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ABSTRACT

This examination of data selection preceding multivariate analysis compares results grained with "gentle" and "draconian" variable elimination. To acquire comparable results, two stages of statistical exploration into an integrated model of motivation, learning strategies, and quality of teaching were used. The goal of the paper was to select variables that were as powerful as possible and to use them to produce a new factor model, applying both standard linear (Statistical Package for the Social Sciences [SPSS]) and Bayesian (BAYDA) statistical software. The second stage of the research, planned for the future, will involve efforts to produce sensible path models related to the theory. The study of motivation, learning strategies, and teaching used research in a Finnish telecommunications company in which 156 respondents answered a questionnaire with 135 items. The statistical analyses used for variable selection are described. Research results indicate that both teaching style and subject material can influence study motivation and the use of learning strategies. Learning material can be described with respect to the degree that broad theoretical perspectives are developed, and the personal meaningfulness of the subject material or the drawing of logical conclusions from detailed evidence is emphasized. The new statistical methods described, especially the nonlinear approaches based on Bayesian networks, enable the application of statistical analysis to the study of student motivation and self-regulated learning. The SPSS syntax is attached. (Contains 19 tables, 6 figures, and 87 references.) (SLD)

Modern Modeling of Student Motivation and Self-Regulated Learning

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MODERN MODELING OF STUDENT MOTIVATION AND SELF-REGULATED LEARNING

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This paper is sequel to our long time comparison project[1] of linear and non-linear statistical methods. This time we want to examine exhaustively data selection process (part A of measurement model) preceding multivariate analysis, in our case, both factor and path analysis. Our goal is to compare results gained with 'gentle' and 'draconian' variable elimination. That path, chosen in the beginning, leads us to factor analysis and path analysis. In the end we tend to compare both solutions (model family's) with Bayesian evaluator.

To forge comparable results we present two stages (the first and the second stage) of statistical exploration into integrated theoretical model of motivation, learning strategies (Ruohotie et al. 1996, pp.201 – 212) and quality of teaching (Kautto-Koivula, 1996, p.176; 1993, p.251). Our goal is to elaborate the original model of motivation and self-regulated learning (Kautto-Koivula, 1996) with same data set but new statistical methods. We refer to the original study with word "original" and our new attempts with word "optimized" (both first and second stage).

The main goal for this paper is to select as powerful variables as possible and to use them to produce a new factor model ('first stage'). To reach the goal we apply both standard linear (SPSS [05]) and bayesian (BAYDA [03], BKD [04]) statistical software.

The word "modern" in the paper title in this first stage stands for explorative and critical use of traditional linear statistical methods (especially on part A we spent several moments on studying preliminar prerequisities for the collected data). It also represents the use of Bayesian calculations for selecting variables and explaining their relationships. (Table 1.)

The second stage, left to future study work, involves efforts to produce sensible path models confirmative to the theory with SEM programs like AMOS [02]. Models are constucted with the help of the first stage (exploratory) discriminant and factor analysis. The main purpose (and justification for the word "modern" on that second stage paper title, too) is to rank different models with bayesian software (EV) which compares applicant Bayesian Belief Networks to the reference network and predicts how many times more probable each applicant network is. We use EV on this paper to compare different variable occupations for factorial dimensions.

Table 1.
The First and Second Stage Research Plan.

Conditions for Learning

Educational effectiveness cannot be assessed solely through the quantitative results of standardized tests. Intended outcomes may also be qualitative in nature. In that case efficacy is indicated by the quality of the learner's dedication as revealed by attributes (such as autonomy and self-direction) and demonstrated by the quality of consequences (such as the ability to apply concepts learned in new situations and in novel ways). In this case, the self-concept, motivation and self-regulating ability of the learner are critical determinants of success. (Ruohotie, 2000.)

Although two learners may be equally motivated to learn they may differ in how they think about themselves, how they relate to a task and how they think about a goal. From this perspective, motivation is seen to be bound to specific cognitive processes such as information processing, metacognition and attribution. It is not to be understood, therefore, simply in quantitative terms of the effort expended or the time used to complete a task, but also in qualitative terms of what learners think about themselves, about the given task and about their performance. (Ruohotie, 1999.)

They may have quite different underlying reasons for studying. For some, learning has inherent value. For others it is a means to gain extrinsic rewards. Because the meaning of a goal can vary significantly according to the context or thought processes which it elicits for different individuals, we cannot understand motivation purely in terms of goals presented to the learner. We must also ask why they process or attend to different information sources, why they value certain goals over others, which metacognitive processes they use while studying and how they evaluate and attribute their accomplishments in different learning contexts.

Certain cognitive skills are typical of effective learners. Such learners succeed not simply because they have more knowledge, but because they have better skills for finding information and better information-processing

[1] Project NONE (Nonlinear Modeling in Social Sciences) with Henry Tirri (tirri@cs.helsinki.fi) and Tomi Silander (tsilande@cs.helsinki.fi), University of Helsinki, Finland.

strategies; that is, they have certain cognitive-motivational skills which are related to self-efficacy, attributions and self-regulation processes. (Zimmerman 1998). These skills can be developed and shaped through training in the same way as other cognitive and social skills. A learner's efficacy should, therefore, be assessed in relation to those beliefs, perceptions, interpretations and expectations which help him/her to perform independently and bind him/her to a task/studies as well as kindle belief and self confidence in learning. The efficacy of instruction should also be assessed in terms of its ability to develop, increase and stimulate specific cognitive-motivational processes.

Knowledge is constructed by individuals. Information which has been perceived only becomes usable personal knowledge when it is reprocessed and integrated into the individual's existing knowledge structures. The learner's understanding of this process directs learning by influencing strategies of knowledge acquisition and thinking. Understanding of this process also directs a teacher's manner of instruction and the expectations that the teacher has for learners.

The metacognitive or internal reflective abilities of the learner are of fundamental importance in all purposeful learning and the use and further development of cognitive skills is an integral part of the process. The pedagogical challenge is to bring the learner to recognize his/her own aims, and to see the learning process as a way of "taking control" of both external and internal circumstances. One central duty of the teacher is to awake in learners a willingness to ask why and how. The teacher is also a model for cognitive performance, a demonstration of how cognitive behaviour works. In reflective teaching the teacher is more a facilitator of learning than a distributor of knowledge.

Effective learning is not only dependent on cognitive skill. The individual's self–confidence and other personality traits also affect the extent to which new patterns and strategies of behaviour will be attempted and the degree to which the learner assumes personal responsibility and control. (Rauste–von Wright, 1986.)

Rauste–von Wright and von Wright (1991) emphasize that the conditions for learning do not really change with advancing age. "Both the learning process and the conditions for learning are by nature the same from early years to old age. Learning to learn is a lifelong process — but the earlier it is started the better the prognosis."

Motivation and Self-Regulation

There is not yet a generally accepted overall theory of motivation that defines and unites all the factors in the motivation process. Integration of the various existing theories is difficult because concepts are not clearly defined, various component phenomena are described in terms of different theories, and narrowly–defined processes and actions are used in constructing some individual theories.

In recent years researchers have increasingly turned their interest towards organizing and integrating the various theories of motivation into a unified description (see Keller, 1983; Locke, 1991). A theory of action should view individuals as fundamentally concerned with seeking knowledge of themselves and the outside world, therefore being goal-oriented and desirous of feedback (see von Wright, 1981). However, the conceptual level of cognition is limited by individual skill and dependent on volition (Binswanger, 1991), as is decision-making, or self-regulation, through which the individual considers alternatives and makes choices. Thus, an individual may avoid responsibility and act thoughtlessly or, in spite of the best intentions, make mistakes and set inappropriate goals.

Directed learning also requires the intentional use of self–reflective (metacognitive) skills. Self-reflection means, on the one hand, the ability to acquire knowledge of one's own internal (psychical) processes — such as the skill to "see" what is understood and what is not understood — and, on the other hand, the ability to control one's own internal processes in order to achieve a personal goal, or to adapt those processes to each task's demands in turn. That means, for example, to seek relevant strategies for learning and for other actions through experimentation (Rauste-von Wright, 1991, p. 13).

Free Will and Cognitive Self-Regulation

Human beings are self–aware. In other words, they have the ability to focus introspectively on their own voluntary acts. They also have the ability to make conscious decisions and choices; that is, to exercise free will. Thus, self-regulation refers to a conscious control of action as the individual attempts to achieve personal aims.

Conceptual processes are subject to assessment and change. They are not pre-determined but can be carried out correctly or incorrectly, logically or illogically. People have the free will to choose to apply their awareness and to determine the level of conceptual awareness at which they will operate. This is cognitive self-regulation.

For example, students can "attend to" or "participate in" lectures to different degrees. Some may be asleep. Some may concentrate deeply enough to develop a line of thought; that is, to respond to the material presented. Students operating at a high level of conceptual awareness process what they learn. They aim at a deeper understanding (including attempting to understand why A came before B and not the other way around), separate the essentials from the details, integrate their new knowledge with that their prior knowledge, actively evaluate the validity of the information being supplied, and pose questions to themselves on the basis of the lecture and their active, personal response to it.

