The development of students' subject attitudes when taking a statistics course

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Abstract

In this empirical study, we investigate two research questions related to students' attitudes toward statistics in a sample of 3500 first year university students. The first question is inspired by a large body of research that concludes that learning attitudes tend to decline while learning for the subject. Using the SATS attitudes instrument that distinguishes six attitudes factors, Affect, Cognitive Competence, Value, Difficulty, Interest, and Effort, we indeed confirm this downward trend, with the exception of Value. But the downward development is not the same for all students, and using a large set of students' background factors, we investigate what determines these changes. As one might expect, academic performances in the course appear to have a positive impact on attitudes developments, but other effects we find are less intuitive, such as the consistent gender effect in attitudes changes.

A second research question refers the position of the Effort construct in our attitudes model. According the Expectancy*Value theory, the two expectancy factors (Cognitive Competence and Difficulty), together with the three value factors (Affect, Value, Interest), determine outcomes of the learning process, such as learning effort and performances. Students demonstrating high effort levels are hypothesized to be more successful. However, in the SATS model Effort is not the best predictor of success; expectancy factors as Cognitive Competence are much stronger related to course performances. Using the available background data, we demonstrate that the relationship between expectancy and value factors and effort is indeed more complex than the E*V model suggests; the effort construct incorporated in SATS does contain aspects of learning dispositions, such as the preference for a surface learning style, that contaminates with the mechanism of the E*V model.

1. Introduction

How do students‟ subject attitudes develop over time? And especially: over the relative short periods in which they take classes in these subjects, like e.g. a class of introductory statistics? These questions have more than pure educational-psychology research related relevance: since the start of the reform movement in statistics education, the creation of positive attitudes toward statistics is as important as the grow of mastery of the subject as an educational objective. However, many empirical studies indicate that we are not very successful in attaining that second goal: attitudes levels tend to decline during the delivery of courses, not to grow. It is only in studies focusing on specific instructional innovations, generally with small samples, that increasing attitudes levels are found (Carlson & Winquist, 2011). But beyond these specific circumstances, most empirical studies with large samples of students tend to find diminishing attitudes levels during the delivery of (introductory) statistics courses (e.g., Verhoeven, 2009. Most of this empirical research into the development of attitudes

toward statistics makes use of the theoretical framework, and the instrument based on it, developed by Schau (2003). This Survey of Attitudes Toward Statistics, in short SATS36©, is based on Eccles‟ expectancy-value theory (Eccles, 2005; Wigfield & Eccles, 2000, 2002; Wigfield, Tonk, & Eccles, 2004). In this general framework, both expectancy and value factors are regarded as aspects of achievement motivation, rather than subject attitudes. And indeed, also empirical research into the development of achievement motivations finds mostly extended trajectories of declines in achievement motivation facets, rather than growth.

We will investigate this puzzle of growing or declining attitudes levels in a large sample of students taking an introductory statistics university course. And profit from the circumstance that beyond pre and post data on attitudes toward statistics, a lot of learning related students‟ background is available. A specific focs of this study is the role of effort and effort beliefs in the development of attitudes.

2. Measures

Attitudes or achievement motivations toward the subject statistics are measured with the instrument Survey of Attitudes Toward Statistics (SATS36©) developed by Schau and colleagues (1995; also see Dauphinee, Schau, & Stevens, 1997; Hilton, Schau, & Olsen, 2004). Expectancy-value models take their name from the key role of two components in the motivation to perform on an achievement task: students‟ expectancies for success, and the task value, that is the value they attribute to succeeding the task. The SATS instrument measures four aspects of post-secondary students‟ subject attitudes: two expectancy factors that deal with students‟ beliefs about their own ability and perceived task difficulty: Cognitive competence and Difficulty, and two subjective task-value constructs that encompass students‟ feelings toward and attitudes about the value of the subject: Affect and Value. Validation research has shown that a four-factor structure provides a good description of responses to the SATS-instrument in two very large samples of undergraduate students (Dauphinee et al., 1997; Hilton et al., 2004) for the subject statistics, and for a range of business subjects Tempelaar, Gijselaers, Schim van der Loeff, and Nijhuis (2007). Recently, the instrument is incremented by two more attitudes scales: Interest and Effort, where the last scale represents the willingness of the student to invest time and other efforts in learning the subject. The naming of the Difficulty scale is somewhat counterintuitive, since in contrast to all other scales, lower scores and not higher scores correspond to higher levels of conceived difficulty. Therefore, the scale is mostly addressed with „lack of Difficulty‟ in the next sections.

