A diagnostic test for students bridging to Engineering Technology:
First analysis and predictive value

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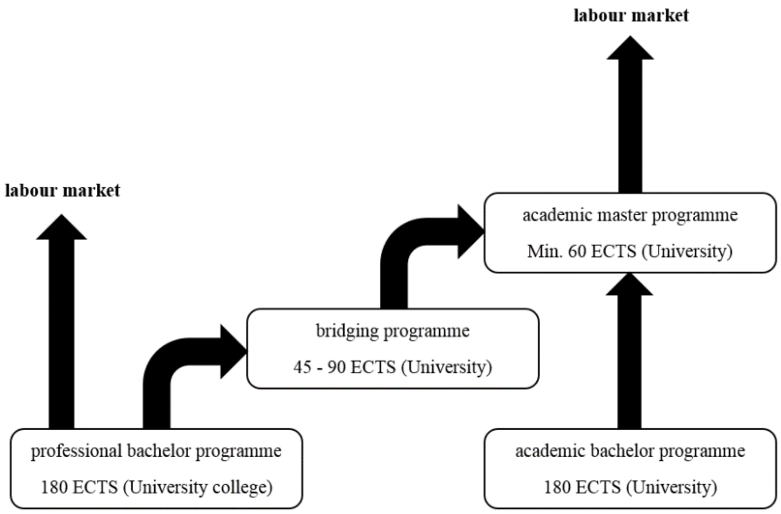
INTRODUCTION

Since entering a STEM study programme at university can be an overwhelming and sometimes even negative experience, it is important to prepare incoming students as good as possible. Several studies aimed at composing and implementing tests that focus on possible study success predictors. These tests can be a tool to select or to help first-year students to position themselves before or at the beginning of the academic year [1,2,3,4].

In Flanders, when a student decides to enter higher education after finishing secondary education (see Figure 1), he/she can choose between two types of bachelor's degrees namely, a professional and an academic one. The purpose of a professional bachelor's degree, organised at an University College, is to prepare the student for a professional occupation. An academic bachelor's degree, organised at a University, is intended to acquire all the necessary knowledge and skills to start a master's programme.

Figure 1. Higher education system in Flanders



In order to stimulate a flexible lifelong learning system, students with a professional bachelor's degree can enrol into an academic master's programme on the condition that they successfully complete a bridging programme. The bridging programme focuses on the missing competences/knowledge that are required to start a master's programme and is organized by the university where the master's degree can be earned. Like first-year students, bridging students also enter university for the first time.

The multi-campus Faculty of Engineering Technology (FET) at KU Leuven counts approximately 800 bridging students. Unfortunately, the success rate of the bridging programme is rather low (around 50%) and although the bridging programme is in theory a one-year programme, in practice half of the students need two (and sometimes even three) years to obtain the certificate.

The combination of the low success rate and the absence of admission requirements in Flanders for STEM programmes, leads to the need for a diagnostic test for possible future bridging students. An optimized, non-binding, and voluntary diagnostic test, for professional bachelor's students (PBA) who are considering enrolling in the bridging programme (BR) is developed and implemented in 2014-2015 [5]. The aim of the diagnostic test is to 1) provide students information on their possible future study success in the bridging programme; 2) stimulate students to make a well-thought-out choice of study programme; and 3) encourage students to participate, if necessary, in intervention initiatives.

The test combines both cognitive as non-cognitive variables and consists of three parts, namely Mathematics Test, four subtests of the Dutch Cognitive Ability Test (CoVaT - CHC) [6], and the Learning And Study Strategies Inventory (LASSI) [7].

In this paper two hypotheses (see 1.3) are tested and a first analysis of the predictive value of the diagnostic test is presented.

1 METHOD

1.1 Diagnostic test

A previous study [5] has focused on the optimized construction of the diagnostic test]. A short description about the three parts of the diagnostic test is provided in the enumeration below.

1) The Mathematics Test consists of 20 multiple choice question, developed by the math lecturers of the bridging programme.

2) The four subtests of the CoVaT- CHC consist of Logical reasoning (i.e. problems similar to the Einstein problem), Proverbs (i.e. find the most suitable explanations for sayings), Folding boxes (i.e. visualize how an unfolded box (2D) can be folded to a box (3D)), and Point series (i.e. discover the mathematical rule and replete the point series).