Sometimes a student may feel "left out" during a lecture and unable to understand much of its content. But this is only a feeling. If, instead of concentrating, the student daydreams about other things this is still the result of a personal decision, either conscious or unconscious. A person operating at a high level of awareness is in control of his/her thoughts, aware of what they are, and can therefore decide on the most suitable mental process for the situation.

Self–Efficacy and Goal Setting

Self-efficacy affects personal goal-setting and goal commitment. It also influences performance in personal goal achievement, which in turn affects self-efficacy. For example, people who set themselves challenging goals usually have a high level of self-confidence (or self-efficacy) and achievement of their goals further enhances their self-confidence. Ability also affects both self-efficacy and goal achievement (Latham & Locke 1991). With respect to goals and performance strategies the following general comments may be made in the light of current knowledge (Latham & Locke 1991).

Specific, challenging goals generally stimulate spontaneous planning and usually result in more and higher-quality planning than "do your best" goals.

If difficult, quantitative goals are assigned, people may lower their work quality in order to achieve them, particularly if they are not confident of their ability to achieve the goals. Therefore, quality should be ensured by setting qualitative, in addition to quantitative, goals.

Social Cognitive Theory of Self-Regulation

Self-regulation is characteristic of human activity. Human beings can set their own goal levels, judge their own actions and think of ways to reward themselves. Motivation is dependent on self-regulation ability — in particular on conscious self-assertion, which allows for the analysis of one's own experience and thought processes. A person's own perception of his/her ability to cope in various situations affects behaviour, influencing, among other things, what tasks people undertake, how much effort they will put into different tasks, and how long they will continue attempting to accomplish a task which seems doomed to failure.

According to Bandura (1986), behaviour is determined by efficacy expectancy; that is, how convinced a person is that he/she can cope with a task and achieve his/her goal. Bandura distinguishes between two different expectations: (1) the perception of one's own ability to perform (efficacy expectancies), and (2) the expectations of attainable outcome (outcome expectancies). A person may be convinced that a particular behaviour will produce the result desired, but he/she may still doubt his/her own ability to cope with the task. The consequence may then be to abandon the task. (Bandura 1977, p. 193; 1982, pp. 122-123)

People use both feedback and prediction processes in order to motivate themselves; in other words, they learn from their own experiences (feedback) and strive to predict the results of their behaviour. A positive perception of one's own performance ability might affect one's motivation, but it cannot lead to the desired performance if the skills or some important capabilities are missing. If both the skills and the motivation are found in an individual, a positive perception of his/her own performance ability will strongly affect the direction of activity, the amount of effort expended in the given activity, and his/her perseverance in a stressful situation (Bandura 1977, p. 194).

One's own perception of performance ability determines how hard one tries and how long one will persist in spite of unpleasant experience and adversity. If an individual has only a little faith in his/her abilities, he/she will give up easily in the face of adversity. Interruption weakens his/her ability to cope with difficult tasks which, in turn, strengthens and reinforces his/her negative self-image (Bandura, 1977, p. 194). Before long, he/she gives in to even small obstacles and thus limits his/her opportunities to receive positive feedback from teachers and friends. Conversely, successful experiences enhance competence and one's feelings of efficacy.

People's beliefs in their own abilities (their effectiveness) affect their choices, their aims and the extent to which they make an effort to achieve goals, as well as their tolerance of setbacks and obstacles. Beliefs related to one's own effectiveness also affect self-regulation, including the interpretation and evaluation of one's own performance and the interpretation of the reasons for success or failure. If one's self-efficacy is high, one tends to regard failure as the result of lack of effort, while a lower self-assessment will result in failure being attributed to lack of skills or abilities.

The same beliefs also have an indirect effect on how strongly causal attributes explain motivation and performance levels and the degree to which social comparisons will motivate one to change one's conduct. It has been shown that the more capable people consider themselves to be, the higher the goals they will set themselves and the more committed to them they will be.

The mechanism of self-regulation operates through three sub-functions: self-monitoring of one's behaviour, its determinants and its effects; evaluation of one's behaviour in relation to personal standards and environmental circumstances; and affective self-reaction (see Bandura, 1991, for a detailed explanation). Self-regulation is also connected with the self-efficacy mechanism through thought, emotion, motivation and action.

Attribution Theory

According to the self-efficacy theory, the underlying motivators of human action are perceptions of personal control and competency. Attribution theory, on the other hand, emphasizes causal interpretations of success and failure. Attribution interpretations of behaviour (e.g. ability, luck, effort expended, difficulty of task) influence emotional reactions, achievements and motivation in different ways. This influence depends on the locus of the causality, and the stability and controllability of the attributions.

Success and failure appear to generally give rise to different causal conclusions. Success tends to be attributed to internal factors (skill, effort), while failure is attributed, although somewhat less strongly, to chance and the difficulty of the task.

Interpretations related to skills are defined by consistency of behaviour or repetition of it and by the performance of others on similar tasks. Repeated success or failure determines whether a person is "competent" or not. Results are frequently compared with the results of others, in other words social norms. If a person is successful in a task where others fail, he/she is regarded as having the necessary skills. Changes and variations in performance levels are thus influential in interpretation of the reasons for them. Interestingly, those whose performance shows success peaks are regarded as more competent than those with consistent performance — at any level.

The more often a person is successful in a task the more likely it is that this success will be regarded as due to the simplicity of the task. Correspondingly, failure will be attributed to difficulty. Chance results are likely to be regarded as resulting from lack of personal control over the task or as random variation.

Change in the pattern of school achievements is not solely dependent on the attributions of performance. A student can also be assisted in developing his/her own ability to regulate learning and to interpret results as the consequence of his/her own efforts. In order to improve self-regulation interpretations, it is essential that knowledge of self-regulated learning increases (education directed at metacognitive processes) and that strategy, effort expended and skill attributions can be distinguished from one another (Schunk 1982 and 1983).

Learning Strategies

Students use different kinds of learning strategies in their pursuit of knowledge. The strategy used is instrumental in determining what they learn.

> *Learning strategies mean relatively broad and functionally complex processes of processing information whose effects are reflected in the quantitative and qualitative characteristics of the learning process* (von Wright, Vauras & Reijonen 1979, p. 6).

Some of the most important research into the qualitative traits of learning processes was conducted at the University of Gothenburg (e.g. Marton, 1982 a, b; Marton & Svensson, 1982, Marton, et al, 1980).

Learners utilize strategies to assist in the acquisition, storage, retrieval and use of information. According to Oxford (1990, p. 8), learning strategies are specific actions taken by learners to make learning easier, faster, more enjoyable, more self-directed, more effective and more transferable to new situations.

Typically, learning strategies are connected to a certain learning situation and to the task therein. However, the strategies can be generalized to be applied outside the subject area and become a way for the individual to approach any subject area. These generalized strategies are called "styles." Information processing concepts can thus be seen as a hierarchical structure — processes required for specific types of tasks are directed and controlled by strategies, and those strategies which have been expanded beyond certain types of tasks are called "styles." (Leino & Leino, 1988, p. 50).

Tobias (1982) has also made a distinction between "microprocesses" and "macroprocesses." Microprocesses deal with primary cognitive processes; for example, the direction of interest and information coding. Macroprocesses, such as formulating summaries, taking notes, and thoughtful examination are connected to the processing of information. This distinction is similar to that Sternberg (1985) makes between performance and cognitive components.

Researchers have often limited themselves to macroprocesses and considered them, from the perspective of learning models, to be more relevant than microprocesses. Many researchers have even considered self-regulated learning to deal only with those cognitive processes which are intentional and in the learner's control. A practical limitation is, among other things, the fact that microprocesses are very difficult to measure.

In their studies, students employ a variety of methods when shaping ideas. One important distinction which can be used to classify these diverse methods is the difference between surface-directed and deep-directed learning strategies.

The Taxonomy of Learning Strategies

Many taxonomies of learning strategies have been proposed (Dansereau, 1985; Pressley, 1986; Weinstein & Mayer, 1986; Pintrich, 1988). One approach is to characterize learning strategies as relating to cognition, metacognition or resource management. Cognitive strategies help the student to codify new material and to structure knowledge. Metacognitive strategies help the student to plan, to regulate, to verify and to shape his/her own cognitive processes. Resource management strategies help the student to control available resources – time, effort and outside help – in order to cope with a task.

How does knowledge of learning strategies help to improve teaching and learning? Pintrich (1988) emphasizes the fact that personal feedback about learning strategies helps one to perceive learning in a new way. The student notices that these strategies are acquired skills and that success is not solely dependent on general intelligence. Students vary in their abilities and can excel in diverse ways. One student may shine on pencil and paper tests of knowledge while another is best suited to practical laboratory activity. Knowledge about self-regulated learning can help to explain individual strengths and to illuminate the reasons for learning difficulties.

Oxford (1990, pp. 14-22) classifies language learning strategies into six categories, three of which are termed direct and three of which are termed indirect. The three direct strategies are: memory strategies, which assist in remembering and retrieving new information; cognitive strategies, which help in understanding and developing language; and compensation strategies, which further language-usage when knowledge gaps occur. The three indirect strategies are related to management of the learning process. Metacognitive strategies help to coordinate learning processes, affective strategies help to regulate emotions, and social strategies assist in learning from others. The indirect strategies work from within to support and order learning processes such as concentration, organization, guidance, assessment, correctional coaching, encouragement and cooperation with other learners. Learners who take responsibility for their own learning, tend to enhance both their direct and indirect strategies.