Learning styles. The Inventory of Learning Styles (ILS) instrument, developed by Vermunt (see Entwistle & Peterson, 2004; Vermunt, 1996; Vermunt & Vermetten, 2004), has been used to assess preferred learning dispositions. Vermunt distinguishes in his learning styles model four domains or components of learning: cognitive processing strategies, metacognitive regulation strategies, learning conceptions or mental models of learning, and learning orientations. Each component is composed of five different scales, as described in Table 1.

Table 1: Domains and scales of the Inventory of Learning Styles

Processing strategies	Regulation strategies	Learning orientations	Learning conceptions, or Mental models of learning
Relating and structuring	Self-regulation of learning processes	Personally interested	Construction of knowledge
Critical processing	Self-regulation of learning content	Certificate directed	Intake of knowledge
Memorising and rehearsing	External regulation of learning processes	Self test directed	Use of knowledge
Analysing	External regulation of learning results	Vocation directed	Stimulating education
Concrete processing	Lack of regulation	Ambivalent	Co-operation

The two processing strategies Relating and structuring and Critical processing together compose the „deep learning" strategy, whereas Memorizing and rehearsing, together with Analysing, compose the „stepwise learning" strategy (also called surface learning in several theories of learning). Similarly, the two regulation scales Self-regulation of learning processes and Self-regulation of learning content together compose the strategy „self-regulation", hypothesised to be prevalent in deep learning students. The two regulation scales External regulation of learning processes and External regulation of learning results constitute the „external regulation" strategy, supposed to be characteristic for stepwise learners.

Implicit theories of intelligence. Measures of entity and incremental implicit theories of intelligence were adopted from Dweck's (1999) Theories of Intelligence Scale – Self Form for Adults. The scale consists of eight items: four entity theory statements (e.g., „You have a certain amount of intelligence, and you can't really do much to change it") and four incremental theory statements (e.g., „You can always substantially change how intelligent you are").

Effort beliefs. Measures of Effort beliefs have two different sources: Dweck (1999) and Blackwell (2002). In Dweck (1999), several sample statements are provided portraying effort as a negative thing, where exerting effort mirrors the view that one has low ability, and effort as a positive thing, where exerting effort is regarded as a way to activate and increase one's ability. Of both of these sets of statements (see Dweck, 1999, p. 40), the first ones are used as the first item of both subscales. These are for the Effort Negative subscale: „If you have to work hard on some problems, you're probably not very good at them", and for the Effort Positive subscale: „When you're good at something, working hard allows you to really understand it". In addition, the full sets of Effort beliefs of Blackwell (2002) were used, containing five positive and five negative items (see also Blackwell et al., 2007). A sample item of viewing effort negatively related to ability is „To tell the truth, when I work hard at my schoolwork, it makes me feel like I'm not very smart", while the item „The harder you work at something, the better you will be at it" expresses the view that effort leads to positive outcomes.