3) LASSI consists of 77 items, divided into 10 scales: Attitude (ATT; the importance of going to university in a students' life); Motivation (MOT; students' persistence when confronted with challenging study tasks); Time management (TMT; students' tendency to procrastinate and to meet deadlines); Anxiety (ANX; anxiety levels that keep students from performing at the maximum level); Concentration (CON; students' concentration level when in class or studying); Information Processing (INP; students' strategies to learn new information and skills to build bridges between existing and new information); Selecting Main Ideas (SMI; student's ability to select the key message from a text); Study Aids (STA; students' ability to use and create techniques for meaningful learning); Self-testing (SFT; degree to which students monitor/test their progress while studying); and Test Strategies (TST; students' techniques for preparing for and taking tests). Students were asked to rate each item on a five-point Likert scale (1= 'Not at all like me' – 5= 'Very much like me'). A high scale score on for example motivation suggests that a student, according to his/her perceptions, possess enough motivation to exert the required efforts to successfully complete the chosen study programme. Another example: a high scale score on anxiety implies that the student does not worry in advance and has faith in his own capacities.

1.2 Sample

This pilot focuses on the 259 new bridging students enrolled in three of the seven campuses of the FET in 2015-2016. The diagnostic test was organised at two moments: 1) the original test moment at the end of the professional bachelor's programme (between March and June 2015, N=93) and 2) the additional moment at the beginning of the bridging programme (September 2015, N=30). Since one of the aims of the diagnostic test is to stimulate a well-thought-out choice of study programme it is important that the moment of the diagnostic test takes place several months before the start of the new academic year. The additional moment was mainly organised for research reasons. Participation was voluntary and every student received individual feedback afterwards. 75 of the 93 students who participated at the original test moment, decided to enrol in the bridging programme. Consequently 105 (75+30) bridging students participated in the diagnostic test, and 95 students of this group are enrolled in the participating campuses, resulting in a response rate of 37% (95 out 259).

The students are divided into five groups: 1) GROUP 1 who participated at the original test moment and not enrolled in the bridging programme; 2) GROUP 2 who joined the test at the original test moment and enrolled in the bridging programme; 3) GROUP 3[2] who took part in the test during the additional moment; 4) GROUP 4 who enrolled in the bridging programme and took voluntary the diagnostic test (sum of GROUP 2 and 3); 5) GROUP 5 who enrolled in the bridging programme and did not participate in the diagnostic test.

1.3 Hypotheses and corresponding research questions

Since the first aim of the diagnostic test is to provide students information on their possible future study success in the bridging programme, there is reason to believe that students who decide to enrol in the bridging programme are the students with better results (in the assumption that there is a positive, linear relation between the diagnostic test and study percentage in the bridging programme). Therefore the prediction is that GROUP 2 obtains higher results on both the cognitive and non-cognitive part than GROUP 1, resulting in the research question:

- Perform students from GROUP 2 (N=75) significantly better on the diagnostic test than students from GROUP 1 (N=17)?

In the following two research questions only bridging students with a standard study programme are included (i.e. minimum 50 ECTS).The hypothesis is that students who participated in this voluntary diagnostic test, (i.e. GROUP 4), perform better in the bridging programme than students who did not participate. The corresponding research question for this hypothesis is:

- Obtain bridging students from GROUP 4 (N=84), a significant higher academic achievement than students from GROUP 5 (N=127)?

The last research question deals with the predictive value of the diagnostic test:

- What is the predictive value of the separate parts of the diagnostic test and which combination of tests results in the highest predictive power?

[2] For group 3 there are no LASSI results available.

2 RESULTS

2.1 Descriptive statistics

Table 1 shows the results on the cognitive part, the lowest mean score was obtained on Mathematics, followed by Logical reasoning, Proverbs, Point series, and Folding boxes.

Table 1. Cognitive test results

Cognitive	Mathematics	CoVat total	Logical reasoning	Proverbs	Point series	Folding boxes
Mean (%)	33.4%	60.7%	38.0%	62.0%	63.4%	79.6%
SD (%)	16.0%	7.8%	14.8%	12.4%	9.4%	14.0%

The discrimination indices of the 20 multiple choice questions of Mathematics, were also calculated, and showed 14 good items (D>0.30), three average items (0.20<D <0.30), and three reasonable items (0.10<D<0.20) [8].

Table 2 presents the results on the non-cognitive part. The lowest mean scale score is for time management and the highest for attitude.