Individual strategies do overlap. For example, students can assess the way in which they have learned to plan their homework. This is a metacognitive strategy that helps students regulate their own cognition. However, metacognitive self-assessment and planning often require reasoning, which in itself is a cognitive strategy. Similarly a compensation strategy such as guessing, which tries to compensate for some missing knowledge, also requires the development of socio-cultural sensitivity typically gained through social strategies. For this reason some would consider guessing to be a cognitive strategy.

Preliminary Research Results

"Motivation and Self-Regulated Learning in Vocational Education" is a research project funded by the Board of Vocational Education in Finland (Ruohotie, 1999), and focuses on answers to the following questions:

- What motivates students to pursue vocational studies and what learning strategies do they use in their studies?
- Which factors explain the differences between students' motivation and learning strategies?
- What connection is there between learning motivation, learning strategies and success in one's studies (learning outcome)?
- How can a student's motivation and learning strategies be developed so that the qualitative and quantitative criteria/goals set for learning can be met?

This research project is divided into numerous sub-projects, from which base a general understanding of the relationship between motivation, learning strategies and learning outcomes in vocational education will be developed. Here we examine a case research conducted during 1998 – 1999 in a well known Finnish telecommunication company. 156 respondents answered to a questionnaire containing 135 propositions.

The questionnaire developed by Pintrich (1995) and his work group at the University of Michigan on the basis of his motivational expectancy model measures both motivational factors and learning strategies. The questionnaire has been revised by the project group so that it is applicable to Finnish vocational education.

The measurement of motivation is based on Pintrich's motivational expectancy model which integrates and categorizes the central elements of modern motivational theories. This model includes different beliefs or expectancies; for example, perceived competence, test anxiety, perceptions of task difficulty, student's belief in his/her efficacy, control and outcome as well as expectancy of success. The student who has a strong self-image and high expectations will put more effort into his/her task and will persist longer even on a difficult task compared to the student who has low expectancy of success.

Figure 1.
The Components of Motivation
(adapted from Pintrich, 1988b)

In Figure 1, a value perspective is evident in the evaluations of the course/task value as well as in the student's goal-orientation. The course/task value has three facets: attainment value, interest value and benefit value. The attainment value refers to the degree of challenge the student anticipates. It is high if a student feels him/herself to be capable and estimates him/herself to be able to master demanding course work. Interest value alludes to a student's intrinsic interest in the contents of a certain subject. The utility value alludes either to the goal itself or to the instrumental task.

First Stage

The study of learning strategies covers cognitive and metacognitive strategies as well as the resource management scale. The organization of strategies corresponds to taxonomies of learning strategies developed by Pintrich (2000a, 2000b). Those concepts are deeply discussed in Ruohotie 2000, pp.15-18.

The aim of the first stage is to examine part A variables and choose acceptable ones for multivariate analysis. Numerous publications declare that certain attributes belong to data appropriate for multivariate analysis (eg. Tabachnick & Fidell, 1996, pp.13-17; Thompson 1999; Bradley & Schaefer, 1998, pp.79-83; Nokelainen & Ruohotie, 1999a, pp.112-114; 1999c, p. 109). First we present the original model and after that, optimized model in which we discuss more precisely factors influencing rejection of variables.

Variable Selection (Part A: Learning Motivation)

Frequency analysis were run for all variables with StatView 4.0 (original solution) and SPSS 9.0 (optimized solution). No normality assumptions were announced with original study (Kautto-Koivula, 1993, p.156).

The Original Model

There were 35 items (a1 … a35) in data file (N = 138). Scale was from 1 (disagree strongly) to 7 (Agree strongly). After casewise deletion there was no missing data (8 cases, 5 %). Table 2 indicates the area covered by the survey questionnaire used in the research project. Extrinsic goal orientation was omitted firstly due to weak loading in correlation matrix and secondly theoretical issues.

Table 2.
Construction of the Original Measurement Instrument

Figure 2.
The Original Measurement Model

Figure 2 describes the original measurement model that was used as a starting point in numerous methodologically oriented research projects in the Research Centre for Vocational Education [01].

The Optimized Model

Criterions for variable rejection are: Non-normality, SD max. half the mean, Correlation between +/- .3 - .7 and Skewness less than +/- .3 (see Munro, 1997, pp.30-48). Data examination results for the learning motivation variables (part A) are presented in Table 3.

Table 3.
Criterions for Variable Rejection
Part A, Learning Motivation

Table 3 indicates lowest rejection (9 %) in original model and highest (65 %) in criteria C (Skewness less than +/- 0.3). We joined criteria A and B because corrations rejected only two additional variables. It is interesting to see that in part A, indicated by skewness, frequensis spread to wide area which leads to massive rejection and the fourth optimized solution (standardized) out of further analysis. Rejected variables in table 3 are marked with "x" and accepted with darken area.

Table 4.
Variable Selection

Factor Analysis (Part A: Learning Motivation)

The Original Model

Factor analysis was selected in the original study to learn about the structure of variables and their main dimensions. Extraction method used was principal axis with Varimax rotation (Kautto-Koivula, 1993, p.156). Original factors are presented in Table 5 (1993, pp. 373-374).

Table 5.
The Original Factor Solution

The Optimized Model

Criteria A and B Factor Analysis

Variables in the analysis (26/35): a1, a2, a5, a6, a7, a10, a11, a12, a13, a14, a15, a17, a18, a19, a20, a22, a23, a24, a25, a26, a27, a28, a29, a30, a32, a35. Method: Factor analysis (Maximum Likelihood, Varimax rotation). Eliminated 9/35 variables due to non-normality before analysis, forced 4 factor solution for theoretically acceptable results and free solution for comparison and further model development. Total variance explained was 51,5 %. (See Table 6.)

Table 6.
Rotated Factor Matrix

After omitting variables with low loading, total variance explained was 65,7 % and reliability estimate alpha 0,88. Table 7 presents rotated factor matrix with 17 variables (9 omitted).

Table 7.
Rotated Factor Matrix
(9 variables omitted)

Factor 1: a6, a22, a23, a32, a35

Factor 2: a11, a12, a24, a29

Factor 3: a2, a7, a17, a27

Factor 4: a5, a19, a25, a28

Criteria A and B Optimized Factor solution

The original theory (see Table 2) suggested four variables for part A, but after rejecting 18 variables due to non-normality or low factor loading we came up with three factor model (Table 8). Total variance explained with new model was 67,1 %. For comparison we also performed free principal components analysis (PCA) as suggested in SPSS Inc., 1997, p.289. The solution was same as with optimized factor solution.

Table 8.
Rotated Factor Matrix
Optimized Solution

Factor 1: a12, a14, a22, a23, a32

Factor 2: a24, a29

Factor 3: a10, a27

Criteria C Factor Analysis

Variables in the analysis (9/35): a10, a12, a14, a22, a23, a24, a27, a29, a32. Extraction method used was Maximum Likelihood with Varimax rotation. Criteria C eliminated 26 out of 35 variables due to non-normality before analysis (see Table 4). First we ran (same as with criteria A and B) forced 4 factor solution for theoretically admittable results. Total variance explained was 76,6 % and alpha valued for ,79. (Table 9.)

Table 9.
Rotated Factor Matrix

Factor 1: a22, a23, a32

Factor 2: a12, a14

Factor 3: a24, a29

Factor 4: a10, a27

Criteria C Optimized Factor solution

After rejecting 26 variables (out of 35!) due to non-normality, low factor loading and skewness, we came up with three factor model (Table 10). Total variance explained with new model was 67,1 %. (Table 10.)

Table 10.
Rotated Factor Matrix

Factor 1: a12, a14, a22, a23, a32

Factor 2: a24, a29

Factor 3: a10, a27

For comparison we also performed free principal components analysis (PCA). The solution was same as with optimized factor solution (see Table 10).

Standardized Factor Solution

Standardized variables were built with symmetric transformations (10^{th} log). Total variance explained with standardized variables was 76,2 % and reliability estimate ,78. (Table 11.)

Table 11.
Rotated Factor Matrix
Final Solution with Standardized Variables

Factor 1: a11, a24, a28, a29

Factor 4: a10

Factor 3: a6, a23

Factor 2: a7, a17, a27

Comparison of Factor Solutions

We can see from Table 12 that all four factor solutions are quite close to the original, almost the same but with fewer variables. Table 13 shows both the original four factor and optimized three factor solutions. New analysis with the original data suggests the second factor (MO 2: Nervousness in examinations / Cognitive Conflict) to be omitted.

Table 12.
Comparison of Factor Solutions

Table 13.
Comparison of the Original and Optimized Factor Solution.

Extracting Bayesian Belief Network's from part A

We applied BKD (Bayesian Knowledge Discoverer 1.0β) computer program[2] to parts A and C of the questionnaire to find out possible relationships amongst variables. The search method used was "greedy search". Figure 3 presents extracted Bayesian Belief Network from part A.

Figure 3.
Bayesian Belief Network extracted from part A.

We can see from Figure 3 that only four variables predict each others behaviour. This is far less than the most optimistic (original solution, 22 variables) or skepticist (criteria C, 9 variables) solutions proposed.