Goal orientations. Three different operationalizations of goal orientations have been applied. Following Dweck's plea to apply measures that pit learning goals against performance goals rather than assessing learning and performance goals independently, we adopted Goal Choice Items Questionnaire (Dweck, 1999, pp. 185-186) (with the last item transformed into the Likert scale format, as the other three items). As a sample item, the last item after transformation became: „If I had to choose between getting a good grade and being challenged in class, I would choose for being challenged." The second instrument measuring students' achievements goals is the revised PALS: Midgley et al. (2000). It is a trichotomous instrument, in that it distinguishes two types of performance goals, approach and avoidance, but only one type of mastery goal: approach. Thirdly, the Grant and Dweck (2003) instrument has been applied, that distinguishes the two learning goals challenge-mastery and learning goals, and four types of performance goals, two of them being of normative nature, the other two being the appearance goals.

Academic Motivation Scale (AMS; Vallerand et al., 1992), based upon Ryan and Deci's (2000) model of intrinsic and extrinsic motivation. The AMS consists of 28 items, to which students respond to the question stem "Why are you going to college?" There are seven subscales on the AMS, of which three belong to intrinsic motivation scale and three to extrinsic motivation scale. In intrinsic motivated learning, the drive to learn is derived from the satisfaction and pleasure of the activity of learning itself; no external rewards come in play. Intrinsic motivation subscales are intrinsic motivation to know (learning for the satisfaction and pleasure to understand something new); intrinsic motivation to accomplish (learning for experiencing satisfaction and pleasure to accomplish something), and intrinsic motivation to experience stimulation (learning to experience stimulating sensations). Externally motivated learning refers to learning that is a means to an end, and not engaged for its own sake. The three extrinsic motivation subscales are identified regulation, introjected regulation, and external regulation. The three constitute a motivational continuum reflecting the degree of self-

determined behaviour. The component most adjacent to intrinsic motivation is identified regulation: the student comes to value learning as important and, therefore, performs it out of choice, but still for extrinsic reasons, as for example achieving personal goals. Regulation is introjected when the formerly external source of motivation has been internalised. Externally regulated learning occus when learning is steered through external means, such as rewards. The last scale, amotivation (AMOT), constitutes the very extreme of the continuum: the absence of regulation, either externally directed or internally.

3. Data and statistical analysis

Participants in this study are 3500 first year university students in two programs based on the principle of problem-based learning: International Economics and International Business Studies. Data has been collected in four cohorts, ranging from academic year 07/08 to academic year 10/11. Somewhat more than one third of the participating students is female (36%), against 64% males. About one third of the students (34.1%) is of Dutch citizenship, the remaining 65.9% being international students, mostly from Germany. Distinguishing national from international students is relevant with regard to prior schooling in statistics: Dutch secondary school programs contain statistics as a major topic, several international programs do not.

During the start of the course, and as part of the fulfilment of a required student project for statistics, students filled several self-report questionnaires on learning related characteristics.

4. Results

All attitudes are measured along a 1…7 Likert scale, implying 4 to be the neutral value of the scale. As Table 2 indicates all scales except (lack of) Difficulty score on average above neutral. This is true for students‟ attitudes at the start of the course, and at the end of the course, be it that five out of six (Value is the exception) decline in level during the course. Pre course level of Effort is even that high, that a ceiling effect takes place: the distribution of Pre effort is clearly left skewed. After the course, the level has decreased that much, that most of the skewness has disappeared.

In the positive view on one‟s own attitudes, a strong gender effect is present, always in the direction that male students regard their attitudes at a higher level than female students, except for the sixth attitude: their willingness to spend effort in learning statistics. In the beginning of the course, all these gender differences are statistically significant. However, due to the changes during the course, the gender differences in Value and Interest diminish in size, and become statistically insignificant. Gender differences in self-perception of competence (in favour of males), and in effort invested in learning (in favour of females) deepen during the course. The two attitudes Affect and (lack of) Difficulty demonstrate parallel developments for both genders, as can be seen in the last panel of Table. 2

Table 2: pre and post course levels of attitudes toward statistics, with gender breakdown

