A COMPARATIVE STUDY OF THE EFFECTS OF MOTIVATIONAL AND ATTITUDINAL FACTORS ON STUDYING STATISTICS

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This study focuses on the differential effects of motivations and attitudes on Critical Thinking and Self-Regulation. Two different samples of Psychology students of Open Universiteit Nederland have been studied. The first sample is composed of students, confronted with an integrated, research-based teaching and learning design; the second sample is composed of students, exposed to classic service courses in statistics and research methods. Results reveal that motivations significantly affect Critical Thinking and Self-Regulation and that motivations and attitudes affect learning processes and achievement in their own characteristic way. Moreover the crucial role of an integrated teaching and learning design as a significant contributor to optimal motivations, more favourable attitudes and more adequate learning strategies for studying statistics and research methods has been endorsed.

BACKGROUND

Most studies concerning statistics (service) courses in the social sciences focus on attitudes and achievement. However, in the domain of educational psychology particularly motivations are regarded as crucial contributors to the learning process (Pintrich and Schunk, 2002). In the domain of statistics education studies generally focus on attitudes, based on empirically proven relations with achievement, disregarding or neglecting motives and learning strategies. Nevertheless, Critical Thinking and Meta-Cognition are recognized as essential learning strategies for the construction of statistical literacy and statistical reasoning (Pfannkuch, 1999; Reading, 1996; Watson and Callingham, 2003). Based on an extensive literature study in the domain of education, psychology and statistics we decided to study motivations and attitudes simultaneously to clarify their relations with Critical Thinking, Meta-Cognitive Strategies and achievement in statistics and research methods. Our comprehensive study comprises four studies, and our research findings go far beyond the space at our disposal in this paper, so we will emphasize our findings concerning motivations, attitudes, Critical Thinking, Meta-Cognitive Strategies and achievement in two different learning contexts in this paper, the latter because of the endorsement of the impact and role of instructional design in educational literature.

Research Context

The School of Psychology of Open Universiteit Nederland has been challenged to develop a new curriculum for statistics, in which the content of statistics and research methods has been integrated (Van Buuren, 2006) and linked to psychological research. The goals of this new curriculum are to actively involve students in the research process and to encourage and support students in developing a research competence. Students are challenged to apply research methods and statistics simultaneously in an authentic and integrated way, just like a professional researcher does. Linking the research topics to psychology offers a profound method to trigger and develop student's interest in the fundamentals of their chosen branch of study (Eccles and Wigfield, 2002) and to promote their inquisitiveness in psychological subjects, which in its turn is supported by methodology and statistics. It took five years and ten quasi-experiments to develop a definite new curriculum. The quasi-experiments have been conducted along with the teaching of the classic, non-integrated service courses, resulting in a new curriculum that has been implemented since September 2004, providing a research context for this present study to compare students' motivations, attitudes, learning strategies and achievement in different learning contexts.

Research Questions

In this paper we will present research questions and findings concerning the following questions: "Are motivations and attitudes different psychological constructs?"; "Do motivations

and attitudes differ in their effects on learning strategies and achievement?"; "Are Critical Thinking and Self-Regulation related to achievement?"; "Do groups that are given different instructional models differ with respect to motivations, attitudes, Critical Thinking and Self-Regulation and do the motivations and attitudes in the integrated curriculum lead to better strategies and outcomes than the motivations and attitudes in the non-integrated curriculum?" Figure 1 reflects the 3P model of Biggs (2003) that has been used as basic principle for our study to clarify and emphasize the role of the teaching context, motivations, attitudes and learning strategies in learning statistics and research methods.

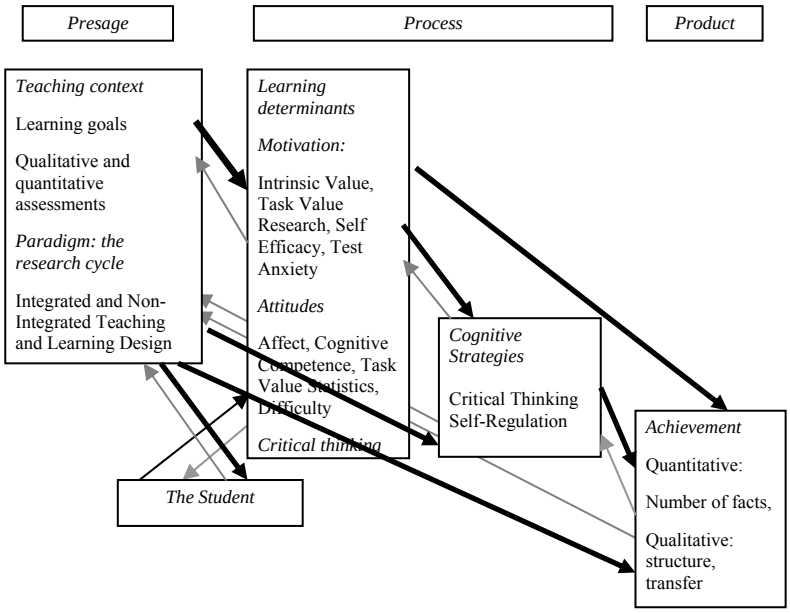

Figure 1: 3P model (Biggs, 2003; Bijker, 2006; Van Buuren, 2006)