First Stage Research Results

Based on research evidence, it appears that both teaching style and subject material can influence study motivation and the use of learning strategies. Teaching strategies can be described according to Entwistle's taxonomy. Learning material can be described with respect to the degree that broad theoretical perspectives are developed and the personal meaningfulness of the subject material or the drawing of logical conclusions from detailed evidence is emphasized (Entwistle, et al, 1979, p. 377). It is also apparent that evaluation (examination questions) influences the use of learning strategies — both beforehand and in the long run when the student realizes what kind of answers are expected (see, e.g., Laurillard 1979, p. 407). An educational institution can be judged by, among other things, the degree to which it rewards short-term memorization at the expense of broad concept development. The most important function of a test which measures learning outcomes is to test how students have understood the content material and how they can apply their knowledge (see Marton et al 1980, 108). Examinations should be designed to reveal the difficulties that students have encountered and any deficiency in previously acquired knowledge and skills. This is one of the important developing areas in education. (Gröhn, 1984, p. 56).

Interest in the processing of information and the study of self-regulated learning has begun to cause a shift in emphasis from the traditional evaluation of learning success to the critical examination of qualitative change. Research results support the fact that strategies presupposing deep processing lead to superior learning with longer lasting effects than other strategies such as the memorization of large bodies of knowledge (Pask, 1976; Svensson 1976; Marton & Säljö 1976; Entwistle 1981; Vauras & von Wright 1981; Gröhn 1984, 33). On the other hand, there is also empirical support for the claim that good learning outcomes can result from similar tasks using several different strategies (Biggs 1973). Strategies themselves should not be labelled as good or poor ways of learning since the relative efficacy of different strategies depends upon the subject and the educational level. The nature of the learning process changes as the student's knowledge increases and his/her instructional schemes are organized. Subjects themselves differ in the manner in which they structure knowledge and in the degree to which a student can construct the structure independently on the basis of familiar everyday life experiences (von Wright et al 1979, p. 56). Ropo (1984, p. 127) emphasizes that the utility and efficacy of a learning style or strategy is always relative and dependent upon what kind of criteria for learning are set in the school.

[2] BKD is developed by M. Ramoni and P. Sebastian at the Knowledge Media Institute, The Open University, England (email: bkd@open.ac.uk).

Efficient study presupposes that a student has the ability to change learning strategies as required by the situation. Nisbet speaks of a seventh sense and of "metacognition," by which he means the conscious and selective use of cognitive processes (Nisbet & Shucksmith 1984).

Our new three factor model for part A is acceptable when examined through our theoretical background knowledge. Items like "My main goal is to succeed in my current studies" (a12) and "If possible, I want to do better than my fellow students" (a14) are not easy to connect to factor named "Nervousness in Examinations".

Part B: Learning and Resource Management Strategies

Part B (N=138) consists of 50 items (b36 ... b85) with scale from 1 to 7 (agree strongly). There is no missing data due to casewise deletion (9 cases). A five factor solution (Table 14) is reported. Seven variables are omitted due to non-normality and low factor loadings. (Kautto-Koivula. 1993.)

Table 14.
Five Factor Solution of Part B (Learning and Resource Management Strategies)

Factor 1: b36, b37, b45, b46, b48, b58, b61, b65, b66, b68, b73, b80, b82, b83

Factor 2: b53, b63, b67, b71, b76

Factor 3: b40, b42, b43, b51, b55, b57, b59, b68, b75, b85

Factor 4: b41, b52, b56, b64, b69, b74, b77, b78, b81, b84

Factor 5: b44, b49, b72, b79

Part C: Effectiveness of Teaching

Original solution

Part C (N=138) consists of 37 items (c1 … c35, c42, c43) with scale from 1 to 7 (agree strongly). There is no missing data due to casewise deletion (9 cases). A one factor solution is reported. Two variables are omitted due to low factor loadings (Kautto-Koivula. 1993).

Factor 1: c1, c2, c3, c4, c5, c7, c8, c9, c10, c11, c13, ... , c35, c42, c43

Optimized Solution

Three factor solution (Maximum Likelihood, Varimax rotation) was found with 14 variables (23 omitted due to low loadings on factors). Total variance explained is 63 %. (Table 15.)

Table 15.
Rotated Factor Matrix
Optimized Solution

Extracting Bayesian Belief Network's from part C

The search method with BKD for part C was also "greedy search". Figure 4 presents extracted Bayesian Belief Network from part C.

Figure 4.
Bayesian Belief Network extracted from part C.

Eight variables were connected in part C according to BKD. It is interesting to see that all of those eight were part of the original one factor solution, but only five were same as in optimized solution (Table 15.)

Influence of training (Affective Learning Outcome)

Affective outcome (Experimental Expansion) is measured as one dimensional factor (AFF_LO). Scale of this item varies from 1 to 5 (agree strongly). (Table 16.)

Table16.
Affective Outcome (AFF_LO)

Training programme (Cognitive Learning Outcome)

Cognitive outcome (Success in studies) is measured with one variable (CO_LO). Scale varies from 1 to 5 (extremely well). (Table 17.)

Table 17.
Cognitive Outcome (CO_LO)

Selecting Variables with BAYDA

At this point it is interesting to see if Bayesian variable selector (BAYDA = Bayesian Discriminant Analysis) can pick the same variables than original and optimized solutions given our outcome factors (affective [aff_lo] and cognitive [co_lo] outcome) as classification variables. See Figure 5 for screen shots from BAYDA during variable selection. Table 18 contains recapitulation of variables selected with different methods.

Table 18.
Recapitulation of Variable Selection in Part A

Second Stage Preliminar Research Results

Figure 5.
The Second Stage Original Model

On Figure 5 we see that learning motivation has an affect on teaching quality. A teacher should be familiar with the kind of study style his/her teaching style calls for or inherently supports. Instruction should assist students in developing flexibility in their study habits and train them to use diverse strategies according to the learning situation (Entwistle 1981, 262-269; Derry & Murphy 1986; Pintrich 1988; Weinstein & Mayer 1986). Improvement in learning abilities is in itself an important teaching goal.

Self-direction by the learner can, of course, be developed. Candy (1991, pp. 318–342), among others, has cast light on strategies which teachers can use for this purpose. The following are some of the tactics which teachers can use to improve self-direction.

Exploitation of Pre-existing Cognitive Structures: New information is understood in terms of previously developed cognitive structures. Learning should be seen more as a qualitative change in the learner's way of thinking and acting than as a quantitative accretion to the store of knowledge. The teacher cannot afford to ignore the range of conceptions and thoughts brought by the learners to the learning situation. They should be drawn out and used as a basis for the instruction.

Encouragement of Deep Processing: Learners should distinguish between surface-level and deep-level processing in their learning and be encouraged to use strategies which lead towards the latter. Such strategies include metacognitive awareness and critical thinking.

Critical Thinking: A prerequisite for self-direction is the ability to think logically, critically and analytically. The responsibility of the teacher is to give examples of critical thinking and to create situations in which the learners are encouraged to develop and practice this by analysis and criticism of written and spoken statements.

Reading Skills: Every subject has its own vocabulary, written form and type of presentation. The teacher must adopt and teach strategies appropriate to the learning of the specific subject which also optimize the learner's learning process.

Active Engagement: A self-directed learner must have the ability to monitor progress and understanding. It is necessary to review and question the material learned, to compare new data with what has been learned and ensure that the new material is understandable and internally consistent. The teacher should model this behaviour by questioning ideas and by leading learners in discussion as well as by bringing forth various opinions and points of view.

Creation of a Supportive Environment: In an environment of trust and collaboration learners are prepared to experiment and to try new ways of thinking and acting without fear of ridicule.

An understanding of the way in which learners process information is also important in the development of teaching material. Pask and Scott (1972) showed that learners performed best when presented with material composed according to their own way of thinking. It is also important to consider what construction and presentation of the material will best promote deep-level processing.

In the last few years, the learning strategies concept has been extended to diverse cognitive processes. The result has been taxonomies of learning strategies; for example, the division into cognitive, metacognitive and resource management strategies (see, e.g., Pintrich 1988). Different kinds of motivational components have been combined with cognitive models because acquisition of knowledge, critical thinking, problem solving, application of knowledge into new situations, and so forth, always require motivation as well.

It is often assumed, incorrectly, that a well-organized training programme will be intrinsically motivating. Keller and Kopp (1987) emphasize that no training programme can be effective unless it also attends to the trainee's motivation. In fact, the motivational and cognitive aspects of a programme may be difficult to distinguish. Feedback, for example, serves not only the primary purpose of informing but also of motivating. Similarly, some motivational strategies, such as putting people at ease and creating a goal-oriented atmosphere also support cognitive functions.

Based on his analysis of training programmes, Keller (1983) suggested the use of "motivational design strategies," which he grouped into four categories: interest, relevance, expectancy and satisfaction. Subsequently, Keller and Kopp (1987) changed the "interest" category to "attention" and the "expectancy" category to "confidence." The result is referred to as the ARCS model (attention, relevance, confidence and satisfaction). While Keller's original version consisted of 17 strategies, this is reduced to 12 in the later version.