	Pre Course					Post Course					Change over course				
	All	**F**	**M**	**D**	**Pval**	**All**	**F**	**M**	**D**	**Pval**	**All**	**F**	**M**	**D**	**Pval**
Affect	4.59	4.32	4.76	0.43	.000	4.39	4.13	4.55	0.42	.000	-.20	-.19	-.21	-.02	.688
Cognitive Competence	5.27	5.08	5.39	0.30	.000	4.87	4.65	5.02	0.36	.000	-.39	-.43	-.37	.06	.087
Value	5.10	4.98	5.17	0.19	.000	5.13	5.13	5.13	0.00	.994	.03	.15	-.04	-.19	.000
Difficulty, lack of	3.56	3.45	3.63	0.17	.000	2.98	2.87	3.03	0.16	.000	-.59	-.58	-.60	-.02	.563
Interest	5.14	5.08	5.18	0.09	.021	4.84	4.88	4.82	-0.06	.213	-.30	-.20	-.35	-.15	.001
Effort	6.46	6.59	6.40	-0.19	.000	5.87	6.07	5.79	-0.29	.000	-.59	-.52	-.61	-.10	.005

Note. All: all students; F: female students; M: male students; D: male-female difference; Pval: significance (P-value) of male-female difference.

Another categorical having a clear impact on students‟ attitudes toward statistics, is their prior education in mathematics: see Table 3. Students educated at advanced levels, indicated MathMajor, have more positive attitudes than students educated at basic level, indicated MathMinor. The exception is obviously the Effort scale: being educated at higher levels, diminishes the need to invest a lot of efforts in the study of statistics. Differences are statistically significant, both for begin of the course and end of the course measurements, except for Interest. Somewhat unexpectedly, the group differences become even more articulated during the course, except for (lack of) Difficulty.

Table 3: pre and post course levels of attitudes toward statistics, with prior education breakdown:

	Pre Course					Post Course					Change over course				
	All	**Maj**	**Min**	**D**	**Pval**	**All**	**Maj**	**Min**	**D**	**Pval**	**All**	**Maj**	**Min**	**D**	**Pval**
Affect	4.59	4.76	4.53	-0.23	.000	4.39	4.66	4.28	-0.38	.000	-.20	-.10	-.26	-.15	.001
Cognitive Competence	5.27	5.46	5.20	-0.26	.000	4.87	5.07	4.80	-0.28	.000	-.39	-.38	-.40	-.02	.680
Value	5.10	5.16	5.08	-0.08	.010	5.13	5.24	5.08	-0.16	.000	.03	.08	.00	-.08	.009
Difficulty, lack of	3.56	3.65	3.53	-0.11	.000	2.98	3.02	2.95	-0.06	.052	-.59	-.63	-.58	.05	.158
Interest	5.14	5.19	5.12	-0.08	.067	4.84	4.99	4.78	-0.21	.000	-.30	-.20	-.34	-.14	.003
Effort	6.46	6.38	6.50	0.12	.000	5.87	5.84	5.91	0.07	.047	-.59	-.54	-.59	-.05	.197

Note. All: all students; Maj: students with Math major; Min: students with Math minor; D: Math minor – Math major difference; Pval: significance (P-value) of Math minor – Math major difference.

Table 4 highlights the attitudes developments over the course, signalling the statistical significance of each of the changes in time with P-values. Some interesting breakdowns show up. Overall, Value is the only attitude that does not diminish in level. However, the constant level of Value is composed of a rather strong positive development for female students, and a smaller negative development for male students. And a positive development for students with mathematics major, against a constant level for students with mathematics minor (in most educational systems, majoring in math implies a strong focus on abstract mathematics, without coverage of statistics, making a valuation at the start of the course difficult).