Table 2. Non-cognitive test results

Non-cognitive	ATT	MOT	TMT	ANX	CON	INP	SMI	STA	SFT	TST
Mean	31.9	28.3	24.6	28.4	27.8	29.5	18.5	24.7	25.1	30.7
SD	3.9	4.6	5.0	4.7	4.7	4.4	2.8	4.4	4.1	4.6

Note. Scores need to be interpreted on 40, except for the scale “Selecting Main Ideas” which is on 25.

2.2 Analyses

2.2.1 Differences in diagnostic test results

The cognitive test results, presented in *Table 3*, show no consistent tendency between GROUP 1 and 2. GROUP 2 obtains higher scores on Mathematics and Proverbs but lower scores on Point series, Logical reasoning, Folding boxes. An Independent Samples t-test revealed only for the subtest Logical reasoning a significant difference between the two groups ($t(89)= 2.115$; $p= .037$). Remarkably, GROUP 1 scores significantly higher on Logical reasoning. *Table 4* shows the mean results of GROUP 1 and 2 on the LASSI scales. The students of GROUP 2 obtain a significant higher scale score for attitude (higher attitude; $t(90)= 2.765$; $p= .007$) and anxiety (less anxiety; $t(90)= 2.054$; $p= .043$).

Table 3. Results cognitive tests for GROUP 1, 2, and 3

Cognitive		Mathematics	Point Series	Logical Reasoning	Proverbs	Folding Boxes
GROUP 1	Mean	30.7%	65%	45.4%	60.4%	82.0%
	SD	14.0%	8.3%	19.0%	9.5%	13.1%
GROUP 2	Mean	31.1%	63.1%	36.8%	61.2%	79.2%
	SD	16.2%	9.4%	13.8%	13.3%	15.4%

GROUP 3	Mean	40.1%	63.5%	37.0%	64.6%	79.5%
	SD	15.0%	10.3%	14.1%	11.6%	10.9%

Note. To be complete the results of GROUP 3 are included.

Table 4. LASSI results for GROUP 1 and 2

Non-cognitive		ATT	MOT	TMT	ANX	CON	INP	SMI	STA	SFT	TST
GROUP 1	Mean	29.6	27.7	24.7	26.4	26.8	28.8	18.4	24.4	24.9	29.2
	SD	4.9	5.2	5.1	5.1	5.5	4.3	3.2	3.4	4.7	5.7
GROUP 2	Mean	32.4	28.5	24.6	28.9	28.0	29.6	18.5	24.8	25.2	31.0
	SD	3.5	4.5	5.0	4.5	4.5	4.4	2.7	4.7	4.0	4.3

The results of GROUP 2 and 3 are combined for the analyses in section 2.2.2 and 2.2.3. An Independent Samples t-test showed a significant difference on Mathematics between these two groups (t(82)= 2.567; p= .012). Two possible explanations for this significant difference are given in the discussion.

2.2.2 Differences in academic achievement

The results of the diagnostic test were linked to the academic achievement of the students at the end of the first semester in the bridging programme (February 2016). Here, two measurements of academic achievement are used, namely study efficiency - SE (i.e. proportion of the number of earned credits and the total number of credits the student subscribed for), and study percentage – Study % (i.e. weighted average of exam results cfr. GPA).

Table 5 reveals that the mean SE and study percentage of GROUP 4 and 5 are very similar. Performing two Independent Samples t-tests results in no significant differences for SE (t(209)= -0.220; p= .826) or study percentage (t(200)= 0.167; p= .867).

Table 5. Comparison of academic achievement

Participation diagnostic test		SE	Study %
GROUP 4	Mean	39.0%	41.7%
	SD	33.0%	16.9%
GROUP 5	Mean	40.0%	41.2%
	SD	35.0%	19.9%

Also a chi-square test for association between participation in the diagnostics test (yes/no) and SE (low, moderate, and high achievers) was carried out. The null hypothesis was retained, which implies that participation and SE are independent of each other (p= .527).

2.2.3 Predictive value of the diagnostic test

To investigate the predictive value of the diagnostic test, the study percentage of the bridging students was used as dependent variable. *Table 6* and *7* give the correlations of the separate parts of the diagnostic test. Only for concentration a significant correlation with study percentage was found (r= .297, p= .026).

