Cross-validated Prediction of Academic Performance of First Year University Students

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Abstract

Background. Early prediction of academic performance is important for student selection and support. We explored, in a multivariate approach, whether pre-entry data (e.g., expectations, capabilities, motivation, attitude) could predict university students' first year academic performance.

Methods. Pre-registered applicants for a bachelor's program filled out the Leiden Intake Questionnaire (LIQ) before study-entry (N=739). Outcome data (first-year GPA, course credits, attrition) were obtained one year later.

Results. Students who performed better in preparatory education, and students who followed a conventional educational path before entering performed better during their first year at university. Non-Dutch students were less successful than Dutch students, and students who expected to spend more time on a study organization were more successful.

Conclusions. The LIQ may be used for identifying upfront who may need additional support, but is not suitable for student selection. Future work on academic performance should include cross-validation to determine how well the findings may generalize.

Keywords: university students; academic performance; GPA; course credits; attrition

1. Introduction

Over the past decades, Western education has been in search for optimal instruments to predict students' academic success. Searching for a high yield, a selection of the more talented and autonomous students is expected to lead to lower student drop-out rate and delay, as well as a smaller necessity for additional support by the university. On the other hand, universities that do not use strict selection procedures have to deal with diverse student populations. These universities need early warning systems that indicate whether a student is lacking in aptitudes, so that tailored support can be provided. Furthermore, because of the diverse student population in less selective universities, the general curriculum may be on an intermediate level of difficulty, and excellent students need to be identified for more elaborate (honors) programs. Importantly, in order to be able to monitor students and provide targeted support, predictors of academic performance need to be identified. The current prospective study examines how pre-entry data may predict academic performance during the first academic year.

1.1 Predictors of academic performance

Academic performance has been studied extensively. Traditional predictors, such as high school GPA and scores on admission tests (e.g., ACT-scores), have been found to be positively associated with academic performance in tertiary education (e.g. Richardson, Abraham, & Bond, 2012; Robbins et al., 2004). Moreover, a number of recent meta-analyses on this subject have shown that motivational factors and personality (e.g., McAbee & Oswald, 2013; Perera & DiGiacomo, 2013; Poropat, 2009; Richardson et al., 2012; Robbins et al., 2004), as well as intellectual investment and learning strategies (e.g. Credé & Phillips, 2011; Richardson et al., 2012; Von Stumm & Ackerman, 2013) predict academic performance. Specifically, Robbins et al. (2004) examined how intellectual, psychosocial and study skill factors predicted academic performance in tertiary education, measured as

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retention in the study program and GPA. Their study showed that high school GPA was a relatively strong predictor of both retention and GPA. Furthermore, academic-related skills, academic self-efficacy, and academic goals appeared as the most important study and psychosocial factors in predicting retention. GPA was best predicted by academic self-efficacy, followed by achievement motivation.

Another meta-analysis by Richardson et al. (2012) investigated how university GPA could be predicted from traditional intellectual constructs, personality traits, motivational factors, self-regulatory learning strategies, students' approaches to learning and psychosocial influences. The traditional intellectual measures of high school GPA and ACT-scores were medium-sized positive correlates of university GPA. Over and above traditional measures, motivational factors were found to be most important. More specifically, performance self-efficacy (i.e., perceptions of academic performance capability) had a large positive correlation with GPA. Academic self-efficacy (i.e., general perceptions of academic capability) and grade goals had medium-sized positive correlations with GPA. Effort regulation, one of the self-regulatory learning strategies, also showed a medium sized-positive correlation with GPA. Constructs in the other domains had small or non-significant correlations with GPA.

A meta-analysis by Poropat (2009) on associations between Big-Five personality characteristics (Costa & McCrae, 1992), intelligence and academic performance showed that conscientiousness and intelligence were strong positive predictors of academic performance in tertiary education. Specifically, a medium-sized positive association between conscientiousness and academic performance was found, and this association remained when intelligence was controlled for. Agreeableness and openness showed small positive associations with academic performance, but the associations between emotional stability and extraversion with academic performance were negligible. Similar conclusions were drawn by

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McAbee and Oswald (2013), who found that higher conscientiousness consistently predicted better academic performance across measures of personality, whereas associations between academic performance and agreeableness, openness, emotional stability and extraversion were much smaller. Finally, Perera and DiGiacomo (2013) showed a small-sized positive association between emotional intelligence and academic performance in tertiary education. In sum, these meta-analyses show that self-efficacy and conscientiousness are important psychosocial predictors of academic performance.

Other meta-analyses have focused on intellectual investment and learning strategies as associates of academic performance. Von Stumm and Ackerman (2013) investigated associations between investment traits, defined as the stable tendency to engage in and enjoy effortful cognitive activity, and academic performance as an indicator of intellect. Of these investment traits, intellectual disposition and intellectual engagement had the strongest associations with academic performance. Thus, students with a theoretical orientation and broad interest, as well as a desire to understand complex topics and problems performed better than students who scored lower on these traits. Moreover, Credé and Phillips (2011) performed a meta-analysis on the associations between subscales of the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich, Smith, Garcia & McKeachie, 1991) and course grades as well as overall GPA in college. Results showed that effort regulation, self-efficacy and time and study environment regulation were the strongest correlates of course grades. Effort regulation, time and study environment regulation and meta-cognitive self-regulation were the strongest correlates of overall GPA. Effects on grades in individual courses were somewhat larger than effects on overall GPA. Interestingly, specific learning strategies such as rehearsal or peer learning were considerably less relevant for academic performance. The authors explain this by suggesting that associations between learning strategies and

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performance might be curvilinear rather than linear, or that the grading in college does not require the use (some of) these learning strategies.

Initially, the search for factors contributing to study success was focused on finding one-on-one relations between a specific concept and one outcome criterion. Recently, more complex statistical approaches have been used to identify patterns in the conglomerate of potential predictors of academic performance. The proportion of variance explained by multivariate models typically ranges between approximately .20 and .50. Thus, although a substantial part of the variance in academic performance can be explained, prediction is far from perfect. Moreover, as far as we know, only few studies applied cross-validation (e.g., Lievens & Coetsier, 2002). This means that the generalizability of most of the predictive models that have been developed so far is unknown and may be systematically overrated in terms of explained variance (Geisser, 1975).

In a number of studies on academic performance in tertiary education, interactions between predictor variables have been found. These are reported by for example Adeyemo (2007), Barling, Zacharatos, and Hepburn (1999), Beaujean *et al.* (2011), Caldwell and Obasi (2010), Cokley and Moore (2007), Cole, Matheson, and Anisman (2007), Deemer, Smith, Carroll, and Carpenter (2014), De Feyter, Caers, Vigna, and Berings (2012), Diseth (2002), Dollinger, Matyja, and Huber (2008), Gaudreau (2012), Gupta and Sinha (2004), Haimeri and Fries (2010), Lozano, Gordillo, and Pérez (2014), McKenzie, Taghavi-Khonsary, and Tindell (2000), Ning and Downing (2012), Nyland, Ybarra, Sammut, Rienecker, and Kameda (2000), Rice, Lopez, Richardson, and Stinson (2013), Rosopa and Schroeder (2009), Smith (1999), Steele-Johnson and Leas (2013), Stupnisky, Perry, Hall, and Guay (2012), Villavicencio and Bernardo (2013), and Yoo and Castro (2011). However, across studies, varying concepts were found to be interacting and do not consistently point in a specific direction. In the above studies, personality factors turn up most frequently in interactions, but

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with a large variety of other variables. Importantly, previous work shows that relations between predictor variables and academic performance are not necessarily linear, and that interactions between predictor variables should be taken into account.

1.2 The Dutch system and the Leiden Intake Questionnaire

The Netherlands has a centralized system for registering intention to start an academic study at one of the Dutch universities. Potential students may pre-register for up to three different studies, choosing from all higher education institutions in the Netherlands (110 institutions for higher professional education and 20 universities). Most higher education institutions in the Netherlands do not have elaborate admission criteria other than appropriate high school diplomas or specific profiles.

From 2014, by Dutch law, universities are obliged to offer so called ‘study-matching’ activities, preceding the final choice and registration of a student for a particular academic discipline (Staatsblad, 2013). At Leiden University, the online Leiden Intake Questionnaire (LIQ) is used as a pre-entry measurement of student expectations, capabilities, motivation and attitude. The LIQ aims to identify potential risks and qualities that precede study success or failure. In addition to well-known constructs such as self-efficacy, questions about relatively novel topics such as past and expected participation in extracurricular activities, as well as aspects of study selection such as preparation for study selection and decision confidence were included. The nature of the questionnaire did not allow for an elaborate measurement of for example intelligence or personality characteristics.