Table 4: development of attitudes over course

	All students		Female students		Male students		Math major students		Math minor students	
	Change	**Pval**	**Change**	**Pval**	**Change**	**Pval**	**Change**	**Pval**	**Change**	**Pval**
Affect	-.20	.000	-.19	.000	-.21	.000	-.10	.005	-.26	.000
Cognitive Competence	-.39	.000	-.43	.000	-.37	.000	-.38	.000	-.40	.000
Value	.03	.067	.15	.000	-.04	.029	.08	.002	.00	.919
Difficulty, lack of	-.59	.000	-.58	.000	-.60	.000	-.63	.000	-.58	.000
Interest	-.30	.000	-.20	.000	-.35	.000	-.20	.000	-.34	.000
Effort	-.59	.000	-.52	.000	-.61	.000	-.54	.000	-.59	.000

Note. Change: change over course, post-pre; Pval: significance (P-value) of change over course

Pre course levels of attitudes, together with course performance, are powerful predictors of post course levels. Table 5 contains these regression equations. The first R^2 provides explained variation by these regression equations; the second R^2 provides explained variation when the regression model is extended with all other students‟ characteristics available. The equations make clear that where pre level is the best single predictor of post level for all attitudes, there is one exception: the StatsQuiz score is a better predictor for post level Effort than pre level Effort. This does not surprise, given that the quizzes are the performance component that allows

for detailed preparation. It might be for the same reason that quiz score does not predict post level of (lack of) Difficulty.

Table 5:prediction models of post attitudes on pre attitudes and course performances

Post Affect	**= 0.504*Pre Affect**	**+ 0.129*StatsExam**	**+ 0.125*StatsQuiz**	**R^2=.344**	**R^2=.407**
Post Cognitive Competence	**= 0.486*Pre Cogn. Competence**	**+ 0.126*StatsExam**	**+ 0.108*StatsQuiz**	**R^2=.327**	**R^2=.385**
Post Value	**= 0.502*Pre Value**	**+ 0.055*StatsExam**	**+ 0.060*StatsQuiz**	**R^2=.280**	**R^2=.347**
Post Difficulty, lack of	**= 0.415*Pre Difficulty, lack of**	**+ 0.058*StatsExam**	**+ 0.000*StatsQuiz**	**R^2=.179**	**R^2=.233**
Post Interest	**= 0.469*Pre Interest**	**+ 0.042*StatsExam**	**+ 0.138*StatsQuiz**	**R^2=.261**	**R^2=.328**
Post Effort	**= 0.294*Pre Effort**	**+ 0.002*StatsExam**	**+ 0.330*StatsQuiz**	**R^2=.224**	**R^2=.312**

The remaining Tables 6-9 provide inside in students‟ background factors that impact the development in attitudes toward statistics during the course. Since there is collinearity amongst these factors, we will provide bivariate intercorrelations of each of the instruments, rather than regression models, since suppression effects take place. The first table, Table 6, refers to intercorrelactions with the ILS: Inventory of Learning Styles. Strong correlations are especially in the third and fourth row of the table, with the two scales Memorising and rehearsing, and Analysing, composing together the surface learning style. So surface learning not only predicts high levels of Effort at the start of the course, but is also positively related to the change in effort levels during the course.

Table 6: Intercorrelations of attitudes developments over the course, and learning styles