Table 6. Correlations cognitive test

		Mathematics	Point series	Logical reasoning	Proverbs	Folding boxes	CoVaT Total	Study %
Mathematics	Pearson Cor.	1	.187	.152	.261*	.097	.267*	.158
	Sig. (2-tailed)		.090	.170	.017	.382	.015	.160
Point series	Pearson Cor.	.187	1	.214	.216*	.215	.584**	.049
	Sig. (2-tailed)	.090		.052	.050	.051	.000	.664
Logical reasoning	Pearson Cor.	.152	.214	1	.197	.231*	.684**	.078
	Sig. (2-tailed)	.170	.052		.075	.035	.000	.490
Proverbs	Pearson Cor.	.261*	.216*	.197	1	.167	.607**	.121
	Sig. (2-tailed)	.017	.050	.075		.132	.000	.284
Folding boxes	Pearson Cor.	.097	.215	.231*	.167	1	.661**	.137
	Sig. (2-tailed)	.382	.051	.035	.132		.000	.226
CoVaT Total	Pearson Cor.	.267*	.584**	.684**	.607**	.661**	1	.153
	Sig. (2-tailed)	.015	.000	.000	.000	.000		.176
Study %	Pearson Cor.	.158	.049	.078	.121	.137	.153	1
	Sig. (2-tailed)	.160	.664	.490	.284	.226	.176	

Note. * Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

Table 7. Correlations non-cognitive test

		ATT	MOT	TMT	ANX	CON	INP	SMI	STA	SFT	TST	Study %
ATT	Pearson Cor.	1	.395**	.562**	.476**	.621**	.464**	.471**	.213	.398**	.634**	.151
	Sig. (2-tailed)		.002	.000	.000	.000	.000	.000	.111	.002	.000	.267
MOT	Pearson Cor.	.395**	1	.593**	.014	.489**	.400**	.053	.387**	.565**	.297*	.110
	Sig. (2-tailed)	.002		.000	.917	.000	.002	.695	.003	.000	.025	.418
TMT	Pearson Cor.	.562**	.593**	1	.190	.687**	.470**	.361**	.470**	.640**	.478**	.147
	Sig. (2-tailed)	.000	.000		.157	.000	.000	.006	.000	.000	.000	.278
ANX	Pearson Cor.	.476**	.014	.190	1	.293*	.193	.335*	-.025	-.052	.586**	.072
	Sig. (2-tailed)	.000	.917	.157		.027	.150	.011	.852	.699	.000	.597
CON	Pearson Cor.	.621**	.489**	.687**	.293*	1	.457**	.350**	.334*	.566**	.482**	.297*
	Sig. (2-tailed)	.000	.000	.000	.027		.000	.008	.011	.000	.000	.026
INP	Pearson Cor.	.464**	.400**	.470**	.193	.457**	1	.494**	.508**	.621**	.520**	.100
	Sig. (2-tailed)	.000	.002	.000	.150	.000		.000	.000	.000	.000	.465
SMI	Pearson Cor.	.471**	.053	.361**	.335*	.350**	.494**	1	.428**	.304*	.477**	-.060
	Sig. (2-tailed)	.000	.695	.006	.011	.008	.000		.001	.021	.000	.659
STA	Pearson Cor.	.213	.387**	.470**	-.025	.334*	.508**	.428**	1	.670**	.142	-.198
	Sig. (2-tailed)	.111	.003	.000	.852	.011	.000	.001		.000	.291	.144
SFT	Pearson Cor.	.398**	.565**	.640**	-.052	.566**	.621**	.304*	.670**	1	.308*	.125
	Sig. (2-tailed)	.002	.000	.000	.699	.000	.000	.021	.000		.020	.360
TST	Pearson Cor.	.634**	.297*	.478**	.586**	.482**	.520**	.477**	.142	.308*	1	.090
	Sig. (2-tailed)	.000	.025	.000	.000	.000	.000	.000	.291	.020		.508
Study %	Pearson Cor.	.151	.110	.147	.072	.297*	.100	-.060	-.198	.125	.090	1
	Sig. (2-tailed)	.267	.418	.278	.597	.026	.465	.659	.144	.360	.508	

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

When only adding concentration in a linear regression model, the model accounted for an explained variance ($R^2_{Adj.}$) of 7%. Adding the average score on three cognitive tests (i.e. Mathematics, Proverbs, and Folding boxes) to the regression model, resulted in an explained variance ($R^2_{Adj.}$) of 13% (r= .405, p= .009). *Table 8* presents the regression coefficients of both variables.