In the Presage stage two "actors" are distinguished: the students and their characteristics and the teaching and learning context. In this paper we highlight the teaching context, activating the targeted determinants for learning activities in the Process stage. In the Process stage we distinguish motivations, attitudes, Critical Thinking and Self-Regulation. The activated determinants lead to learning outcomes, reflected in quantitative and qualitative products, analysed with the SOLO taxonomy (Structure of the Observed Learning Outcomes, Biggs and Collis, 1982).

Motivations

Pintrich *et al*. (2002) define motivation as "the process whereby goal-directed activity is instigated and sustained," reflecting a dynamic process between individual and context. In a revised Expectancy Value model (see e.g., Eccles and Wigfield, 2002). Pintrich *et al*. relate motivational dimensions to learning strategies. Biggs (2003) endorses that teaching activities and tasks have to stimulate students' interest (Renninger, Hidi and Krapp, 1992), which is related to cognitive engagement and the cognitive strategies that are used ("CSU's," Pintrich, Smith, Garcia, and McKeachie, 1991, 1993; Lewalter and Krapp, 2004).

Intrinsic Value is a mastery oriented task evaluation, characterised by positive affect and related to interest, CSU's and Self-Regulation (Pintrich *et al*., 1991, 1993). It represents the cognitive and affective reasons for being engaged in a task, reflecting knowledge, positive affect and appreciation of the task (Csikszentmihalyi, 1990; Renninger *et al*., 1992).

Task Value Research is a 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 (Eccles *et al*., 2002; Pintrich *et al*., 1991, 1993).

Test Anxiety is "a set of phenomenological, physiological and behavioural responses that accompanies concern about possible negative consequences or failure on an exam or similar evaluative situation" (Zeidner, in Pintrich *et al*., 2002). It relates to avoidance goals and occurs in specific domains, like mathematics and perhaps statistics. Test Anxiety includes a cognitive and affective component. Empirical studies have shown that the worry (cognitive) component in particular is closely linked to performance decrement (Covington, 1993).

The expectancy component in the EV model is reflected by *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" (see Pintrich *et al*., 2002). Self-Efficacy is goal-directed and related to behavioural engagement, reflected by effort and persistence. Compared with other self-concepts Self-Efficacy is the most contextual defined and domain related construct, it varies as a function of personal and environmental differences and shows little generalization across areas (Pintrich *et al*., 2002).

Based on literature in the motivational domain we can infer that motivations are intra-individual, multi-dimensional dynamic processes constituted by the individual's interactions with the environment, closely linked to cognitions (goals) and affect and that they can be consciously controlled and regulated by the individual himself. For learning processes motivations are elementary conditions to start and sustain learning activities.

Attitudes

Attitudes originate from social psychology as fundamentals for constructs like social categorisation and social identity. Attitudes mirror influences from the social environment on the individual, reflected in automatic evaluations of situations. Eagly and Chaiken (1993) define attitudes as "psychological tendencies, expressed by evaluating particular entities with some degree of favour or disfavour." They consider attitudes as well established subsystems of cognitive schemas, having a considerable impact on behavioural and affective responses, especially selective perception. Attitudes protect the ego against uncomfortable reality and organize and simplify experiences, expressing self-concept and personalised values. Socialisation processes, including academic socialisation (Donald, 2002), affect the construction of attitudes. In their impact on behaviour, attitudes are more automatic and subconscious, and are assumed to act via worn paths in subsystems of cognitive schemas. As a consequence attitudes are less flexible and less sensitive to direct cognitive regulation, because they act from an established sublevel in the cognitive schemes and show a tendency to outperform the coordinating cognitive schemes. They automatically influence series of general behaviour rather than affecting specific behaviour. Here we see an analogy with conditioned responses from behaviourism. Eagly and Chaiken (1993) consider attitudes to be related to selective perception. A heritage of behaviourism though is to neglect the information processes involved in learning. In the statistics domain attitudes toward statistics are studied and related to statistics anxiety or achievement. Anxiety negatively influences academic achievement. Schau, Stevens, Dauphinee and Del Vecchio (1995) distinguish four attitudinal dimensions, which are of interest in studying statistics: *Affect*, which reflects affective evaluations of statistics; *Cognitive Competence*, representing opinions about the cognitive skills needed to master statistics; *Task 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.