1.3 The current study

The current study was undertaken as a pilot for the LIQ, and to explore, in a multivariate approach, whether early predictors of academic performance could be identified. Academic performance can be measured in many ways, for example as grade point average, study speed, retention, and majoring. In the current study, we will focus on three of these: a)

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First year GPA, calculated as a weighted mean of the course grades in the first academic year, as an indicator of quality of outcome b) the number of ECTS¹ achieved during the first academic year, as an indicator of efficiency of outcome, and c) attrition before the start of the second academic year, as an indicator of study continuity, defined as a lack of re-enrollment for the second academic year. The use of these three different outcome variables allows us to examine which factors predict different aspects of academic performance, and whether and how certain variables are relevant in the prediction of each of these aspects. In combination, these three outcome measures allow for comparison to national and international standards. The current study was guided by two research questions. First, we explored whether the questionnaire data could be used to construct reliable scales (RQ1). Second, we examined which factors were related to academic performance during the first academic year, defined as a) quality of outcome (GPA), b) efficiency of outcome (ECTS in first year), and c) study continuity (attrition; RQ2). In addition to identifying individual predictors, we aimed for an adequate multivariate prediction of academic performance, with as few as possible incorrect predictions being made. Moreover, we explored whether any meaningful interactions could be found between predictor variables that would improve the prediction of academic performance. Finally, cross-validation was used to examine the extent to which the predictive models could be generalized beyond the sample.

2. Method

2.1 Participants

Invitations for the intake questionnaire were sent to all 1230 pre-registered applicants for the studies of Law, Physics, Biology, Philosophy and Religious Studies at Leiden University in the academic year 2012-2013². The majority of the approached applicants (739, 60%) filled

¹ ECTS stands for European Credit Transfer and accumulation System, the norm being 60 ECTS a year for a full time study program (1500-1800 hours).

² This was not necessarily their study of first-choice: applicants can apply for a maximum of three tertiary education studies in the Netherlands.

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out the online questionnaire, of whom 656 (89%) filled it out completely and 83 applicants (11%) filled it out partially. Out of the 739 applicants who filled out the intake questionnaire, 501 also definitively entered the study for which they had taken the questionnaire. These 501 participants that actually started ('starters') were compared with the 238 participants who did not definitively sign up ('non-starters', see Table 1 for associations between study entry and categorical variables). Both groups did not differ significantly in terms of gender nor on preparatory education GPA (Starters $M = 6.80$, $SD = 0.68$; and non-starters $M = 6.83$, $SD = 0.74$), $t(557) = -0.45$, $p = 0.65$, $d = 0.07$. However, starters were significantly younger ($M = 19.01$, $SD = 3.75$) than non-starters ($M = 20.41$, $SD = 5.68$), *Welch's* $t(321.52) = 3.38$, $p < .001$, $d = 0.31$. Starters were also significantly more likely to have the Dutch nationality and had more often indicated that the study was their first choice than non-starters. Finally, starters were significantly more likely to have been in pre-university secondary education, whereas they were significantly less likely to have been in 'other' education than non-starters.

[Table 1 About Here]

2.2 Procedure

Each applicant received a personalized e-mail invitation on behalf of the educational director of the particular study they had pre-registered for, with the request to fill out an online intake questionnaire within four days. They were instructed to fill out the questionnaire honestly and comprehensively, and were informed that their answers would be treated confidentially and would not be used for selection purposes. Applicants who did not fill out the questionnaire within two weeks received a reminder. Partially completed questionnaires were automatically recorded after six months, or shortly after the start of the academic year (on September 15th), whichever came first. Invitations were sent out to new applicants at regular, one week intervals to ensure that applicants received the invitation soon

after their pre-registration. The intake questionnaire was presented to applicants using the Qualtrics online survey system (www.qualtrics.com).

2.3 Measures

2.3.1 Predictor variables. A large number of variables were assessed, of which those relevant to the current research questions will be described below. Predictor variables may be clustered in seven domains with related content. The description of the variables below is organized accordingly. Descriptive statistics are shown in Appendices A and B.

Horizontal slider scales were used for most discrete numerical variables. The scales ranged from 0 to 10, with the starting points located at the lower end of the scales. Unless indicated otherwise, the extremes were labeled with ‘completely disagree’ (lower extreme) and ‘completely agree’ (upper extreme). Labels were provided for ‘disagree’, ‘neutral’, and ‘agree’ at evenly spaced intervals above the slider scales. The distances of the scores on the slider scales from 0 were rounded to the closest integer between 0 and 10.

Domain 1: Socio-demographic characteristics.

Demographics. The Dutch centralized system for registration provided the applicant’s *gender*, date of birth and country of origin. Participants were given the opportunity to correct this information if necessary. Date of birth was then converted into *age in years* at the time of application, and country of origin was recoded in a dichotomous *nationality* variable indicating whether participants were Dutch or not.

Perceived personal risk factors. Participants indicated which circumstances or difficulties applied to them, by selecting these from a list that contained ten pre-set circumstances commonly considered by study-advisors to bear risk for study progress (e.g., ‘I have problems concentrating’, ‘I intend to have a job in addition to my study’). Participants were also offered an option to add another personal (non-listed) circumstance. For each of the selected circumstances, participants indicated to what extent they deemed that particular

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situation a risk to their study progress. Slider scales were used with labels for ‘no risk’ and ‘large risk’ at the lower and upper extreme, respectively, and ‘small risk’ and ‘substantial risk’ at equally spaced intervals above the slider scales. For each of the ten circumstances, a variable was constructed with [1] ‘not applicable’, [2] ‘low risk’(below median), and [3] ‘high risk’ (above median). For ‘physical disability’, the categories ‘low risk’ and ‘high risk’ were merged, as this condition applied to very few participants.

Domain 2: Educational history.

Preparatory education type. The specific type of preparatory education was provided by the Dutch centralized system and could be corrected by the participant if necessary. A categorical variable was then constructed with ‘pre-university secondary education’ (the highest level in high school), ‘higher professional education’, ‘university education’, and ‘different tracks’ (e.g., foreign diplomas, alternative educational paths).

Preparatory education GPA. The Dutch centralized system provided final grades for those participants who had been in pre-university secondary education before their application. The final grades for the core courses mathematics, English and Dutch were averaged to create a measure of high school GPA. Participants with earlier tertiary education reported their average grade on their most recent grade list, first year exam, and final exam. If available, the average grade on the final exam grade was used as an indicator of preparatory education GPA. If not, we used the first year exam, or, if first year exam was unavailable, the average grade on the most recent grade list. Preparatory education GPA ranged from 5 to 9, with higher grades indicating better academic performance in the past.

Preparatory education time investment. One question assessed how many hours participants had spent on their preparatory education on average per week during the last year at school.

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Preparatory education extracurricular activities. Participants indicated in which activities they had participated in addition to their preparatory education, by selecting these from a list that contained eight pre-set activities (e.g., ‘professional sports’, ‘volunteer job’), as well as an option to add another activity. One answer category (i.e., ‘music education at a conservatory’) applied to a very small number of participants and was therefore not used in the prediction analyses.

Tertiary education drop-out. Participants indicated whether they had previously dropped out from a study or not by selecting one or more of the following options: ‘no’ (exclusive answer), ‘yes, higher professional education’, ‘yes, university education’, or ‘yes, other education’. A categorical variable was constructed that indicated whether participants had not dropped out from a study, or had dropped out from higher professional education, or university education, or from either other education or at least two types of education.

Tertiary education failure. Participants were asked with one question whether they had ever received a negative binding study recommendation in tertiary education (i.e., were excluded from the program), with answer categories [1] ‘no’, [2] ‘I don’t know’, [3] ‘yes’. The first and second category were used as one combined category in the analyses.

Domain 3: Academic social encouragement.

Academic social context. In order to assess familiarity with the academic social context, participants were asked to indicate whom of their family members had attended or currently attends education at a university by selecting one or more of the following options: ‘At least one of my parents/caregivers attended university education’, ‘I have at least one brother/sister who attends/attended university education’, ‘I have other family members who attend/attended university education’, or ‘I am the first in my family to attend university education’ (exclusive answer). A categorical variable was constructed that reflected the eight possible answer combinations.

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Academic motivational support. Participants indicated on slider scales to what extent they agreed with seven statements that assessed how much social support participants received from their social environment for attending university education, for example ‘My parents/caregivers stimulated me to study’.

Domain 4: Discipline selection process.