Both models address such issues as how to get and direct the trainee's attention and how to arouse and maintain motivation during the training programme. The teaching approach provides explicitly for getting the trainee's attention, establishing the relevance of the training to the trainee's wider goals, giving the trainee sufficient confidence to engage in the training and rewarding the outcome of a trainee's efforts. These purposes must be considered right from the initial planning stages of the programme.

Ultimately, motivation always finds its spark in the individual's own experience. Students should feel that the lesson and the information contained therein are personally relevant (psychologically meaningful) in order to activate the students' intellectual capabilities to process; that is, to help students to find a purpose for school in terms of everyday tasks and achievements. Olkinuora and Lehtinen (1984) see psychological meaningfulness for attending school to be based particularly on the fact that a student sees his/her present attendance at school as serving both academic and vocational long-term goals. However, relevance does not necessarily guarantee either a successful outcome or enjoyment of the process itself. It motivates and helps one to concentrate in a task-oriented manner, creating in this way the possibility to find meaningfulness or significance, but the learner must also have the necessary cognitive structures, concepts and schemes in order to find meaning and understand the value of the activity.

Bayesian Belief Network Comparison

The computer program used in this analysis is a little java-made software called EV (EVidence)[3]. EV is accessible via character command line interface called CEV, which takes the data and both reference and applicant Bayesian Belief Networks (later BBN) as input. Program produces comparison of networks as output.

The software compares applicant networks to the reference network and predicts how many times more probable each applicant network is. The EV program predicts the probability of the Bayesian network structure by calculating marginal likelihood's (1)

$$P(D \mid M) = \prod_{i=1}^{n} \prod_{j=1}^{q_i} \frac{\Gamma(N'_{ij})}{\Gamma(N'_{ij} + N_{ij})} \prod_{k=1}^{r_i} \frac{\Gamma(N'_{ijk} + N_{ijk})}{\Gamma(N'_{ijk})} \qquad (1)$$

logarithm called Bayesian Dirichlet score (see Tirri, 1997; Myllymäki & Tirri, 1998, 63) and the comparison between the networks is made with a posteori probabilities.

[3] To get more information about the software, contact T. Silander at The CoSCo Research Group, the University of Helsinki, Finland (email: cosco@cs.helsinki.fi).

After extracting Bayesian Belief Networks with different methodological prerequisites (see p. 7-8 in this paper) we compared them with EV. Following results are experimental in nature and thus ment to interpreted with caution.

Table 19 presents comparison of the original and free (decided by software) Bayesian Belief Network's.

Table 19.
Comparison of Bayesian Belief Networks from Part A and C.

Conclusion

Strategic behaviour in this paper has been regarded as the deliberate application of skills and knowledge in goal-oriented study. Motivation is considered to be a prerequisite for strategic behaviour. The development of learning strategies should be connected to the practice of self-control and self-regulation strategies (study plan, organization of knowledge, goal setting, time management) as well as to the changing of values and beliefs; in other words, the improvement of the motivational base.

Based on research evidence, it appears that both teaching style and subject material can influence study motivation and the use of learning strategies. Learning material can be described with respect to the degree that broad theoretical perspectives are developed and the personal meaningfulness of the subject material or the drawing of logical conclusions from detailed evidence is emphasized.

New statistical methods available today, especially nonlinear approaches based on Bayesian networks, enable applying of statistical analysis which bring new perspectives to a study of student motivation and self-regulated learning.

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[05] SPSS Inc.: http://www.spss.com

TABLES

TABLE 1. First and second stage research plan.

		FIRST STAGE					SECOND STAGE	
		VARIABLE SELECTION			FACTOR ANALYSIS		PATH MODEL	
		A. Motivation (MO)	B. Learning Strategies (ST)	C. Effectiveness of Teaching (OP)	Original Model	Optimized Model	SEM	Comparison
LINEAR	Original data (Normality)	x	x	x	x		x	x
	Criteria A and B (SD. r)	x	x	x	x	x	x	x
	Criteria C (Skewness)	x	x	x	x	x	x	x
	Standardized variables (10log)	x			x		x	x
BAYESIAN	BAYDA (Variable selection)	x	x	x				
	BKD (Network structure)	x	x	x				
	EV (Network Comparison)							x

TABLE 2. Construction of the Measurement Instrument.

TARGET OF MEASUREMENT	THEORETICAL ANALYSIS OF MEASUREMENT INSTRUMENT		ORIGINAL DIMENSIONS (FACTOR ANALYSIS)
PART A MOTIVATIONAL SCALE	VALUE COMPONENTS	Intrinsic Goal Orientation [Mo1a] Task Value of Learning [Mo1c]	**MO1** Expectations of Success **MO2** Nervousness in Examinations / Cognitive Conflict **MO3** Meaningfulness of Studies **MO4** Self-efficacy
	EXPECTANCY COMPONENTS	Intrinsic Control Beliefs [Mo2aS] Extrinsic Control Beliefs [Mo2aU] Self-efficacy [Mo2b] Expectancy for Success [Mo2c]	
	AFFECTIVE COMPONENTS	Test Anxiety and Self-Worth [Mo3a]	
PART B COGNITIVE SCALE	COGNITIVE STRATEGIES	Rehearsal Strategy [Str1] Elaboration Strategy [Str2] Organization Strategy [Str3] Critical Thinking Strategy [Str4]	**ST1** Metacognitive Skills **ST2** Note-taking **ST3** Deepening and Repetition of What has been Learned
	METACOGNITIVE STRATEGIES [Str 5]	Planning Activities Monitoring Activities Regulating Strategy	
	RESOURCE MANAGEMENT STRATEGIES	Time and Study Environment Management Strategy [Res1] Effort Regulation Strategy [Res2] Peer Learning Strategy [Res3] Help Seeking Strategy [Res4]	**RE1** Resource Management Skills **RE2** Resorting to the Help of Others
PART C EFFECTIVENESS OF TEACHING	TEACHING QUALITY	Reflection Based Teaching [Teach1] Teacher Support [Teach2] Total Evaluation of the Quality of Teaching [Teach3]	**OP1** Effectiveness of Teaching
LEARNING OUTCOMES	**Influence of Training**	Experimental Expansion [AFF_LO]	Affective Learning Outcomes
	Training Program	Success in Studies [CO_LO]	Cognitive Learning Outcomes

TABLE 3. Criterions for Variable Rejection (Part A).

		VARIABLES (N)	
	CRITERIA	**ACCEPTED**	**REJECTED (%)**
Original	Non-normality	32	3 (9)
A	SD max. half the mean	26	9 (35)
B	Correlation between +/- .3 - .7	24	11 (46)
C	Skewness less than +/- .3	9	26 (65)
Standardized	Non-normality	10	25 (60)

TABLE 4. Variable Selection (Part A).

								OPTIMIZED SOLUTIONS			
								1		2	3
	Rev	N	Min	Max	Mean	SD	Skewness	Criteria A (SD)	Criteria B (r)	Criteria C (Skewness)	Standardized
A1		138	3	7	5,65	1,06	-0,61			x	x
A2		138	3	7	6,25	0,86	-1,35			x	x
A3		138	1	6	1,96	1,16	1,38	x		x	x
A4		138	1	7	2,43	1,35	1,14	x		x	x
A5		138	1	7	5,60	1,13	-1,10			x	x
A6		138	3	7	5,66	1,06	-0,32			x	
A7		138	1	7	4,63	1,67	-0,41			x	
A8		138	1	7	2,93	1,37	0,31	x		x	x
A9		138	1	7	3,17	1,72	0,48	x		x	x
A10		138	1	7	4,41	1,63	-0,18				
A11		138	1	7	4,56	1,30	-0,37			x	
A12		138	1	7	4,14	1,46	-0,26				
A13		138	1	7	6,21	1,07	-2,06			x	x
A14		138	1	7	3,51	1,67	0,00				x
A15		138	1	7	3,04	1,44	0,53		x	x	x
A16		138	1	6	2,08	1,22	1,43	x		x	x
A17		138	1	7	4,52	1,67	-0,37			x	
A18		138	1	7	5,45	1,33	-1,06			x	x
A19		138	1	7	5,06	1,15	-0,52			x	x
A20		138	2	7	5,79	1,17	-0,92			x	x
A21	x	138	1	6	2,75	1,44	0,64	x		x	x
A22		138	1	7	3,51	1,63	0,28				
A23		138	2	7	4,54	1,29	0,00				
A24		138	1	7	4,13	1,57	-0,13				
A25		138	2	7	5,67	1,16	-0,94			x	x
A26		138	2	7	5,53	1,23	-0,79			x	x
A27		138	1	7	4,49	1,59	-0,14				
A28		138	1	7	4,68	1,10	-0,40			x	
A29		138	2	7	4,62	1,30	-0,18				
A30		138	1	7	3,92	1,36	-0,21		x		
A31	x	138	1	6	2,20	1,38	1,31	x		x	x
A32		138	1	7	4,98	1,32	-0,27				x
A33		138	1	7	2,71	1,26	0,63	x	x	x	x
A34		138	1	7	3,28	1,69	0,24	x			x
A35		138	1	7	4,91	1,38	-0,53			x	x

TABLE 5. The Original Factor solution for Part A (Learning Motivation).