Based on literature regarding motivations and attitudes we can consider both psychological concepts as different in their qualities and effects. Motivations are multi-dimensional intra-individual concepts, goal-oriented, cognitively controlled by the individual and flexible and dynamic in their interaction with the context. They start and sustain learning processes. Motivations can be self-regulated, in contrast with attitudes, which act more or less automatically from subschema levels, surpassing the coordinating cognitive schemas and affecting perceptions. Attitudes act like conditioned evaluations and beliefs.

Critical Thinking and Self-Regulation

Critical Thinking is a constituent part of the process of constructing cognitive schemas for information processing. The structure and complexity of cognitive schemas determine

understanding (Biggs *et al*., 1982). Critical Thinking is applying knowledge and domain-related criteria in a variety of situations in which problem solving, decision-making and critical evaluations are required (Donald, 2002; Pintrich *et al*., 1991, 1993). It is a well reasoned, substantiated and questioning strategy, investigating assumptions and seeking for evidence. Critical Thinking encompasses logical thinking, problem solving and abstracting (Donald, 2002). Self-Regulation is a meta-cognitive strategy, activating prior knowledge and monitoring, planning and regulating the cognitive learning strategies that are used (Pintrich *et al*., 1991, 1993).

METHODS

Research Design

Two samples of distance students of the school of psychology are studied: a) Integrated (I): students that either participated in the quasi CSCL experiments or the newly launched curriculum since September 2004, the first part of the cyclical whole-task, research-based, integrated curriculum (Van Buuren, 2006). b) Non-integrated (NI): students in a teaching context of regular separate classic statistics and methods courses. A cross-sectional comparison of the two groups has been executed using self-report questionnaires.

Participants and Procedures

Data were collected from 468 psychology students in distance education, in two different samples (see above); 340 students participated in the non-integrated classic statistics and methods courses; 128 students have been confronted with the whole-task based teaching design. Students were invited to participate in the study via e-mail or a letter two weeks before the questionnaire was submitted. The questionnaire was offered via a closed website or by letter for participants without an e-mail address.

Measurement Instruments and Variables

Dutch translations of the MSLQ (Pintrich *et al*., 1991, 1993) and SATS (Schau *et al*., 1995) were used to assess motivations, attitudes, Critical Thinking and Self-Regulation, using 1 to 5 points Likert scales, whereby 1 indicates “I don’t agree at all” and 5 “I totally agree.” A self-developed scale for Intrinsic Value used similar Likert items. An example from this scale is “I’m completely wrapped up in doing research.” The MSLQ scale for Critical Thinking was revised and optimized, especially contextualized for statistical reasoning. An example from this revised scale is “I always focus on the quality of the measurement instruments used in different studies and check their reliability and validity.” For the included SOLO (Biggs and Collis, 1982) statistics and methods assessment, seven open questions and one closed question were developed (Van Buuren, 2006), based on the principles of the Structure of Observed Learning Outcomes (Biggs *et al*., 1982; Reading, 1996; Watson *et al*., 2003) and theories, regarding statistical literacy and statistical reasoning (Pfannkuch, 1999; Watson *et al*., 2003). All scales (including SOLO) were analysed by the Rasch model for one dimensionality, misfits, and person and item reliability, followed by Structural Equation Modelling of the Rasch scales in the 3P model. Presage variables that were studied are Intrinsic Value (IV), Task Value Research (TVR), Self Efficacy Research (SER), Test Anxiety (TA), Affect (Af), Cognitive Competence (CC), Task Value Statistics (TVS) and Difficulty (Di) (SATS, Schau *et al*., 1992; 1995). Strategies highlighted in this paper are Critical Thinking and Self-Regulation. The achievement variable presented in this study is SOLO.

Analysis

Two independent raters, using statistical and methodological criteria developed by experts, expressed in SOLO levels, simultaneously coded 620 SOLO responses. Cohen’s Kappa for the SOLO tasks was between .90 and 1.0. All scales have been Rasch modelled. In AMOS 5.0 CFA was used to test the invariance of regression paths and factor covariances across samples, in an equally split calibration and validation sample. Multi-sample structural equation modelling was used to analyze the 3P model across samples. Alpha’s for all scales were sufficient and between .62 and .92. Means differences were computed with *t*-tests and GLM multivariate analysis in SPSS 11.5 for Windows.

RESULTS

Testing for Differences in Means

The *t*-tests reveal that means of all variables are significantly higher and TA and Difficulty are significantly lower in the I-group than in the NI-group. Attitudes means are significantly more favourable in the I-group than in the NI-group, with the exception of TVS mean (SATS). SR, CT and SOLO means are significantly higher in the I-group than in the NI-group (Table 1).