Informational preparation. Participants selected which out of fourteen approaches they had used to familiarize themselves with the discipline they had applied for. These ranged from more distal sources (e.g., ‘via high school’ or ‘via a brochure’) to intensive preparation (e.g., taking part in student-for-a-day program and consultations with advisers of the particular academic stud program). Participants could also add another method, or indicate that they had not yet familiarized themselves with the study at all (exclusive answer, not used as a category in the analyses).

Knowledge of regulations. Participants were asked with two questions whether they were familiar with two measures instigated by Leiden University to improve study success, or not: the so-called ‘binding study recommendation’ and the ‘regulation for long-term students’.

Perceived adequacy of preparation. Participants indicated on a slider scale to what extent they agreed with the statement ‘I have prepared my choice for (name of the discipline) very thoroughly’.

Discipline preference. Participants were asked with one question whether the discipline that they had applied for was the discipline of their first choice or not.

Perceived discipline match. One question was used to assess the extent to which participants perceived the discipline to fit with who they are, with answer categories [1] ‘no, I do not think (name of the discipline) fits me’, [2] ‘I’m not sure whether (name of the

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discipline) fits me', or [3] 'yes, (name of the discipline) completely fits me'. The first and second category were used as one combined category in the analyses.

Decision confidence. One question was used to assess the likelihood that participants would start with their study in the subsequent semester, provided they would, by then, meet entry requirements. Answer categories were [1] 'I'm sure I'll start with (name of the discipline)', [2] 'I'm not completely sure yet', [3] 'I might study something else', [4] 'I'm already sure that I will study something else'. These categories were recoded into a dichotomous variable that indicated whether participants would definitely start or not.

Domain 5: Study skills, attributions, perceptions and expectations.

Perceived context-discipline match. Participants indicated on a slider scale to what extent they agreed with the statement 'My own situation and background are optimal to study (name of the discipline)'.

Perceived study skills and academic self-efficacy. Participants indicated on slider scales to what extent they agreed with 23 statements that assessed several aspects of their study skills and academic self-efficacy, for example 'I study easily', 'When I have lot of homework, I first make a schedule', 'The study needs to offer much supervision'. One additional item assessed participants' general academic self-efficacy, 'My study skills are excellent'.

Attribution of past study success. Participants indicated on slider scales to what extent they agreed with six statements that assessed their attribution of past academic success, for example 'I've come this far due to my parents' support' and 'I've come this far due to my own persistence'.

Motivational incentives (extrinsic and intrinsic motivation). Participants indicated to what extent each of thirteen motives had influenced their choice for the discipline that they had applied for. Both intrinsic (e.g., 'I would love to have a job in this field') and extrinsic

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motivation (e.g., ‘I will be able to make a lot of money when I’ve finished (name of the discipline)’)) were assessed. Slider scales were used with labels at [1] ‘no influence at all’, [3] ‘no influence’, [5] ‘neutral’, [7] ‘small influence’, and [9] ‘strong influence’. In addition, participants indicated on a slider scale to what extent they agreed with the more general statement ‘I am very motivated to start working on (name of the discipline)’.

Perceived preparatory education-requirements match. Participants indicated on a slider scale to what extent they agreed with the statement ‘I think my preparatory education perfectly matches the requirements of (name of the discipline)’.

Perceived preparatory education – progress expectations. Participants indicated on a slider scale to what extent they agreed with the statement ‘My preparatory education has equipped me well enough to pass the first year without delay’.

Expected study progress (ECTS). Participants indicated on a slider scale how many of the nominal progress of 60 ECTS they expected to obtain in their first year. They were informed that at least 40 ECTS were necessary to receive a positive binding study recommendation. The scale ranged from 0 to 60, with labels at [0] ‘none’, [30] ‘half’ and [60] ‘all’.

Expected study time investment. One question was used to assess how many hours per week participants intended to spend on their study.

Expected time investment other activities. Participants selected which out of thirteen pre-set activities they intended to undertake in addition to their study, such as ‘actively participate in a student organization’ or ‘a discipline related side job’. Participants could also add another activity. Participants subsequently indicated how many hours a week they intended to spend on each of the selected activities.

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Expected study prioritization. Participants indicated on a slider scale to what extent they agreed with the statement ‘I easily give my study priority over leisure, other activities, and work’.

Domain 6: Response characteristics. *Questionnaire completion* indicated whether participants had completed the questionnaire or not, and *response time* indicated how long it took to fill out the questionnaire in hours.

Domain 7: Discipline characteristics (control variables).

Type of discipline. A single variable indicated which specific discipline participants had applied for, that is, Law, Physics, Biology, Philosophy or Religious Studies. Philosophy and Religious Studies were taken together in the analyses.

Mode of study. One variable indicated whether participants were part-time or fulltime students.

2.3.2 Outcome variables. After the first academic year, the data obtained with the intake questionnaire were enriched with data from the university’s student tracking system. Three indicators of academic performance in the first academic year were used as separate outcome variables.

GPA. GPA was calculated as a weighted mean of the grades obtained for obligatory courses in the first academic year. In the Dutch education system grades may range from 1 to 10, with higher scores indicating better performance and scores below 6 indicating unsatisfactory performance. As only grades obtained for passed courses were registered in the university’s student tracking system, a 5 was imputed when a grade was missing for a certain course. This approach corresponds with grading systems in the UK and US that award an ‘F’ for failed courses, regardless of proximity to satisfactory performance. No GPA was calculated for students who had not passed any course. Further, grades for exempted courses were not used for the calculation of GPA, as these grades were automatically set to be a 6 in

the student tracking system. They therefore do not necessarily reflect actual performance level. The correlation between the original GPA variable and the GPA variable with imputed 5s was strong and positive, $r = .85$, $p < .001$.

ECTS in first year. ECTS was calculated as the total number of ECTS obtained for obligatory courses in the first academic year and ranged from 0 to 60. In line with the university's policy, ECTS for exempted courses were included in the calculation of ECTS (i.e., the propaedeutic diploma can be acquired when an exemption has been granted for certain courses). This continuous variable was then recoded into a categorical variable with meaningful categories in line with the university's policy. Specifically, we distinguished between failure (students who received a negative binding study recommendation), delay (students who did not obtain the required number of ECTS), and nominal progress (students who passed their propaedeutic exam), with [1] 'below 40 ECTS', [2] '40 to 60 ECTS', and [3] '60 ECTS or more', respectively. The second category of students with delayed progress was used as the reference category in the analyses, to allow for comparison with students who failed or had nominal study progress.

Attrition. Attrition was operationalized as absence of retention. Students who did not re-enroll for the same discipline in the second year were treated as drop-outs, whereas students who dropped out *during* the second year were not.

2.4 Statistical analyses

To answer RQ1 (i.e., scale construction), we performed multiple correspondence analyses on (groups of) categorical predictor variables, and categorical principal component analyses (CATPCA) on interval variables and combinations of categorical and interval variables (Linting & Van der Kooij, 2012). CATPCA is an appropriate approach to analyze variables with different measurement levels that may have nonlinear relationships. CATPCA differs from linear PCA as it takes the measurement levels of variables into account, and can

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quantify variables in order to optimally represent the information in the data. Multiple correspondence analyses and CATPCAs were performed using SPSS. In the CATPCAs, the scaling levels were selected taking the improvement of Cronbach's α of the dimensions and the variance accounted for by the dimensions into account. CATPCA was followed by conventional principal component analysis (PCA) with Varimax rotation to allow for interpretation of the components. Scales were then constructed by adding the quantified items that had a minimum component loading of .30 on the respective component. Items with negative component loadings were multiplied by -1. To enhance the sample size, we used data from both the 2012-2013 cohort and the 2013-2014 cohort in these analyses. This led to the inclusion of 2445 participants in the analyses, of whom 2233 filled out the entire intake questionnaire.

To answer RQ2 (i.e., prediction of academic performance), we performed linear, multinomial logistic and binomial logistic regression analyses to predict GPA, ECTS and attrition, respectively, in the 2012-2013 cohort. Before conducting these analyses, associations between GPA, ECTS and attrition were examined with ANOVAs and χ^2 -tests. All prediction analyses were then performed in R statistical software (R Core Team, 2014). The analyses were conducted in two steps for each of the outcome variables. Within-domain analyses of Domains 1 to 6 were performed first, controlled for Discipline characteristics (Domain 7) in each within-domain analysis. Predictors with a p -value $< .10$ for the regression coefficient were then entered in a final model.³ Multinomial logistic regression analyses were performed with the MLOGIT package (Croissant, 2013). The goodness of fit of each of the final models was estimated using leave-one-out cross-validation (R^2 for GPA, correct classification rate for ECTS and attrition, and area under the curve for attrition). Predicted

³ Predictors were also selected through an elastic net regularization approach (Friedman, Hastie, & Tibshirani, 2010). The value of the regularization parameter lambda was selected based on minimum mean cross-validated error. However, this procedure did not lead to models with better cross-validated fit than the selection of predictors with $p < .10$.