Bivariate intercorrelations	**Delta Affect**	**Delta Cogn. Competence**	**Delta Value**	**Delta Difficulty, lack of**	**Delta Interest**	**Delta Effort**
Relating and structuring	0.009	-0.004	-0.005	-0.027	-0.014	0.038
Critical processing	0.020	0.014	0.004	-0.019	-0.003	0.006
Memorising and rehearsing	-0.006	0.003	0.043	0.001	0.008	0.075
Analysing	0.030	-0.005	0.076	-0.037	0.016	0.088
Concrete processing	-0.050	-0.036	-0.042	-0.035	-0.050	-0.014
Self-regulation learning processes	-0.011	0.008	0.022	-0.018	0.008	0.027
Self-regulation learning content	-0.028	-0.024	0.032	-0.019	-0.028	0.028
External regulation learning processes	0.025	0.005	0.050	-0.009	0.019	0.107
External regulation learning results	0.010	-0.006	0.014	-0.022	0.006	0.068
Lack of regulation	0.017	0.026	-0.006	0.039	-0.035	0.004
Personally interested	-0.006	-0.007	0.035	-0.008	0.015	0.004
Certificate directed	-0.037	-0.036	0.031	-0.013	-0.009	0.044
Self test directed	-0.008	-0.027	0.013	-0.010	-0.039	0.049
Vocation directed	-0.023	-0.019	0.013	-0.041	-0.038	0.018
Ambivalent	-0.004	-0.018	-0.003	0.038	-0.030	-0.036
Construction of knowledge	0.031	0.012	0.064	0.000	0.026	0.048
Intake of knowledge	0.010	-0.017	0.057	0.000	0.014	0.061
Use of knowledge	0.004	0.011	-0.002	-0.012	-0.030	0.058
Stimulating education	0.024	0.006	0.016	0.010	0.003	0.009
Co-operation	-0.008	-0.033	0.027	0.011	-0.001	0.009

Note: correlations larger or equal .045 are significant at .01 level; correlations larger or equal .035 are significant at .05 level.

Table 7 provides intercorrelactions with Dweck‟s implicit theory of intelligence. Especially the effort views resulting from different intelligence views are strongly related to changes in attitudes. The negative effort view is negatively related to the development of attitudes toward statistics, in contrast to the positive effort view. Affect, Value, and Effort are most open for influence from these beliefs on the nature of intelligence.

Table 7: Intercorrelations of attitudes developments over the course, and implicit theories

Bivariate intercorrelations	Delta Affect	Delta Cogn. Competence	Delta Value	Delta Difficulty, lack of	Delta Interest	Delta Effort
EntityTheory	-0.005	-0.009	-0.017	-0.019	-0.009	0.002
IncreTheory	-0.021	-0.019	0.028	0.009	-0.010	0.006
EffortNegative	-0.049	-0.023	-0.040	0.020	-0.053	-0.035
EffortPositive	0.051	0.039	0.107	0.010	0.043	0.060

Note: correlations larger or equal .045 are significant at .01 level; correlations larger or equal .035 are significant at .05 level.

Table 8 contains intercorrelactions of the two different instruments for Goal setting: the Grant and Dweck (2003), and the PALS instruments, and attitudes changes. Correlations are in general larger than those in the previous two tables: goal setting has a clear impact on attitudes changes. Patterns visible are different from the patterns in levels of goal setting. First: AppearanceGoal, both in absolute and normative form, positively impacts all attitudes developments, where it has a negative impact on the level of most attitudes. Apparently, this represents students who start at a low level, but grow over the course. The reverse is true for students initially high in Learning and Challenge/Mastery Goal.

Table 8: Intercorrelations of attitudes developments over the course, and goal orientation

Bivariate intercorrelations	Delta Affect	Delta Cogn. Competence	Delta Value	Delta Difficulty, lack of	Delta Interest	Delta Effort
OutcomeGoal	-0.076	-0.058	0.005	-0.073	-0.032	0.065
AppearanceGoal	0.055	0.064	0.085	0.016	0.052	0.065
NormativeOutcomeGoal	0.162	0.115	0.101	0.082	0.094	0.069
NormativeAppearanceGoal	0.125	0.082	0.082	0.090	0.078	0.035
LearningGoal	-0.058	-0.040	0.021	-0.073	0.015	0.062
ChallengeMasteryGoal	-0.076	-0.058	-0.005	-0.074	0.003	0.019
PALSMasteryGoal	0.041	0.054	0.110	-0.007	0.051	0.103
PALSPerformanceApproachGoal	0.001	0.009	0.006	0.006	0.030	0.037
PALSPerformanceAvoidGoal	-0.011	0.006	0.021	-0.009	0.036	0.041

Note: correlations larger or equal .045 are significant at .01 level; correlations larger or equal .035 are significant at .05 level.