Table 1: *t*-Test Process and Product variables Integrated versus Non-Integrated

	F	Sig.	*t*	df	Sig. (1-tailed)	Mean Difference	Std. Error Difference
Flow	0.65	0.42	4.02	466	0.00	1.36	0.34
TVR	0.12	0.73	3.75	466	0.00	0.67	0.18
SER	5.84	0.02	3.68	328.24	0.00	0.84	0.23
TA	1.80	0.18	-2.24	466	0.02	-0.76	0.34
Affect	0.98	0.32	3.64	466	0.00	0.79	0.22
CC	8.24	0.00	4.11	301.59	0.00	0.73	0.18
TVS	2.38	0.12	1.30	466	0.10	0.23	0.18
Difficulty	6.05	0.01	-3.35	289.75	0.00	-0.45	0.13
CT	0.68	0.41	3.14	466	0.00	0.47	0.15
SR	0.00	0.97	3.91	466	0.00	0.36	0.09
SOLO	0.35	0.56	3.73	466	0.00	0.77	0.21

Multivariate analyses show that motivational levels have significant main effects on CT, $F(1,460) = 32.37$, $p = .00$, SR: $F(1,460) = 44.23$, $p = .00$, and SOLO: $F(1,460) = 8.89$, $p = .00$. Attitudinal levels have significant main effects on CT, $F(1,460) = 5.50$, $p = .02$; SR, $F(1,460) = 4.83$, $p = .01$, and SOLO, $F(1,460) = 8.14$, $p = .02$. Design has significant main effects on SR, $F(1,460) = 7.14$, $p = .01$, and on SOLO, $F(1,460) = 7.06$, $p = .01$. None of the interactions is significant. Cohen's Kappa of motivational levels-attitudinal levels is .24.

SEM fit statistics of the constrained model are good, reflecting $\chi^2 = 52.15$, df = 43, GFI = .98, AGFI = .94, CFI = 1.00, TLI = .99 and RMSEA = .02.

In the model motivations explain all unique variance in $R^2_{(Critical\ Thinking)}$ in Integrated which is .28 and 15% unique variance of $R^2_{(Critical\ Thinking)}$, in Non-Integrated, with a total $R^2_{(Critical\ Thinking)} = .26$. Attitudes exclusively add 11% unique variance to $R^2_{(Critical\ Thinking)}$ in Non-Integrated. Motivations explain all unique variance in Self-Regulation, both in Integrated and Non-Integrated, with respective R^2's$_{(Self\text{-}Regulation)}$ of .25 and .23. Attitudes explain between 6% and 10% unique variance in $R^2_{(SOLO)}$ and Self-Regulation explains 4% unique variance in SOLO. In this sub-study there are no significant paths from Critical Thinking to SOLO in both groups.

DISCUSSION

Our first research question has been answered. Motivations are dynamically involved in the study process, while attitudes modestly affect the process. Motivations and attitudes act in different ways, answering our second research question. Attitudes particularly have their effects on achievement. All motivations, in different path patterns, affect Critical Thinking and Self-Regulation. Affect and Task Value Statistics affect Critical Thinking exclusively in Non-Integrated and do not significantly affect Self-Regulation in both groups. Attitudes significantly affect cognitive achievement, both in Integrated and Non-Integrated, in combination with Self-Regulation. Our third question partially has been answered in this sub-study, yet the answer has been provided in our comprehensive study (Bijker, 2006). In this sub-study only Self-Regulation significantly affects achievement and attitudes dominate the effects of Self-regulation in their impact on SOLO. Yet, Intrinsic Value and Task Value Research are major contributors of Critical Thinking, stressing the importance of the teaching design, as an activator of student's interest and provider of useful and important authentic research tasks. Exclusively in Integrated Task Value

Research has a significant path to Critical Thinking. This endorses our findings and is part of the answer to our last research question. The *t*-tests reveal that motivations, attitudes, strategies and achievement are significantly more positive in the I-group than in the NI group. Multivariate analyses reveal that particularly motivational levels and teaching and learning design have substantial impacts on strategies and outcomes. Our comprehensive study will reveal how integrated and motivating teaching and learning designs can optimize the impact of Critical Thinking and Self-Regulation on studying statistics and research methods.

This sub-study clarifies Biggs' basic assumption: teaching contexts affect students' motivation, attitudes and strategies and integrated, research-based teaching and learning designs can activate more appropriate strategies and facilitate and optimize learning and achievement in statistics. The new teaching context for distance learning removes statistics as a discipline from the narrow, mathematically focused and anxiety inducing perspective to a research embedded context, related to the Psychology domain (Van Buuren, 2006), which triggers student's interest and engagement, and as a consequence, facilitates learning. Results are promising!

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