Factor 1	Expectations of Success	a6, a8, a12, a14, a22 ,a23, a34, a35
Factor 2	Nervousness in examinations	a3, a4, a9, a15, a16, a21, a31
Factor 3	Meaningfulness of studies	a5, a11, a19, a24, a25, a28, a29
Factor 4	Learner's own perception of him/herself as a learner (self-efficacy)	a1, a2, a7, a10, a17, a18, a20, a26, a27, a32

TABLE 6. Rotated Factor Matrix.

	FACTOR			
	1	2	3	4
~~A1~~	~~,206~~	~~,351~~	~~,098~~	~~,394~~
A2	,347	,453	,125	,191
A5	,728	,052	,084	-,131
A6	,368	,309	,556	-,006
A7	,148	,886	,189	,107
~~A10~~	~~-,026~~	~~,172~~	~~,112~~	~~,250~~
A11	,488	,188	,155	,540
A12	,067	,182	,416	,438
~~A13~~	~~,307~~	~~,154~~	~~,146~~	~~,225~~
~~A14~~	~~-,017~~	~~,223~~	~~,311~~	~~,258~~
~~A15~~	~~,094~~	~~,065~~	~~-,189~~	~~,190~~
A17	,110	,828	,234	,178
~~A18~~	~~,124~~	~~,336~~	~~,065~~	~~,420~~
A19	,737	,038	-,035	,271
~~A20~~	~~,298~~	~~,376~~	~~,116~~	~~,142~~
A22	,181	,387	,514	,306
A23	,097	,223	,909	,096
A24	,330	,067	,166	,642
A25	,553	,258	,129	-,144
~~A26~~	~~,197~~	~~,112~~	~~,005~~	~~,189~~
A27	,004	,498	,018	-,012
A28	,645	,036	,176	,153
A29	,580	,058	,197	,534
~~A30~~	~~-,104~~	~~-,093~~	~~,046~~	~~,264~~
A32	,167	,373	,527	,377
A35	,237	-,044	,538	,141

Extraction Method: Maximum Likelihood.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 14 iterations.

TABLE 7. Rotated Factor Matrix

	FACTOR			
	1	**2**	**3**	**4**
A2	,152	,244	**,428**	,284
A5	,083	,106	,039	**,761**
A6	**,568**	,082	,290	,371
A7	,198	,135	**,912**	,125
A11	,167	**,701**	,186	,281
A12	,419	**,442**	,184	-,061
A17	,263	,190	**,809**	,063
A19	-,023	,479	,028	**,610**
A22	**,531**	,321	,384	,094
A23	**,907**	,102	,207	,066
A24	,189	**,698**	,071	,116
A25	,138	,039	,238	**,547**
A27	,018	-,023	**,485**	,033
A28	,187	,349	,026	**,553**
A29	,205	**,715**	,066	,372
A32	**,551**	,390	,358	,025
A35	**,551**	,164	-,050	,200

Extraction Method: Maximum Likelihood.

Rotation Method: Varimax with Kaiser Normalization.

Rotation converged in 6 iterations.

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TABLE 8. Rotated Factor Matrix (Optimized Factor Solution).

	FACTOR		
	1	2	3
A10	,072	,119	,813
A12	,498	,368	,074
A14	,392	,135	,309
A22	,630	,334	,096
A23	,887	,105	,067
A24	,205	,741	,098
A27	,109	-,007	,517
A29	,253	,704	,024
A32	,610	,343	,276

Extraction Method: Maximum Likelihood.

Rotation Method: Varimax with Kaiser Normalization.

Rotation converged in 5 iterations.

TABLE 9. Rotated Factor Matrix.

	FACTOR			
	MO1	MO2	MO3	MO4
	1	2	3	4
A10	,064	,091	,130	,683
A12	,293	,690	,343	-,024
A14	,177	,719	,051	,306
A22	,539	,274	,339	,109
A23	,899	,243	,122	,043
A24	,152	,158	,705	,072
A27	,082	,072	-,012	,602
A29	,204	,093	,740	,023
A32	,586	,103	,408	,295

Extraction Method: Maximum Likelihood.

Rotation Method: Varimax with Kaiser Normalization.

Rotation converged in 5 iterations.

TABLE 10. Rotated Factor Matrix.

	FACTOR		
	1	2	3
A10	,072	,119	,813
A12	,498	,368	,074
A14	,392	,135	,309
A22	,630	,334	,096
A23	,887	,105	,067
A24	,205	,741	,098
A27	,109	-,007	,517
A29	,253	,704	,024
A32	,610	,343	,276

Extraction Method: Maximum Likelihood.

Rotation Method: Varimax with Kaiser Normalization.

Rotation converged in 5 iterations.

TABLE 11. Rotated Factor Matrix.

	FACTOR			
	1	2	3	4
LOG_A6	,161	,185	**,822**	,127
LOG_A7	,170	**,916**	,204	,021
LOG_A10	,109	,046	,111	**,941**
LOG_A11	**,671**	,286	,151	,012
LOG_A17	,139	**,816**	,247	,015
LOG_A23	,187	,186	**,639**	-,010
LOG_A24	**,681**	,095	,046	,133
LOG_A27	,034	**,468**	-,026	,388
LOG_A28	**,470**	-,014	,395	,036
LOG_A29	**,849**	,041	,237	,003

Extraction Method: Maximum Likelihood.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 5 iterations.

TABLE 12. Comparison of First Stage Factor Solutions (Part A).

MO1 EXPECTATIONS OF SUCCESS	
Original	a6, a8, a12, a14, a22, a23, a34, a35
Criteria A and B **FA 1 / PC 1**	a6, a22, a23, a32, a35
Criteria C **FA 1 / PC 1**	a22, a23, a32
Standardized **FA 3**	a6, a23
MO2 NERVOUSNESS IN EXAMINATIONS (ORIGINAL FACTOR) / NEED FOR EFFICACY	
Original	a3, a4, a9, a15, a16, a21, a31
Criteria A and B **FA 2 / PC 2**	a11, a12, a24, a29
Criteria C **FA 2 / PC 2**	a12, a14
Standardized **FA 4**	a10
MO3 MEANINGFULNESS OF STUDIES	
Original	a5, a11, a19, a24, a25, a28, a29
Criteria A and B **FA 4 / PC 4**	a5, a19, a25, a28
Criteria C **FA 3 / PC 3**	a24, a29
Standardized **FA 1**	a11, a24, a28, a29
MO4 LEARNER'S OWN PERCEPTION OF HIM/HERSELF AS A LEARNER (SELF-EFFICACY)	
Original	a1, a2, a7, a10, a17, a18, a20, a26, a27, a32
Criteria A and B **FA 3 / PC 3**	a2, a7, a17, a27
Criteria C **FA 4 / PC 4**	a10, a27
Standardized **FA 2**	a7, a17, a27

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TABLE 13. Comparison of the Original and Optimized Factor Solution.

PART A: MOTIVATIONAL SCALE			
	Theoretical Analysis of Measurement Instrument	**Original Dimensions** (4 Factor Solution)	**Optimized Dimensions** (3 Factor Solution)
VALUE COMPONENTS	Intrinsic Goal Orientation [Mo1a] Task Value of Learning [Mo1c]	**MO1** Expectations of Success **MO2** Nervousness in examinations / Cognitive Conflict **MO3** Meaningfulness of Studies **MO4** Self-efficacy	**MO1** Expectations of Success **MO2** Meaningfulness of Studies **MO3** Self-efficacy
EXPECTANCY COMPONENTS	Intrinsic Control Beliefs [Mo2aS] Extrinsic Control Beliefs [Mo2aU] Self-efficacy [Mo2b] Expectancy for Success [Mo2c]		
AFFECTIVE COMPONENTS	Test Anxiety and Self-Worth [Mo3a]		

TABLE 14. Five Factor Solution of Part B (Learning and Resource Management Strategies)

FACTOR	DESCRIPTION	VARIABLES
St1	Metacognitive skills	b36, b37, b45, b46, b48, b58, b61, b65, b66, b68, b73, b80, b82, b83
St2	Note-taking	b53, b63, b67, b71, b76
St3	Meaningfulness of studies	b40, b42, b43, b51, b55, b57, b59, b68, b75, b85
Re1	Resource management skills	b41, b52, b56, b64, b69, b74, b77, b78, b81, b84
Re2	Resorting to the help of others	b44, b49, b72, b79

TABLE 15. Rotated Factor Matrix, Optimized Solution.

	FACTOR		
	1	**2**	**3**
C1	0,242	0,198	**0,633**
C2	**0,614**	0,208	0,209
C3	0,322	**0,641**	0,141
C4	**0,703**	0,162	0,172
C10	**0,899**	0,110	0,115
C11	**0,621**	0,323	0,234
C12	0,099	**0,426**	0,128
C18	0,236	0,212	**0,651**
C19	0,165	0,188	**0,746**
C22	0,258	**0,744**	0,223
C24	0,119	**0,613**	0,268
C31	**0,438**	0,266	0,140
C32	0,260	**0,865**	0,101
C43	**0,627**	0,299	0,366

Extraction Method: Maximum Likelihood. Rotation Method: Varimax with Kaiser Normalization.

Rotation converged in 6 iterations.