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classifications were based on the highest predicted probability for ECTS. For attrition, a cut-off score was specified such that the specificity (i.e., correct classification of re-enrollment) was at least .80 and the sensitivity (i.e., correct classification of drop-out) was maximized. For cases whose predicted probabilities were above this cut-off score, 'drop-out' was predicted. Furthermore, to identify possible interaction effects, Regression tree analysis (Breiman, Friedman, Olshen, & Stone, 1984) were performed with the RPART package (Therneau, Atkinson & Ripley, 2015) on all predictors. The minimum number of participants in a leaf was fixed at 5, and the minimum increase in fit (complexity parameter) was set at 0.0001. For the remaining we used the default options. The selection process of the initial, non-pruned tree was performed 1000 times. The best tree was then pruned.

3. Results

3.1 Scale construction (RQ1)

We performed separate CATPCAs on the 31 items that assessed aspects of learning and studying (i.e., perceived study skills and academic self-efficacy, attribution of past study success, perceived context-discipline match), the fourteen items that assessed motivational incentives, and the seven items that assessed academic motivational support. This led to the construction of reliable and meaningful scales that could be used in the prediction of academic performance.

3.1.1 Learning and studying. Three meaningful and reliable scales were constructed to measure aspects of learning and studying. Specifically, two categorical principal component analyses (CATPCA) were performed on the 31 items that assessed perceived study skills and academic self-efficacy, attribution of past study success, and perceived context-discipline match. An initial CATPCA with 31 variables and ordinal quantifications showed three large components. A second CATPCA was then performed with optimal quantifications for three dimensions. Based on the Cronbach's α of each of the three

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dimensions and the variance accounted for by these dimensions, spline ordinal was selected as the best scaling level. Together, the three dimensions accounted for 39.31% of variance. Conventional PCA with Varimax rotation was then performed on the scaled variables to interpret the three components (see Table 2 for rotated component loadings). The first component could be interpreted as 'Academic self-efficacy', the second component as 'Self-regulation', and the third component as a need for 'Practical education and close contact'. To improve reliability of the scales, two items were removed from the Self-regulation component (i.e., 'I've come this far due to my parents' support' and 'I did not have to work hard in school so far'), and three items were removed from the Practical education and close contact component (i.e., 'I've come this far due to inspiring teachers', 'I want to discuss the study material with others to gain more knowledge', and 'I need help with studying'). These five items were also not included in the subsequent prediction analyses of academic performance. One item (i.e., 'I've come this far due to my friends') had component loadings below .30 on each of the components and was included in the prediction analyses in its original form. The final scales were reliable, with Academic self-efficacy $\alpha = .88$, Self-regulation $\alpha = .82$, and Practical education and close contact $\alpha = .74$. Academic self-efficacy and Self-regulation were strongly correlated ($r = .71$), whereas Practical education and close contact had weak correlations with Academic self-efficacy ($r = .12$) and Self-regulation ($r = .18$).

[Table 2 About Here]

3.1.2 Motivational incentives. Two meaningful and reliable scales were constructed that assessed strength of intrinsic and extrinsic motivation. Specifically, we analyzed the fourteen motivation items with a CATPCA that optimized quantifications for two dimensions. Based on the α of each of the two dimensions and the variance accounted for by these dimensions, spline ordinal was selected as the best scaling level. Together, the two

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dimensions accounted for 51.75% of variance. Conventional PCA with Varimax rotation suggested that the two components reflected Intrinsic motivation and Extrinsic motivation, respectively (see Table 3 for rotated component loadings). Two items were removed from the Extrinsic motivation component to improve the reliability of the scale (i.e., '(Name of the discipline) offers me broad general knowledge', and 'I expect (name of the discipline) to allow enough time for a side job, additional activities, hobbies, etcetera'). The Intrinsic motivation and final Extrinsic motivation scales were reliable, with $\alpha = .85$ and $\alpha = .86$, respectively. Extrinsic and intrinsic motivation were weakly correlated ($r = .20$).

[Table 3 About Here]

3.1.3 Academic motivational support. One meaningful and reliable scale was constructed to assess academic motivational support for attending university education. CATPCA on the seven social support items showed one dimension in the data. Ordinal quantification allowed for the most straightforward interpretation. The dimension accounted for 48.82% of variance ($\alpha = .80$).

3.1.4 Additional scale construction analyses. We also performed CATPCA on the eight numeric items that assessed perceived personal risk factors, and on a combination of perceived preparatory education-requirements match, perceived preparatory education – progress expectations, expected study progress (ECTS), and the fourteen items that measured expected time investment in other activities. The results of these analyses indicated that the items could not be combined into meaningful and reliable scales, as no solutions were found with dimensions that had both satisfactory Cronbach's α and variances accounted for (VAF). Specifically, for perceived personal risk factors Cronbach's α s of the dimensions did not exceed .56 in all solutions, and total VAFs ranged between 15.56% and 36.07%. For expected progress and time investment, Cronbach's α s did not exceed .64 and total VAFs ranged between 12.26% and 38.73%. Similarly, multiple correspondence analyses were

unsuccessful on the academic social context items (Cronbach's $\alpha < .44$), the nine preparatory education extracurricular activities items (Cronbach's $\alpha < .26$), fifteen informational preparation items (Cronbach's $\alpha < .59$), and the eight binary items that measured perceived personal risk factors (Cronbach's $\alpha < .30$). Items that were not combined into a scale were therefore used in their original form, or recoded according to the description in the methods section, to predict academic performance.

3.2 Prediction of academic performance (RQ2)

3.2.1 Preliminary analyses. Before performing the prediction analyses, associations between GPA, ECTS and attrition were examined. First, ANOVA showed a significant association between GPA and ECTS, $F(2,490) = 314.52, p < .001, \eta^2 = 0.56$. Follow-up t-tests corrected for unequal variances showed that students with study failure (<40 ECTS) had a significantly lower GPA ($M=5.56, SD=0.31$) than students who obtained more than 40 ECTS ($M=6.80, SD=0.68; t(392.99)=-27.38, p < .001, d=2.04$). Also, GPA was significantly lower among students with study delay (40-60 ECTS; $M=6.40, SD=0.54$) than among students with nominal progress (≥ 60 ECTS; $M=7.09, SD=0.60, t(367.94)=-11.75; p < .001, d=1.20$). Second, a t-test showed a significant association between GPA and attrition, such that students who dropped out had a lower GPA ($M=5.76, SD=0.73$) than students who re-enrolled ($M=6.69, SD=0.71, t(491) = -11.13, p < .001, d=1.30$). Third, a significant association was found between attrition and ECTS in first year, $\chi^2(2)=201.90, p < .001$ (see Table 4). Specifically, among students who dropped out there were significantly more students with study failure (<40 ECTS) than would be expected if attrition and ECTS were not associated. Also, among drop-outs, there were significantly less students than expected who obtained more than 40 ECTS. Similarly, among students who re-enrolled there were significantly more students than expected who obtained more than 40 ECTS, and there were significantly less students than expected who obtained less than 40 ECTS.

[Table 4 About Here]

3.2.2 GPA.

Linear regression analyses. Linear regression analysis showed that variables from the domains Socio-demographic characteristics, Educational history and Study skills, attributions, perceptions and expectations predicted GPA (see Table 5; see also note 3). Specifically, the final model showed that non-Dutch students had a significantly lower GPA than Dutch students. Also, compared with students who were not enrolled in a second discipline, students with a second discipline who estimated the risk for study delay to be high had a significantly lower GPA. With regard to Educational history, students who had been in ‘different tracks’ before applying for Leiden University had significantly lower GPAs than students who had been in pre-university secondary education, and students who had been in higher professional education tended to have lower GPAs than students who had been in pre-university secondary education. Further, higher preparatory education GPA significantly predicted higher GPA. With regard to Study skills, attributions, perceptions and expectations, the more hours students expected to spend on student organizations, the lower their GPA. Finally, marginally significant associations were found between stronger extrinsic motivation and lower GPA, and between larger expected study progress and higher GPA. The model explained a substantial part of the variance in GPA ($R^2 = .31$). Leave-one-out cross-validation showed a somewhat weaker fit (cross-validated $R^2 = .23$), suggesting that the model does not generalize very well beyond the sample.