Table 8. Regression models

Model		Unstandardized Coefficients B	Unstandardized Coefficients SE	Standardized Coefficients Beta	t	Sig.
1	(Constant)	6.200	15.495		.400	.691
	Concentration	1.234	.541	.297	2.282	.026
2	(Constant)	-19.274	18.941		-1.018	.313
	Concentration	1.160	.524	.279	2.216	.031
	Math_Proverbs_Folding boxes	.473	.215	.276	2.196	.032

Note. Dependent Variable: Study percentage

3 DISCUSSION AND FURTHER DEVELOPMENTS

Students who participated in the diagnostic test and enrol in the bridging programme (GROUP 2) have, on average, a higher score on attitude and a lower score on anxiety than the students who did not enrol (GROUP 1), which is in line with the expectations. But on the cognitive part they do not outperform the students of GROUP 1. These results imply that the students of GROUP 2 are not necessary the students with better cognitive skills. However, the students that participated and are enrolled in the bridging programmes possess, for some aspects, better learning and study strategies than the ones who participated in the test and did not enrol.

Students who participated at the beginning of the bridging programme (GROUP 3) scored significantly higher on Mathematics than the students who participated at the end of the professional bachelor's programme (GROUP 2). Two possible explanations for the higher scores on mathematics are: 1) the students who did the test at the beginning of the bridging programme took the summer course in mathematics (46% participated) and by consequence refreshed their prior knowledge before the test and/or 2) they followed another level of mathematics during secondary education (Distribution for GROUP 2: 26% low (less than four hours of mathematics/week), 44% medium (less than six hours of mathematics/week), and 30% advanced (six or more hours of mathematics/week) level of mathematics; Distribution for GROUP 3: 14% low, 38% medium, and 48% advanced level of mathematics).

No significant differences were found in academic achievement between the students who participated at the diagnostic test (GROUP 4) and the ones who did not (GROUP 5), suggesting that not the better performing students participated in this initiative. The hypothesis was that the ones who did participate would be the better students. Three possible explanations why the students of GROUP 4 do not have a significant higher academic achievement than GROUP 5: 1) the sample of students who participated in the diagnostic test is representative for the total group of bridging students; 2) the students who participated are the ones who are in doubt whether they are able to be successful in the bridging programme; 3) maybe some students of GROUP 5 had the intention to participate in the diagnostic during the professional bachelor programme, but could not participate on that specific moment or were not aware of the possibility to participate in the diagnostic test during the professional bachelor programme (e.g. students who followed a professional bachelor programme on other campuses) and did not see the added value of participating when already enrolled in the bridging programme.

Regarding the predictive value, the correlations between the diagnostic test and academic achievement are not as high as expected. Especially for Mathematics a higher correlation was assumed. Reasonable explanations for the low correlation between Mathematics and study percentage are: 1) the amount and level of mathematics in the professional bachelor programme. In general, the professional bachelor’s programmes include only one course of mathematics during the first year. This, in combination with the practical approach of the professional bachelor programme results in the fact that the students do not use their mathematical knowledge regularly; 2) students who participated during the professional bachelor programme did not had the opportunity to refresh their mathematical knowledge in advance; and 3) students and lecturers of the bridging programme reported that insufficient mathematical knowledge and skills are a major stumbling block, therefore if all students have a problem with mathematics it is feasible that the test does not differentiate well and consequently does not correlate well.

In the next academic year some adaptations to the Mathematics test will be made and students are given the opportunity to refresh their mathematical knowledge in advance thanks to the recently developed SPOC (small private online course).

Since it is the students’ first encounter with university and because the first semester of the bridging programme has a very general focus with mainly basic sciences and engineering courses, this first semester is for many students an adaptation period [9]. Therefore it will be interesting to investigate the predictive value of the test when the study results at the end of the academic year are available.

This first analysis suggests that a diagnostic test alone is not sufficient to predict study success for bridging students. Subject of future work is 1) the addition of one or more academic background variable (e.g. High school GPA) and other student characteristics (e.g. gender and self-efficacy) to the prediction model [10,11]; and 2) a further optimization of the diagnostic test by adapting the Mathematics test and perhaps adding other tests. It is also possible that predicting study success of all the bridging students is too ambitious. Therefore, in further research, parallel analyses will focus on the group of at risk students (i.e. students with a SE < 30%).

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