TABLE 16. Affective Learning Outcome (AFF_LO)

AFFECTIVE OUTCOME (EXPERIMENTAL EXPANSION)		
Original variables	31.2	I have gained courage and self-confidence in my work
	31.3	I have noticed that I am more respected in my work
	31.5	I have been assigned new, more demanding tasks
	31.8	I have received new meaning and goals into my life
	31.14	Conflicts at home have increasec
	31.16	I have made new friends through my studies
	31.21	It gives me great pleasure to realise that I am still able to learn new things
	31.25	Studies have made my life more active
	31.29	I have come to realise that even the most difficult matters can be learned
	31.30	My professional frame of reference has clearly expanded
	31.32	Training has substantially increased my contacts with other experts in my field

TABLE 17. Cognitive Learning Outcome (CO_LO)

COGNITIVE OUTCOME (SUCCESS IN STUDIES)		
Original variable	CO_LO	How have you succeeded in your studies?

TABLE 18. Recapitulation of Variable Selection in part A.

VARIABLES SELECTED	ORIGINAL	CRITERIA A, B	BKD	BAYDA
Cognitive Outcome [CO_LO]	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A14, A15, A16, A17, A18, A19, A20, A21, A22, A23, A24, A25, A26, A27, A28, A29, A31, A32, A34, A35	A2, A5, A6, A7, a11, A12, A17, A22, A23, A24, A25, A27, A28, A29, A32, A35	A7, A11, A17, A29	A3, A5, A8, A9, A10, A12, A15, A16, A17, A19, A21, A23, A24, A25, A26, A27, A28, A30, A33, A34, A35.
Affective Outcome [AFF_LO]				A6, A7, A8, A9, A10, A11, A12, A14, A15, A16, A17, A18, A19, A20, A21, A22, A23, A24, A25, A26, A27, A30, A31, A33, A34, A35

TABLE 19. Comparison of Bayesian Belief Networks from Part A and C.

TARGET OF MEASUREMENT	VARIABLE RELATIONSHIPS		
	ORIGINAL	OPTIMIZED	FREE (BKD)
PART A Learning Motivation	1	$1 \times 6,3 \times 10^{34}$	$1 \times 5,6 \times 10^{26}$
PART C Teaching Quality	1	1 x 835	$1 \times 4,9 \times 10^{15}$

FIGURES

FIGURE 1. The Components of Motivation.

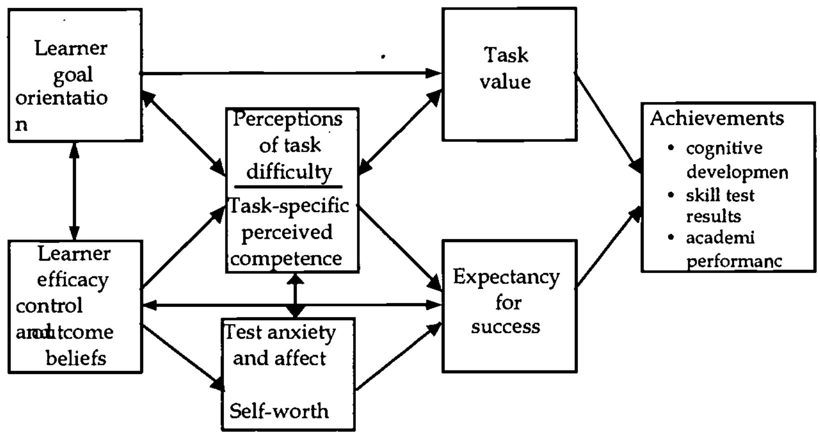

FIGURE 2. The Original Measurement Model.

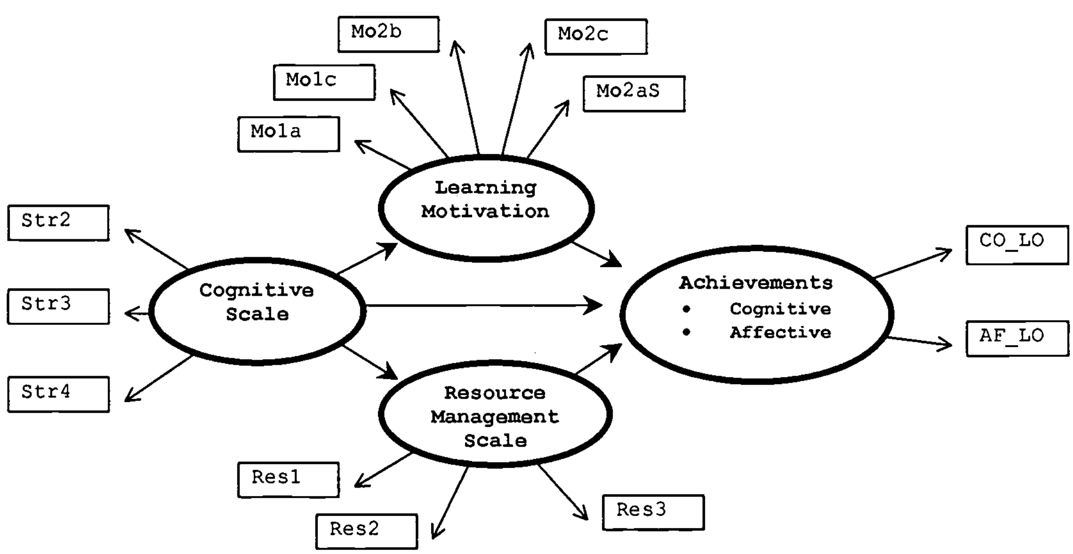

FIGURE 3. Bayesian Belief Network extracted from part A.

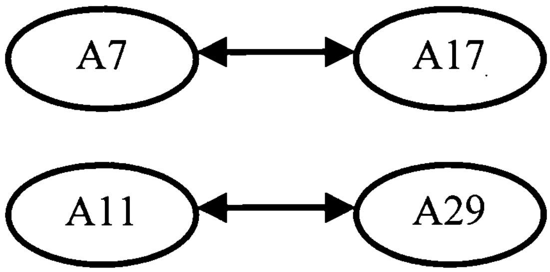

FIGURE 4. Bayesian Belief Network extracted from part C.

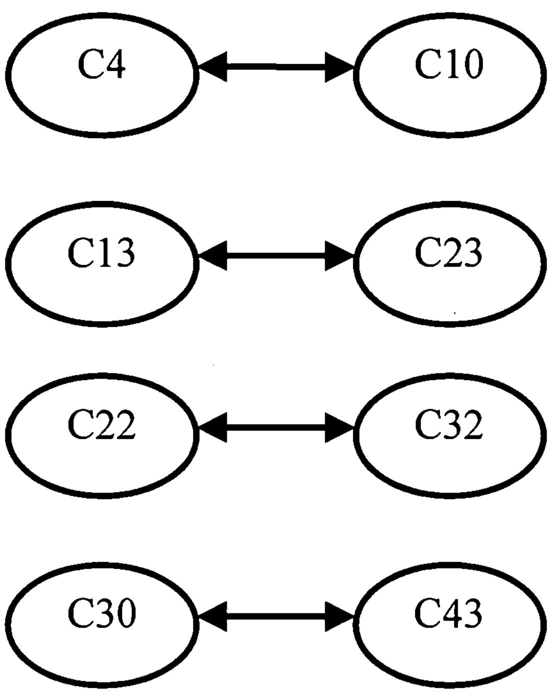

FIGURE 5. BAYDA Screen Shots During Variable Selection for Cognitive Outcome.

