategies that are used.

In total three *learning outcomes* were included. For *Autonomy* and *Dependency* items of the Big Five Scale (Goldberg, 1990) have been used. The *statistics performance test* consisting of 7 open questions (for examples see for instance Reading, 1996) that allow students to write down their own answers.

With exception of the performance test all items of the scales used 5 points Likert scales, whereby 1 indicates ' don't agree at all' and 5 'I totally agree'. The answers and arguments on the 7 open questions in the performance test were evaluated and classified in accordance with the Structure of Observed Learning Outcomes (SOLO) taxonomy (Biggs & Collis, 1982).

Procedure

Students who were on the edge of completing their course were invited to participate in the study, thus participation was voluntary, i.e. it did not carry any rewards. The questionnaire was offered via a closed website or by letter for participants without an e-mail address. After a month students received a reminder to stimulate them to submit the questionnaire.

Initial analyse

All scales (including the statistics performance test) were analysed by the Rasch model for one dimensionality, misfits, and person and item reliability.

RESULTS

Rasch model scores of all scales range from level -4 till +4 logits with a mean of 0. A one-way between groups MANOVA was performed to investigate differences in attitude, motivation, cognitive strategies and learning outcomes. There was a statistical significant difference between the two approaches, F (15, 452) = 4.616, p = .000; Wilks' Lambda = .867 and partial eta squared = .13. Then the results for the dependent variables were considered separately.

With regard to *attitude* results show that the competency-based course resulted in more positive attitudes toward the subject of statistics, although not statistical significant for the *value* attached to statistics. The scores on the four variables that measured aspects of *motivation* indicate that the competency-based course resulted into higher levels of motivation. Students attending the competency-based course report higher levels of some *cognitive strategies*: their scores on *critical thinking* and *self-regulation* are significantly higher and their scores on *rehearsal* are significantly lower. The redesigned course did not increase the levels of *elaboration significantly*. All effects except one (rehearsal) were in the predicted direction in favour of the competence-based approach (see Table 2). Finally, the competency-based course produces more favourable *learning outcomes* with regard to *autonomy* and *statistical knowledge* but it did not result into significant lower levels of *dependency*.

Table 2: MANOVA for differences in means (in logits) between Competence-based (COMP) (n = 128) and Conventional (Conventional (n = 340) course

	M COMP	*SD* COMP	*M* Conv	*SD* Conv	*F*	*df*	Sig	*Part eta*^{2}
Attitude								
Affect	0.67	2.03	-0.13	2.12	13.264	1, 467	.000	.028
Cogn Competence	1.47	1.57	0.74	2.08	13.121	1, 467	.000	.027
Value statistics	0.65	1.48	0.42	1.76	1.687	1, 467	.195	.004
Difficulty	0.32	1.19	0.77	1.52	9.048	1, 467	.003	.019
Motivation								
Intrinsic value	2.57	3.22	1.21	3.27	16.200	1, 467	.000	.034
Task value research	1.96	1.76	1.29	1.70	14.037	1, 467	.000	.029
Sel-efficacy	1.19	1.93	0.35	2.78	9.837	1, 467	.002	.021
Test anxiety	-2.82	2.99	-2.06	3.37	5.090	1, 467	.026	.011
Cogn strategy								
Rehearsal	-0.26	2.09	-0.72	1.96	4.988	1, 467	.026	.011
Elaboration	1.85	1.87	1.69	1.76	.712	1, 467	.399	.002
Critical thinking	1.20	1.57	0.73	1.40	9.889	1, 467	.002	.021
Self-regulation	1.10	0.90	0.74	0.88	15.311	1, 467	.000	.032
Learning outcomes								
Autonomy	1.41	1.40	0.73	1.49	19.948	1, 467	.000	.041
Dependency	-0.71	1.79	-0.71	1.66	0.000	1, 467	.987	.000
Statistical knowledge	-2.21	2.09	-2.98	1.95	13.931	1, 467	.000	.029

DISCUSSION AND CONCLUSION

This paper presents the findings of the reform of the conventional statistics service courses of the bachelor psychology curriculum of the Open University of the Netherlands. The research discussed in this paper has some limitations.

Firstly, the paper limits to the very first redesigned course and compares the results of the conventional and the redesigned course. Findings seem to allow the tentative conclusion that the effects of the competency-based course are promising, but additional research is required before more firm conclusions can be drawn.

Secondly, respondents received no pre-test before attending the conventional or the redesigned course, respectively. However, respondents have usually no prior knowledge or experience in the field of statistics so it is unlikely that this caused a bias in the findings.

Thirdly, the research findings offer a rough indication but do not allow to establish more detailed observations regarding which aspects of the course are responsible for the observed effects. However, it was found to be appropriate to establish first the effects of the entire course, before examining aspects of the new approach more in detail.

Though more research work needs to be done, the findings provide support for the claim that the competence-based approach increase attitudes, motivation, application of deep learning strategies and learning outcomes in statistics. The new approach removes from statistics its perception as a discipline with a narrow, mathematically focused and anxiety-provoking perspective and nests it in a research-embedded context, related to the psychology domain that triggers student interest and commitment, and as a consequence, facilitates the study process.

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