[Table 5 About Here]

Regression tree analysis. Regression tree analysis with all predictor variables resulted in a regression tree with one split on preparatory education GPA and two terminal nodes (N=392, see Figure 1). Specifically, for students with a preparatory education GPA below 7.32, first year GPA was predicted to be 6.38 (n=291), and for students with a preparatory

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education GPA equal to or above 7.32 first year GPA was predicted to be 7.07 ($n=101$), yielding a large effect size $d = 0.91$. Leave-one-out cross-validation of this model showed that the model did not predict GPA better than the regression model (cross-validated $R^2 = .14$).

[Figure 1 About Here]

3.2.3 ECTS in first year. Multinomial logistic regression analyses were performed to predict ECTS in first year. In this analysis, 40-60 ECTS (study delay) was used as the reference category, such that the likelihoods of obtaining less than 40 ECTS (failure) or obtaining 60 ECTS or more (nominal progress) were compared with study delay. Variables from all domains predicted the number of ECTS obtained in the first year (see Table 5). Specifically, with regard to Socio-demographic characteristics, the final model showed that compared with Dutch students, non-Dutch students were significantly more likely to show study failure. Also, students who indicated that their tasks in housekeeping would be a risk to their study progress were most likely to show study delay. With regard to Educational history, students who had been in university before applying for Leiden University (compared with students who had been in pre-university secondary education), and students with higher preparatory education GPA were significantly more likely to show nominal progress. In addition, marginal effects of preparatory education time investment and tertiary education failure were found. Specifically, larger time investment in preparatory education was associated with a higher likelihood of study failure, and students who had received a negative binding study recommendation before (compared with students who had not) tended to be less likely to show nominal progress. With regard to Academic social encouragement, the more academic motivational support students received, the more likely they were to have study delay. Discipline selection process variables also predicted ECTS, such that students who had gathered information about the discipline through school or a study advisor

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(compared with students who had not) were significantly more likely to show nominal progress, and students who had gathered information by reading a brochure tended to be more likely to show nominal progress. Further, students who were familiar with the regulation for long-term students (compared with students who were not) were significantly less likely to show nominal progress. A marginal effect of decision confidence was found, such that students who were not sure that they would start with their study in the subsequent semester tended to be less likely to show nominal progress. With regard to Study skills, attributions, perceptions and expectations, results showed that stronger Self-regulation significantly predicted a higher likelihood of nominal progress. Also, students with a stronger preference for practical education and close contact were significantly less likely to have study delay than to fail or show nominal progress. Further, the more students attributed past study success to friends, the less likely they were to show nominal progress, and students with stronger extrinsic motivation tended to be less likely to show nominal progress. Finally, the more time students expected to spend on a side job unrelated to the discipline, a second discipline, or other activities (e.g., a paid/unpaid job, hobbies), the less likely they were to show nominal progress. With regard to Discipline characteristics, compared with Law students, Physics students were less likely to show nominal progress. Finally, a marginal effect of response time was found, such that students who spent more time on filling out the questionnaire tended to be more likely to have study delay. The overall correct classification rate of the model was 0.66. Leave-one-out cross-validation yielded a smaller cross-validated correct classification rate of 0.52 (see Table 6 for a cross tabulation of predicted and observed classes). The correct classification rate of the model compares favorably to the correct classification rate based on chance alone, that is the overall correct classification rate if the largest class of ‘nominal progress’ (≥ 60 ECTS) would be predicted for all participants (correct classification rate 0.48). Importantly, the correct classification rate of those who

failed (< 40 ECTS) or those with study delay (40-60 ECTS) would by definition be 0 in this model. Regression tree analysis with all predictors did not lead to an alternative model.

[Tables 6 and 7 About Here]

3.2.4 Attrition. Binomial logistic regression analyses showed that variables from the domains Educational history, Discipline selection process, Study skills, attributions, perceptions and expectations, and Discipline characteristics predicted attrition (see Table 5). Specifically, results showed that preparatory education predicted attrition, such that students who had been in ‘different tracks’ were significantly more likely to drop out than students who had been in pre-university secondary education. In addition, the lower students’ preparatory education GPA, the more likely they were to drop out. With regard to Discipline selection process, students who had familiarized themselves with the discipline through an e-study guide or a professional with a discipline-related job were significantly less likely to drop out than students who had not done so, and students who were not sure whether they would start with their studies at the time they filled out the LIQ were marginally more likely to drop out. Furthermore, the more time students expected to spend on a study organization, the lower the likelihood that they would drop out. Finally, compared with Law students, students of Philosophy or Religious studies were significantly more likely to drop out. The AUC of the model was .76. Leave-one-out cross-validation yielded a cross-validated AUC of .68. Further, results showed that the optimal cut-off score for individual prediction was 0.27, such that participants with a predicted probability of attrition below 0.27 were predicted to re-enroll, and participants with a predicted probability of attrition equal to or above 0.27 were predicted to drop out (see Table 7). The model with a cut-off score of 0.27 had a specificity of 0.82 (correct prediction of re-enrollment) and a sensitivity of 0.46 (correct prediction of attrition). The overall correct classification rate was 0.75. Leave-one-out cross-validation yielded a similar cross-validated correct classification rate of 0.72. The correct classification

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rate based on chance alone, that is, when the largest outcome category (i.e., re-enrollment) would be predicted for all participants is somewhat higher (correct classification rate 0.82). Importantly, the correct classification rate of those who dropped out would by definition be 0 in this model. Regression tree analysis with all predictors did not lead to an alternative model.

4. Discussion

The current prospective study examined how pre-entry data obtained with the Leiden Intake Questionnaire (LIQ) may be used to predict academic performance in university students in their first academic year. Reliable scales were constructed, and used in the prediction of quality of outcome (GPA), efficiency of outcome (ECTS) and study continuity (attrition).

Results showed that educational history is a very important determinant of first year academic performance. First, linear and logistic regression analyses showed that preparatory education GPA predicted all three indicators of academic performance, such that students with a higher GPA in preparatory education had a significantly higher first year GPA at university, were significantly more likely to obtain 60 ECTS (i.e., pass their propaedeutic exam), and were significantly less likely to drop out. The regression tree analysis confirmed the importance of preparatory education GPA in predicating first year GPA. In addition, these showed that the critical cut-off point lies at 7.32. In other words, students with a preparatory education GPA below 7.32 had a much higher chance of having a low first year GPA at university than students with a preparatory education GPA equal to or above 7.32. Second, linear and logistic regression analyses showed that the type of preparatory education was also important in predicting all three indicators of academic performance. Specifically, compared with students who had been in pre-university secondary education (i.e., the conventional preparatory educational path for university-entry), those who had been in higher professional education were significantly more likely to obtain less than 40 ECTS (i.e., receive a negative binding study recommendation), and those who had been in 'different tracks' were

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significantly more likely to drop out, and had significantly lower first year GPAs. Arguably, students who have been in pre-university secondary education, or who have already studied at a university, may be better prepared for their academic studies than students with other educational backgrounds.

Nationality and expected time investment in a study organization both predicted two of the indicators of academic performance. Students who did not have the Dutch nationality were less successful than Dutch students. Specifically, foreign students had significantly lower GPAs and were also significantly more likely to obtain less than 40 ECTS and thus receive a negative binding study recommendation. Interestingly, nationality and the other socio-demographic characteristics (e.g., personal risk factors) did not predict attrition, suggesting that the group of drop-outs, in this respect, might be heterogeneous in terms of demographics. Furthermore, students who expected to spend more time on a study organization were more successful in terms of a lower likelihood to obtain less than 40 ECTS and to drop out. Since these organizations pay considerable attention to both improving the social network within the discipline, as well as deepening and broadening subjects that pertain to that discipline, this may reflect both motivation and belongingness.

Finally, a number of predictors was important for one of our outcome variables. With regard to GPA, students who beforehand wanted to take on a second discipline and judged this to be a high risk to their study success, and students who expected to invest more time in student organizations had significantly lower GPAs. In contrast to findings for *study* organizations, *student* organizations thus had a negative effect on academic performance. Although investment in student organizations also reflects belongingness, students who invest much time in student organizations can be expected to have a weaker focus on their studies. With regard to ECTS, students who had familiarized themselves with the discipline through school or a study advisor, and students with higher self-regulation were more

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significantly likely to obtain 60 ECTS. Those who knew about the regulation for long-term students, attributed their past study success to friends to a greater extent, and students who expected to spend more time on a side job unrelated to the discipline, a second discipline or other activities such as a paid/unpaid job or hobbies were significantly less likely to obtain 60 ECTS. Moreover, students who perceived their tasks in housekeeping as a high risk for their study success and students who received more academic motivational support were most likely to have study delay (obtain 40-60 ECTS). Interestingly, students who had a stronger need for practical education and close contact were least likely to experience study delay (obtain 40-60 ECTS), but more likely to either fail or show nominal performance. Finally, students who had familiarized themselves with the discipline through an e-study guide or a professional with a discipline-related job were less likely to drop out.