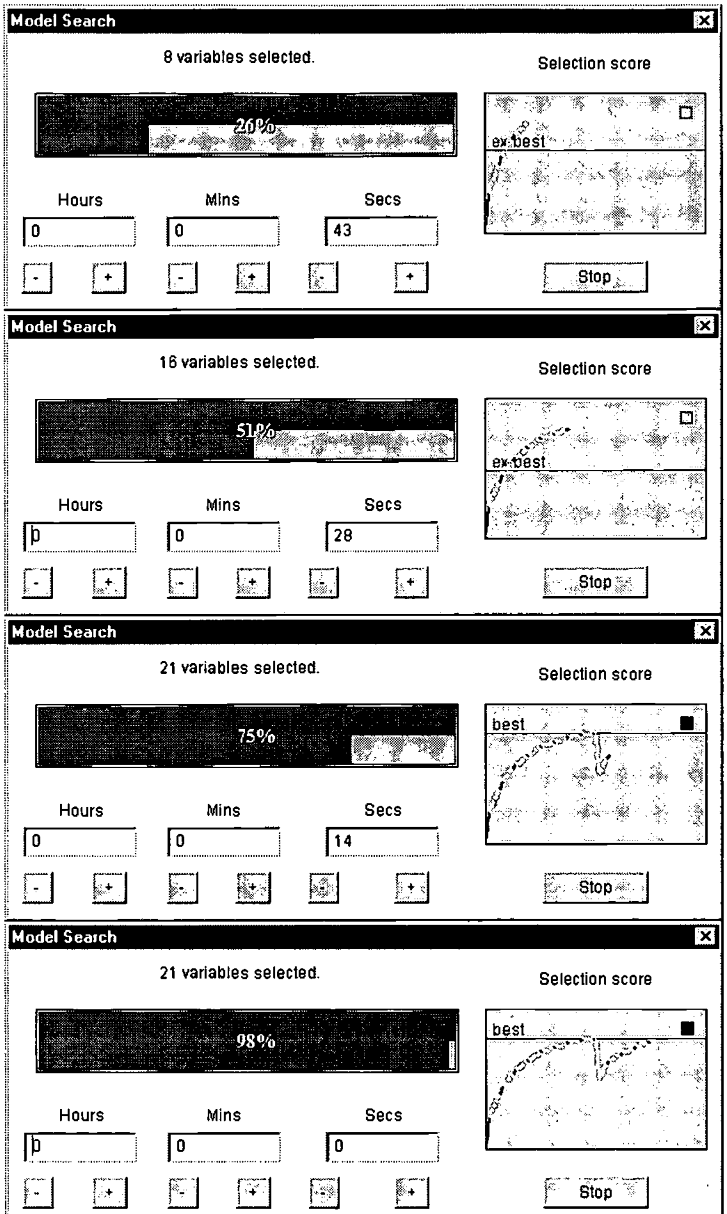

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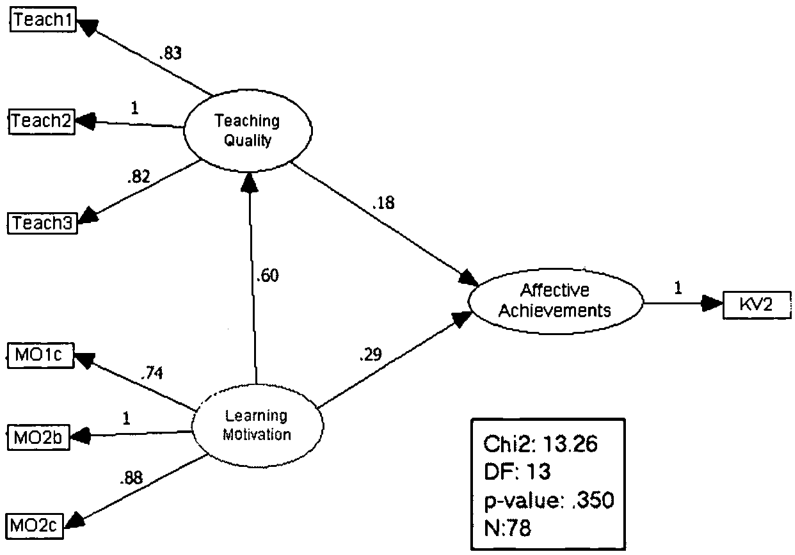
FIGURE 6. The Second Stage Original Model.



SPSS Syntax

SPSS Syntax for Four Factor Solution (Part A, Criteria A and B)

```
FACTOR
 /VARIABLES a1 a2 a5 a6 a7 a10 a11 a12 a13 a14 a15 a17 a18 a19 a20 a22 a23 a24 a25 a26 a27 a28 a29 a30 a32 a35
 /MISSING LISTWISE
 /ANALYSIS a1 a2 a5 a6 a7 a10 a11 a12 a13 a14 a15 a17 a18 a19 a20 a22 a23 a24 a25 a26 a27 a28 a29 a30 a32 a35
 /PRINT INITIAL EXTRACTION ROTATION
 /PLOT EIGEN ROTATION
 /CRITERIA FACTORS(4) ITERATE(25)
 /EXTRACTION ML
 /CRITERIA ITERATE(25)
 /ROTATION VARIMAX .
```

SPSS Syntax for Corrected Four Factor Solution (Part A, Criteria A and B)

```
FACTOR
 /VARIABLES a2 a5 a6 a7 a11 a12 a17 a19 a22 a23 a24 a25 a27 a28 a29 a32 a35
 /MISSING LISTWISE
 /ANALYSIS  a2 a5 a6 a7 a11 a12 a17 a19 a22 a23 a24 a25 a27 a28 a29 a32 a35
 /PRINT INITIAL EXTRACTION ROTATION
 /PLOT EIGEN ROTATION
 /CRITERIA FACTORS(4) ITERATE(25)
 /EXTRACTION ML
 /CRITERIA ITERATE(25)
 /ROTATION VARIMAX .
```

SPSS Syntax for Optimized Factor Solution (Part A, Criteria A and B)

```
FACTOR
 /VARIABLES a2 a5 a6 a7 a11 a12 a17 a19 a22 a23 a24 a25 a27 a28 a29 a32 a35
 /MISSING LISTWISE
 /ANALYSIS  a2 a5 a6 a7 a11 a12 a17 a19 a22 a23 a24 a25 a27 a28 a29 a32 a35
 /PRINT INITIAL EXTRACTION ROTATION
 /PLOT EIGEN ROTATION
 /CRITERIA MINEIGEN(1) ITERATE(25)
 /EXTRACTION ML
 /CRITERIA ITERATE(25)
 /ROTATION VARIMAX .
```

SPSS Syntax for Reliability (Part A, Criteria A and B)

```
 /VARIABLES a2 a5 a6 a7 a11 a12 a17 a19 a22 a23 a24 a25 a27 a28 a29 a32 a35
 /FORMAT=NOLABELS
 /SCALE(ALPHA)=ALL/MODEL=ALPHA.
```

SPSS Syntax for Four Factor solution (Part A, Criteria C)

```
FACTOR
 /VARIABLES a10 a12 a14a22 a23 a24 a27 a29 a32
 /MISSING LISTWISE /ANALYSIS a10 a12 a14 a22 a23 a24 a27 a29 a32
 /PRINT INITIAL EXTRACTION ROTATION
 /PLOT EIGEN ROTATION
 /CRITERIA FACTORS(4) ITERATE(25)
 /EXTRACTION ML
 /CRITERIA ITERATE(25)
 /ROTATION VARIMAX .
```

SPSS Syntax for Optimized Factor Solution (Part A, Criteria C)

```
FACTOR
 /VARIABLES a10 a12 a14 a22 a23 a24 a27 a29 a32
 /MISSING LISTWISE /ANALYSIS a10 a12 a14 a22 a23 a24 a27 a29 a32
 /PRINT INITIAL EXTRACTION ROTATION
 /PLOT EIGEN ROTATION
 /CRITERIA MINEIGEN(1) ITERATE(25)
 /EXTRACTION ML
 /CRITERIA ITERATE(25)
 /ROTATION VARIMAX .
```

SPSS Syntax for Creating part A standardized variables

```
COMPUTE log_a1 = LG10(a1) .
COMPUTE log_a2 = LG10(a2) .
COMPUTE log_a3 = LG10(a3) .
COMPUTE log_a4 = LG10(a4) .
COMPUTE log_a5 = LG10(a5) .
COMPUTE log_a6 = LG10(a6) .
COMPUTE log_a7 = LG10(a7) .
COMPUTE log_a8 = LG10(a8) .
COMPUTE log_a9 = LG10(a9) .
COMPUTE log_a10 = LG10(a10) .
COMPUTE log_a11 = LG10(a11) .
COMPUTE log_a12 = LG10(a12) .
COMPUTE log_a13 = LG10(a13) .
COMPUTE log_a14 = LG10(a14) .
COMPUTE log_a15 = LG10(a15) .
COMPUTE log_a16 = LG10(a16) .
COMPUTE log_a17 = LG10(a17) .
COMPUTE log_a18 = LG10(a18) .
COMPUTE log_a19 = LG10(a19) .
COMPUTE log_a20 = LG10(a20) .
COMPUTE log_a21 = LG10(a21) .
COMPUTE log_a22 = LG10(a22) .
COMPUTE log_a23 = LG10(a23) .
COMPUTE log_a24 = LG10(a24) .
COMPUTE log_a25 = LG10(a25) .
COMPUTE log_a26 = LG10(a26) .
COMPUTE log_a27 = LG10(a27) .
COMPUTE log_a28 = LG10(a28) .
COMPUTE log_a29 = LG10(a29) .
COMPUTE log_a30 = LG10(a30) .
COMPUTE log_a31 = LG10(a31) .
COMPUTE log_a32 = LG10(a32) .
COMPUTE log_a33 = LG10(a33) .
COMPUTE log_a34 = LG10(a34) .
COMPUTE log_a35 = LG10(a35) .
EXECUTE .
```

SPSS Syntax for Final Solution Solution (Part A, Standardized Variables)

```
FACTOR
 /VARIABLES log_a6 log_a7 log_a10 log_a11 log_a17 log_a23 log_a24 log_a27
 log_a28 log_a29
 /MISSING LISTWISE
 /ANALYSIS log_a6 log_a7 log_a10 log_a11
 log_a17 log_a23 log_a24 log_a27 log_a28 log_a29
 /PRINT INITIAL EXTRACTION ROTATION
 /PLOT EIGEN ROTATION
 /CRITERIA FACTORS(4) ITERATE(25)
 /EXTRACTION ML
 /CRITERIA ITERATE(25)
 /ROTATION VARIMAX .
```

EV Output for part A

```
bkd_part_a_criteriaAB.bbn / bkd_part_a_original.bbn : 63452922727424348181091161426487030.72770432870941757294
bkd_part_a_free.bbn / bkd_part_a_original.bbn : 5631916432739427236957185041.28679805235560498561
```

EV Output for part C

```
bkd_part_c_optimized.bbn / bkd_part_c_original.bbn : 835.32686752926830446391
bkd_part_c_free.bbn / bkd_part_c_original.bbn : 4866966175163507.80071468046136415373
```

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