The last Table, 9, depicts intercorrelactions of attitudes developments with the AMS: Academic Motivations. Correlations are less strong than those for goal setting behaviour. Being intrinsically motivated has a positive impact on attitudes developments, being extrinsically motivated, or amotivated, generally a negative impact. The exception is the change in level of perceived (lack of) Difficulty; there, the pattern is reversed.

Explaining performance and the effort attitude factor

The last step in the analysis entails the relationship of both course performance, and students‟ attitude component effort, with the complete set of students‟ characteristics. In assessing student performance, a portfolio of different types of assessments has been applied; we will focus on two components.

Table 9: Intercorrelations of attitudes developments over the course, and academic motivations

Bivariate intercorrelations	Delta Affect	Delta Cogn. Competence	Delta Value	Delta Difficulty, lack of	Delta Interest	Delta Effort
IntrinsicMotivationToKnow	0.028	0.022	0.065	-0.015	0.022	0.021
IntrinsicMotivatioToAccomplish	0.045	0.038	0.069	0.001	0.056	0.017
IntrinsicMotivationsToExpStimulation	0.004	0.015	0.059	-0.002	0.047	0.000
ExtrinsicMotivationIdentified	0.007	0.008	0.030	-0.053	-0.034	0.023
ExtrinsicMotivationIntrojected	0.008	0.008	0.027	0.003	0.009	0.032
ExtrinsicMotivationExternal	-0.013	0.003	0.025	-0.014	-0.025	0.029
Amotivation	-0.022	-0.042	-0.046	0.045	0.001	-0.043

Note: correlations larger or equal .045 are significant at .01 level; correlations larger or equal .035 are significant at .05 level.

These are: the score in quizzes (StatsQuiz), and the score in the final exam (StatExam). Quizzes are integrated into an adaptive e-tutorial that allows students to prepare quiz sessions by practicing related problem cases. In contrast, the final exam consists of a set of statistical problems that cannot be prepared in a similar, focussed approach; to determine what statistical tools may help solving the statistical problem is a first and rather open step in solving these problems. For that reason, quiz scores are expected to be more dependent on effort related students‟ characteristics, than the score in the final exam. With regard to the effort construct, two different measurement moments are included: prior to the course, so an assessment of planned effort, and a post measurement at the end of the course: a self-assessment of study efforts invested in learning statistics. Table 10 contains the outcomes of regression models explaining these four constructs.

Table 10: beta's or standardized regression coefficients in the explanation of performance and effort

StatsQuiz	**= 0.087*Pre Affect + 0.107*Pre Cogn.Comp. + 0.067*Pre Value – 0.044*Pre DifficultyLack -0.078*Pre Interest +0.075*Pre Effort +0.081*MathMajor – 0.082*Dutch + 0.039*CriticalProc + 0.039*Analysing – 0.094*ConcretProc –0.069*SelfReglearnProc + 0.101*ExtRegLearnCont -0.070*PersonInter – 0.045*VocationInter +0.061*IntakeKnw +0.103*OutcomeGoal -0.156*NormAppearGoal + 0.183*LearningGoal + 0.079*ChallengeMastGoal**	**R^2=.220**
StatsExam	**= 0.157*Pre Cogn.Comp. + 0.106*Pre Value -0.06*Pre Interest +0.144*MathMajor +0.059*Dutch + 0.119*CriticalProc – 0.060*ConcretProc –0.069*SelfReglearnProc –0.076*SelfReglearnCont + 0.088*ExtRegLearnCont -0.053*PersonInter -0.083*CertificateDirect + 0.063*StimulEduc -0.077*Cooperation +0.065*AppearGoal + 0.102*LearningGoal -0.080*IntrinsMotivStim + 0.081*ExtrinMotivIdent - 0.074*ExtrinMotivExt**	**R^2=.152**
Pre Effort	**= -0.129*Pre Affect + 0.185*Pre Cogn.Comp. – 0.177* Pre DifficultyLack +0.223*Pre Interest -0.081*MathMajor – 0.062*Dutch +0.078*Female -0.042*Relating - 0.043*CriticalProc + 0.043*Analysing + 0.061*ExtRegLearnProc - 0.038*LackReg +0.066*CertificateDirect -0.042*Ambivalent +0.042*ConstrKnw -0.057*EffortNeg +0.044*EffortPos +0079*OutcomeGoal -0.101*AppearGoal +0.096*NormOutcomeGoal +0.058*MasteryGoal + 0.090* ExtrinMotivIdent -0.052*ExtrinMotivExt -0.053*Amotivation**	**R^2=.299**
Post Effort	**= 0.187*Pre Effort+ 0.236*Post Cogn.Comp. – 0.237* Post DifficultyLack +0.268*Post Interest -0.108*Pre Interest - 0.039*MathMajor +0.088*Female +0.033*Memorising + 0.103*ExtRegLearnProc +0.052*CertificateDirect +0069*OutcomeGoal +0.049*NormOutcomeGoal +0.062*MasteryGoal**	**R^2=.342**