Our findings relate to findings by Richardson and colleagues (2012) and Robbins and colleagues (2004), showing that GPA in preparatory education is an important predictor of academic performance in university. Further, in line with previous work showing that stronger self-regulation predicts better academic performance in terms of higher GPA and lower attrition, we found that stronger self-regulation predicts better academic performance in terms of ECTS. However, self-regulation did not predict GPA and attrition in our sample. Also, in contrast to the literature (e.g., Richardson et al., 2012; Robbins et al., 2004), we did not find that academic self-efficacy predicted academic performance in the final models, although it did emerge as a predictor of ECTS in the within-domain analyses. The difference between self-regulation and self-efficacy in this respect may again point to the more general finding in our study that variables tapping concrete pre-university behavior (the regulation-variables assessed how students concretely organized and planned their current study activities) have higher predictive value than psychological attributions (such as academic self-efficacy).

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The current study also has limitations. First, the current sample was relatively small and specific with the majority being Leiden University Law students. Also, as filling out the LIQ was not obligatory, it could be that the sample reflects a specific group of students, for example those who are more motivated. Findings may differ for the broader university student population. Related to this, a larger sample will allow for more differentiation between subgroups of students, for example in terms of type of preparatory education. On the other hand, a common limitation of work on academic performance in tertiary education is range restriction as a consequence of strict selection procedures (e.g., Perera & DiGiacomo, 2013). However, as Leiden University does not use strict selection criteria other than adequate preparatory education, a strength of our study is that a more diverse student population is included. Second, Leiden University's student tracking system lacks grades obtained for failed courses. GPA may have been overestimated to some extent, due to imputation 5's instead of grades ranging from 1 to 5. However, our approach is conservative and more closely mimics the Anglo-Saxon system of an F grade for a failed exam. Third, the pilot version of the LIQ was initially developed as a study-matching tool, with participant engagement being an important goal. Although sliders are thought to be more appealing and to engage participants, their use has been criticized. Sliders have been found to be associated with higher breakoff than visual analogue scales and radio buttons, and data collected with sliders may be biased, mostly because of the use of a starting point that may guide participants' answers (Funke, 2015; Grey Matter Research and Consulting, 2013). The LIQ may therefore be improved by using discrete answer possibilities. Finally, the data obtained with the LIQ was self-reported and might be prone to social desirability biases.

A strength of the current study is the application of regression tree analysis as an advanced way to search for interactions between predictor variables. Another strength is the use of cross-validation, which results in more realistic estimates of the model fit. Our finding

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that the cross-validated fit of the models was approximately 4-26% (attrition and GPA, respectively) less than the apparent fit suggests that caution is warranted when generalizing predictive models of academic performance. Importantly, although the model fit was similar to that found in comparable studies, the chances of prediction errors are too high to use the LIQ as a basis for student selection. The results may however provide a guide for identifying upfront which students may be candidate for more elaborate study programs and who may benefit from additional support. Results suggest that attending to students' preparatory education GPA and type of preparatory education will improve the identification of these students, and may eventually increase academic performance.

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Table 1. Associations between study entry and categorical variables: χ^2 tests (N=660-709).

<i>Variable</i>	<i>Categories</i>	<i>Observed count (expected count)</i>		χ^2 -statistic
		Non-starters	Starters	
Gender	Female	137 (130)	286 (293)	$\chi^2(1) = 1.10, p = .29$
	Male	80 (86)	202 (195)	
Nationality	Dutch	195 (130)**	430 (293)**	$\chi^2(1) = 7.04, p < .01$
	Non-Dutch	19 (87)**	16 (195)**	
Preparatory education type	Pre-university secondary education	151 (168)**	381 (364)**	$\chi^2(3) = 14.57, p < .01$
	Higher professional education	33 (28)	55 (60)	
	University education	11 (10)	22 (23)	
	Other	29 (18)***	27 (38)***	
Discipline preference	Yes	156 (171)**	405 (390)**	$\chi^2(1) = 8.56, p < .01$
	No	57 (42)**	82 (97)**	

*** $p < .001$, ** $p < .01$

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Table 2. Learning and studying: Component loadings after CATPCA quantifications and Varimax rotations (N=2301).

<i>Item</i>	Component		
	<i>1</i>	<i>2</i>	<i>3</i>
I study easily	.753	-.028	-.095
I can easily discern major and minor issues	.687	.134	-.007
I am able to explain others what I've learnt	.627	.189	.104
I've come this far due to my own intelligence	.611	.071	.088
I find it interesting to engage with theoretical matters	.588	.177	.068
I want to explore the study material by myself, rather than have it explained	.562	.186	.215
If I fail a course, I know why	.539	-.170	.014
The study needs to contain exercises that lead me to explore, investigate and solve things autonomously	.525	.195	.222
Before I start working on an exercise, I consider what I am expected to do	.450	.289	.136
My own situation and background are optimal to study (name of the study)	.429	.283	.004
I enjoy reading	.426	.263	.087
I've come this far due to sheer luck	-.304	-.211	.125
I need help with studying	-.491	-.064	.343*
I want to discuss the study material with others to gain more knowledge	.492	.118	.310*
My study skills are excellent	.593	.398	-.004
I am able to concentrate on one topic for a long time	.569	.373	.070
I did not have to work hard in school so far	.541	-.506*	-.085
I can motivate myself to study autonomously	.498	.619	-.007
When I have lot of homework, I first make a schedule	.074	.727	.037
I can easily make a schedule	.285	.687	-.082
I've come this far due to my own persistence	.217	.681	.130
After having studied, I rehearse the study material	.255	.492	.160
I've come this far due to my parents' support	.081	.338*	.226
The study needs to offer much supervision	-.246	.031	.741
The study needs to contain many contact hours (lectures, work groups, practice sessions)	-.054	.053	.725
I immediately want to apply the material I've learnt	.100	.080	.612
The teacher needs to explain much about the study material	.116	-.051	.573
Texts need to be concrete and practical	.017	.109	.572
I find it important that the teachers know me	.208	.130	.520
I've come this far due to inspiring teachers	.203	.018	.342*
I've come this far due to my friends	-.092	.253	.255

Note. Component 1 = Academic self-efficacy; component 2 = Self-regulation; component 3 = Practical education and close contact. Component loadings $\geq .30$ are in bold.

* These items are not included in the scale that is based on the respective component.

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Table 3. Motivational incentives: Component loadings after CATPCA quantifications and Varimax rotations (N=2301).

<i>Item</i>	Component	
	<i>1</i>	<i>2</i>
I am interested in the content of (name of the study)	.788	-.123
I am interested in the field of (name of the study)	.769	-.180
I am very motivated to start working on (name of the study)	.750	-.014
I would love to have a job in this field	.735	.088
I see (name of the study) as a preparation for applying the study in practice later	.659	.188
(Name of the study) completely matches my capacities and skills	.655	.080
The academic training offered by (name of the study) is important to me	.653	.251
I see (name of the study) as a preparation for a future in science	.507	.003
(Name of the study) offers me broad general knowledge	.461	.335*
I will be able to make a lot of money when I've finished (name of the study)	.019	.848
I think I will find a good job after this study	.117	.834
(Name of study) will increase my chances of finding a good job	.135	.809
I think I will gain social status after this study	.096	.749
I expect (name of the study) to allow enough time for a side job, additional activities, hobbies, etcetera	-.113	.558*
<i>Note.</i> Component 1 = Intrinsic motivation; component 2 = Extrinsic motivation. Component loadings $\geq .30$ are in bold.		
* These items are not included in the scale that is based on the respective component.		

Table 4. Association between ECTS in first year and attrition: χ^2 test (N=501).

		<i>Observed count (expected count)</i>	
		Attrition	
ECTS in first year	Failure (< 40 ECTS)	73 (21)***	45 (97)***
	Delay (40-60 ECTS)	8 (29)***	156 (135)***
	Nominal (≥ 60 ECTS)	9 (39)***	210 (180)***

*** $p < .001$

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Table 5. Prediction of GPA, ECTS, and attrition: linear and logistic regression analyses.

Predictors	Categories	GPA (N=392)	ECTS (N=392)		Attrition (N=435; n _{drop-out} =78)
			≥60 (n=188) vs. 40-60 (n=120)	Below 40 (n=84) vs. 40-60 (n=120)	
		<i>b</i> (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Intercept		3.99 (2.81-5.17)	13.72 (0.03-5581.46)	10.06 (0.03-3832.77)	0.66 (0.01-31.98)
Domain 1. Socio-demographic characteristics					
Nationality (non-Dutch)		-0.58 (-1.02- -0.15)**	0.15 (0.01-3.17)	7.99* (1.25-51.06)	
Perceived personal risk factor: concentration problems	Not applicable (<i>Ref</i>)	1.00			
	Low risk	-0.14 (-0.58-0.30)			
	High risk	-0.21 (-0.60-0.19)			
Perceived personal risk factor: many additional activities	Not applicable (<i>Ref</i>)	1.00	1.00	1.00	
	Low risk		0.62 (0.27-1.42)	0.92 (0.34-2.44)	
	High risk		0.65 (0.27-1.58)	0.53 (0.19-1.46)	
Perceived personal risk factor: second discipline	Not applicable (<i>Ref</i>)	1.00			
	Low risk	-0.03 (-0.47-0.41)			
	High risk	-0.50 (-0.95- -0.04)*			
Perceived personal risk factor: housekeeping	Not applicable (<i>Ref</i>)	1.00	1.00	1.00	
	Low risk		0.22 (0.03-1.50)	0.98 (0.19-4.97)	
	High risk		0.05** (0.01-0.30)	0.04** (0.01-0.35)	
Domain 2. Educational history					
Preparatory education type	Pre-university secondary education(<i>Ref</i>)	1.00	1.00	1.00	1.00
	Higher professional education	-0.24 (-0.49-0.01) ⁺	2.13 (0.65-6.94)	4.36* (1.27-14.96)	1.38 (0.59-3.21)
	University education	0.18 (-0.20-0.56)	3.38 (0.60-19.19)	2.07 (0.30-14.19)	0.42 (0.08-2.20)
	Other	-0.56 (-0.9- -0.21)**	0.78 (0.19-3.25)	1.47 (0.34-6.43)	3.40* (1.10-10.48)
Preparatory education GPA		0.46 (0.34-0.58)***	2.55*** (1.52-4.30)	0.62 (0.34-1.14)	0.62* (0.39-0.97)
Preparatory education time investment			1.02 (0.99-1.05)	1.03 ⁺ (1.00-1.07)	
Preparatory education extracurricular additional activities: Other					0.60 (0.27-1.32)
Tertiary education failure			0.19 ⁺ (0.03-1.31)	0.77 (0.17-3.50)	
Domain 3. Academic social					

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<i>encouragement</i>				
Academic motivational support		0.90** (0.83-0.97)	0.93 ⁺ (0.85-1.01)	
<i>Domain 4. Discipline selection process</i>				
Informational preparation: school		1.93* (1.07-3.48)	1.49 (0.75-2.96)	
Informational preparation: brochure	0.03 (-0.12-0.19)	0.57 ⁺ (0.30-1.07)	0.67(0.33-1.34)	
Informational preparation: Pre-University College	0.07 (-0.36-0.50)	3.64 (0.51-26.03)	0.58 (0.04-9.45)	
Informational preparation: e-study guide				0.30* (0.12-0.77)
Informational preparation: professional with discipline-related job				0.31** (0.14-0.70)
Informational preparation: study advisor		3.95** (1.48-10.55)	1.87 (0.60-5.82)	
Knowledge of regulations: binding study recommendation				1.64 (0.90-2.99)
Knowledge of regulations: regulation for long-term students		0.37** (0.19-0.74)	0.79 (0.35-1.80)	
Decision confidence (not sure)		0.26 ⁺ (0.07-1.00)	2.40 (0.75-7.68)	2.41 ⁺ (0.93-6.21)
<i>Domain 5. Study skills, attributions, perceptions and expectations</i>				
Academic self-efficacy		1.02 (0.97-1.07)	0.97 (0.92-1.03)	
Self-regulation	0.01 (-0.01-0.03)	1.09* (1.00-1.20)	0.99 (0.89-1.09)	
Practical education and close contact		1.12** (1.03-1.22)	1.10* (1.00-1.22)	
Attribution past of study success to friends	-0.03 (-0.06-0.01)	0.86* (0.75-0.98)	0.98 (0.84-1.15)	1.11 (0.98-1.25)
Intrinsic motivation	-0.01 (-0.03-0.00)	0.96 (0.89-1.03)	1.06 (0.98-1.15)	
Extrinsic motivation	-0.02 (-0.05-0.00) ⁺	0.92 ⁺ (0.83-1.01)	0.99 (0.88-1.12)	1.05 (0.96-1.15)
Perceived preparatory education – progress expectations	0.06 (-0.00-0.13) ⁺	1.03 (0.76-1.38)	0.87 (0.63-1.20)	
Expected study time investment		1.01 (0.98-1.04)	1.00 (0.96-1.03)	
Expected time investment other activities: student organization	-0.02 (-0.04- -0.01)**			
Expected time investment: representative board		1.95 (0.84-4.49)	2.19 ⁺ (0.92-5.24)	1.22 (0.83-1.80)

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Expected time investment other activities: study organization			0.95 (0.84-1.09)	0.80* (0.66-0.97)	0.76** (0.63-0.91)
Expected time investment other activities: going out with other students			1.03 (0.96-1.10)	0.98 (0.90-1.07)	
Expected time investment other activities: side job unrelated to discipline		-0.01 (-0.02-0.00)	0.94** (0.89-0.98)	0.97 (0.92-1.03)	
Expected time investment other activities: second discipline			0.93* (0.88-0.99)	0.98 (0.92-1.05)	
Expected time investment other activities: internship			1.05 (0.95-1.17)	0.99 (0.88-1.12)	
Expected time investment other activities: other			0.92* (0.86-1.00)	0.97 (0.90-1.05)	
Domain 6. Response characteristics					
Response time			1.00 ⁺ (0.99-1.00)	0.99 ⁺ (0.99-1.00)	
Domain 7. Discipline characteristics					
Type of discipline	Law (<i>Ref</i>)	1.00	1.00	1.00	1.00
	Physics	0.15 (-0.24-0.54)	0.07** (0.02-0.35)	0.54 (0.10-2.96)	1.19 (0.34-4.18)
	Biology	0.02 (-0.22-0.26)	0.96 (0.32-2.85)	0.80 (0.24-2.75)	1.12 (0.47-2.66)
	Philosophy/Religious Studies	-0.18 (-0.58-0.22)	0.26 (0.04-1.54)	2.55 (0.49-13.21)	8.81*** (2.69-28.93)
Mode of study (fulltime)		-0.18 (-0.60-0.25)	0.25 (0.02-2.63)	0.39 (0.04-4.31)	

⁺ $p < .10$, * $p < .05$, ** $p < .01$

Note. GPA $R^2 = .31$; ECTS McFadden $R^2 = .25$; Attrition Nagelkerke $R^2 = .22$. '40-60 ECTS' was used as the reference category in the analyses of ECTS. Variables that did not predict GPA, ECTS or Attrition are not shown.

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Table 6. Cross tabulation of ECTS: Predicted and observed classes (N=392).

		Observed class		
		Failure (< 40 ECTS)	Delay (40 – 60 ECTS)	Nominal ($\geq$ 60 ECTS)
Predicted class (cross-validated)	Failure (< 40 ECTS)	21	25	18
	Delay (40 – 60 ECTS)	31	45	34
	Nominal ($\geq$ 60 ECTS)	32	50	136

Note. Values in the table reflect frequencies. Predicted classes result from multinomial logistic regression analysis.

Table 7. Cross tabulation of Attrition: Predicted and observed classes (N=435).

		Observed class	
		Re-enrollment	Attrition
Predicted class (cross-validated)	Re-enrollment	281	47
	Attrition	76	31

Note. Values in the table reflect frequencies. Predicted classes result from binomial logistic regression analysis.

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Figure 1. Prediction of first year GPA by preparatory education GPA: Regression tree.

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Appendix A. Descriptive statistics of categorical predictor variables.