With regard to prior and post Effort self-assessment: both are dominantly depending on other attitudes components. Interest, and the feeling of Cognitive Competence, have a positive effect on Effort, whereas the judgement that statistics is not Difficult has a negative effect. In the equation for Post Effort, Pre Interest has the

opposite sign, indicating that Post Effort depends both on the level and the change of interest at the end of the course. In both Effort relationships, we find evidence for positive relationship with surface learning, and a negative with deep learning: negative beta‟s of Relating & structuring and Critical Processing, positive beta‟s of Memorizing & Rehearsing and Analyzing. Outcome goals, be it normative or nonnormative, and Learning/Mastery goals impact Effort positively, Appearance Goals negatively. Lastly, External Regulation of learning, rather than self-regulation, and Identified motivation, rather than intrinsic motivation, help attaining high Effort levels.

Some of these characteristics return in the relationships for student performance: Self-Regulation has a negative impact, against External Regulation of positive impact, Intrinsic Motivation a negative impact, against Identified Motivation a positive impact. These effects are however weak. Strongest effects are from the prior education dummy, signalling MathMajor, from the self-perception of competence, and goal setting. Due to coverage of statistics in high school, Dutch students take the quizzing more easy, but still keep an advantage in the final exam. The main difference between Effort levels and Performance scores is that deep learning is helpful for achieving better scores. Critical Processing, the „deepest‟ component of deep learning, positively impacts student performance, most strongly the final exam, where it only restrained the level study efforts.

5. Discussion and conclusions

This study is in line with a majority of empirical research that the development in time of students‟ achievement motivations, or learning attitudes, can be described by two different changes: attitudes get better articulated, but at the same time demonstrate a downward movement: over time, students become less motivated, or more realistic, in their self-perceptions of subject attitudes (Verhoeven, 2009). This is also true for the large sample of students investigated in this empirical study: students express a well articulated set of attitudes, but except for the valuation of the subject of statistics, all other attitudes levels diminish during the introductory statistics course. However, this development is no uniform one: students effort beliefs, part of students‟ implicit intelligence beliefs, do e.g. impact the developmental process of attitudes toward statistics. Extending this variables based research with a person based investigation into the characteristics of students who grow, and those who regress, with regards to attitudes levels, suggest being an attractive next step of research.

The last part of the analysis focuses on a different aspect of learning effort: the achievement motivation Effort. Expectancy*value theory hypothesizes that this construct is the resultant of both expectancy factors, as cognitive competence and perceived difficulty, and value factors, as value itself, interest and affect. However, the Effort construct is more complex than this hypothesis suggests, since it does contain elements of a less attractive learning approach: that of an effortful, surface approach of learning. Again, a complication that deserves further investigation in future research.

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