Predictors	Categories	Frequency (%)
<i>Domain 1. Student background characteristics</i>		
Gender	Female	
	Male	
Nationality	Dutch	430 (96.4%)
	Non-Dutch	16 (3.6%)
Perceived risk: physical disability	Not applicable	473 (98.8%)
	Low/high risk	6 (1.3%)
Perceived risk: dyslexia	Not applicable	459 (95.8%)
	Low risk	12 (2.5%)
	High risk	8 (1.7%)
Perceived risk: concentration problems	Not applicable	447 (93.3%)
	Low risk	14 (2.9%)
	High risk	18 (3.8%)
Perceived risk: conservatory/sports	Not applicable	470 (98.1%)
	Low risk	6 (1.3%)
	High risk	3 (0.6%)
Perceived risk: many additional activities	Not applicable	345 (72.0%)
	Low risk	69 (14.4%)
	High risk	65 (13.6%)
Perceived risk: job	Not applicable	181 (37.8%)
	Low risk	173 (36.1%)
	High risk	125 (26.1%)
Perceived risk: second study	Not applicable	434 (90.6%)
	Low risk	27 (5.6%)
	High risk	18 (3.76%)
Perceived risk: housekeeping	Not applicable	442 (92.3%)
	Low risk	16 (3.3%)
	High risk	21 (4.4%)
Perceived risk: other personal circumstances	Not applicable	430 (89.8%)
	Low risk	21 (4.4%)
	High risk	28 (5.9%)
Perceived risk: living independently	Not applicable	251 (52.4%)
	Low risk	124 (25.9%)
	High risk	104 (21.7%)
<i>Domain 2. Educational history</i>		
Preparatory education type	Pre-university secondary education	381 (78.6)
	Higher professional education	55 (11.3%)
	University education	22 (4.5%)
	Other	27 (5.6%)
Extracurricular activities: work in committee or board	Yes	81 (17.0%)
	No	396 (83.0%)
Extracurricular activities: professional sports	Yes	23 (4.8%)
	No	454 (95.2%)
Extracurricular activities: societal internship	Yes	58 (12.2%)
	No	419 (87.8%)
Extracurricular activities: side-job	Yes	337 (70.7%)
	No	140 (29.4%)
Extracurricular activities: volunteer job	Yes	46 (9.6%)
	No	431 (90.4%)
Extracurricular activities: two or more additional courses in pre-university secondary education	Yes	54 (11.3%)
	No	423 (88.7%)
Extracurricular activities: courses in tertiary educational in addition to pre-university secondary education	Yes	19 (4.0%)
	No	458 (96.0%)
Extracurricular activities: Other	Yes	95 (19.9%)

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	No	382 (80.1%)
Tertiary education drop-out	No	388 (79.7%)
	Higher professional education	45 (9.2%)
	University education	33 (6.8%)
	Other or at least two types of education	21 (4.3%)
Tertiary education failure	Yes	25 (5.1%)
	No	462 (94.9%)
Domain 3. Academic social encouragement		
Academic social context	First university student in family	124 (25.9%)
	Only parent/caretaker	39 (8.1%)
	Only brother/sister	23 (4.8%)
	Only other family members	120 (25.1%)
	Parent/caretaker and brother/sister	6 (1.3%)
	Parent/caretaker and other family members	76 (15.9%)
	Brother/sister and other family members	29 (6.1%)
	Parent/caretaker, brother/sister and other family members	62 (12.9%)
Domain 4. Discipline selection process		
Informational preparation: school	Yes	217 (45.3%)
	No	262 (54.7%)
Informational preparation: information meeting	Yes	95 (19.8%)
	No	384 (80.2%)
Informational preparation: family, friends, acquaintances	Yes	273 (56.9%)
	No	207 (43.1%)
Informational preparation: digital programs	Yes	115 (24.0%)
	No	364 (76.0%)
Informational preparation: study fair	Yes	83 (17.3%)
	No	396 (82.7%)
Informational preparation: Leiden University information day	Yes	274 (57.2%)
	No	205 (42.8%)
Informational preparation: brochure	Yes	281 (58.7%)
	No	198 (41.3%)
Informational preparation: website	Yes	352 (73.5%)
	No	127 (26.5%)
Informational preparation: current/former student	Yes	254 (52.9%)
	No	226 (47.1%)
Informational preparation: student for a day	Yes	184 (38.3%)
	No	296 (61.7%)
Informational preparation: Pre-University College	Yes	12 (2.5%)
	No	467 (97.5%)
Informational preparation: e-study guide	Yes	82 (17.1%)
	No	397 (82.9%)
Informational preparation: professional with study-related job	Yes	122 (25.5%)
	No	357 (74.5%)
Informational preparation: study advisor	Yes	57 (11.9%)
	No	422 (88.1%)
Informational preparation: other	Yes	23 (4.8%)
	No	456 (95.2%)
Knowledge of regulations: binding study recommendation	Yes	326 (67.9%)
	No	154 (32.1%)
Knowledge of regulations: regulation for long-term students	Yes	357 (74.4%)
	No	123 (25.6%)
Discipline preference	First choice	405 (83.2%)
	No first choice	82 (16.8%)
Perceived discipline match	Yes	417 (86.0%)
	No/not sure	68 (14.0%)
Decision confidence	Sure to start	453 (94.4%)

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<i>Domain 6. Response characteristics</i> Questionnaire completion	Not sure to start	27 (5.6%)
	Yes	461 (92.0%)
	No	40 (8.0%)
<i>Domain 7. Discipline characteristics</i>		
Type of discipline	Law	387 (77.35%)
	Physics	30 (6.0%)
	Biology	54 (10.8%)
	Philosophy/Religious Studies	30 (6.0%)
	Fulltime	464 (95.7%)
Mode of study	Part-time	21 (4.3%)

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Appendix B. Descriptive statistics of numeric predictor variables.

Predictors	N	M (SD)	Range
<i>Domain 1. Student background characteristics</i>			
Age in years	484	19.01 (3.75)	16.00-60.00
<i>Domain 2. Educational history</i>			
Preparatory education GPA	465	6.83 (0.68)	5.00-9.00
Preparatory education time investment	477	32.37 (13.57)	0.00-70.00
<i>Domain 3. Academic social encouragement</i>			
Academic motivational support	479	0.18 (4.62)	-9.98-9.99
<i>Domain 4. Discipline selection process</i>			
Perceived adequacy of preparation	479	7.53 (1.64)	1.00-10.00
<i>Domain 5. Study skills, attributions, perceptions and expectations</i>			
Academic self-efficacy	474	0.47 (9.82)	-20.22-34.38
Self-regulation	474	-0.10 (4.98)	-10.36-16.48
Practical education and close contact	474	-0.23 (4.00)	-14.43-15.65
Attribution of past study success to friends	479	5.64 (2.31)	0.00-10.00
Intrinsic motivation	480	-0.02 (6.01)	-12.20-17.19
Extrinsic motivation	480	0.19 (3.37)	-10.76-7.65
Perceived preparatory education – requirements match	463	7.32 (1.70)	0.00-10.00
Perceived preparatory education – progress expectations	485	8.12 (1.24)	4.00-10.00
Expected study progress	463	53.34 (6.36)	21.00-60.00
Expected study time investment	475	36.46 (12.48)	0.00-80.00
Expected time investment: student organization	475	3.09 (4.42)	0.00-30.00
Expected time investment: representative board	475	0.16 (0.79)	0.00-8.00
Expected time investment: study organization	475	1.27 (2.23)	0.00-15.00
Expected time investment: managerial activities	475	0.38 (1.57)	0.00-20.00
Expected time investment: going out with other students	475	4.15 (4.36)	0.00-30.00
Expected time investment: discipline-related side job	475	2.92 (4.73)	0.00-20.00
Expected time investment: side job unrelated to discipline	475	5.15 (6.08)	0.00-40.00
Expected time investment: Honors College	475	0.67 (2.31)	0.00-15.00
Expected time investment: second discipline	475	1.88 (6.65)	0.00-40.00
Expected time investment: additional courses	475	1.27 (3.03)	0.00-20.00
Expected time investment: social media/gaming	475	1.82 (4.19)	0.00-40.00
Expected time investment: internship	475	0.88 (3.67)	0.00-32.00
Expected time investment: sports	475	3.50 (3.55)	0.00-32.00
Expected time investment: other	475	1.26 (8.98)	0.00-168.00
Expected study prioritization	475	7.32 (1.84)	0.00-10.00
<i>Domain 6. Response characteristics</i>			
Response time	501	38.38 (261.79)	0.01-5593.00

N = 392

Preparatory education GPA < 7.3

Preparatory education GPA ≥ 7.3

Group 1 (n = 291)

Group 2 (n = 101)

AUTHOR DISCLOSURE

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We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property.

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