Learning and study strategies of incoming science and engineering students

A comparative study between three institutions in Belgium, Slovakia, and Hungary

M. Pinxten[1]
Research Associate, project coordinator readySTEMgo
Katholieke Universiteit Leuven (KULeuven)
Leuven Engineering and Science Education Centre (LESEC)
Leuven, Belgium
Maarten.Pinxten@kuleuven.be

C. Van Soom
Professor, Head of Tutorial Services Science
Tutorial Services, Faculty of Science, KU Leuven
Leuven Engineering and Science Education Centre (LESEC)
Leuven, Belgium
Carolien.Vansoom@wet.kuleuven.be

C. Peeters
Professor, Head Expertise Unit on Educational Provision
Faculty of Bioscience Engineering, KU Leuven
Leuven Engineering and Science Education Centre (LESEC)
Leuven, Belgium
Christine.Peeters@kuleuven.be

T. De Laet
Professor, Head of Tutorial Services Engineering Science and Head of Leuven Engineering and Science Education Centre (LESEC)
Tutorial Services, Faculty of Engineering Science, KU Leuven
Leuven, Belgium
Tinne.Delaet@kuleuven.be

P. Hockicko
Professor, Vice Dean of Education
Faculty of Electrical Engineering, University of Žilina (UniZa)
Žilina, Slovakia
hockicko@fyzika.uniza.sk

P. Pacher
Professor, Department of Physics
Department of Physics, Budapest University of Technology and Economics (BME)
Budapest, Hungary
pacher@eik.bme.hu

[1] Corresponding author: M. Pinxten
Maarten.pinxten@kuleuven.be

G. Langie
Professor, Vice Dean Faculty of Engineering Technology
Katholieke Universiteit Leuven (KULeuven)
Leuven Engineering and Science Education Centre (LESEC)
Leuven, Belgium
Greet.Langie@kuleuven.be

Conference Key Areas: Engineering Education Research

Keywords: First-year students, transition, learning strategies, and self-regulatory skills

INTRODUCTION

The transition from secondary school to university is still a quantum leap for a substantial number of science and engineering students. In predicting first-year student success, a large number of variables enter the equation, for example, prior grades, prior study programme in secondary school, their motivation, attitudes, study and time management skills, etc. To date, there is ample research on the predictive power of students' prior grades and domain-specific prior knowledge on their achievement in the first year and results show that high grades are a necessary but not sufficient condition to be successful in the first year ([1]-[3]). In this paper, the focus shifts to other important variables in the equation, that is, the learning and study skills of incoming science and engineering students. More specifically, it will be demonstrated how levels of learning and study skills are related to different educational contexts.

The European readySTEMgo project aims to improve the retention rates of higher education STEM programmes. More specifically, the prime objective of this project is to identify those students with an increased propensity of dropping out in an early stage of the chosen STEM programme. In the framework of this project, differences in the learning and study skills of incoming science and engineering students will be explored in the STEM faculties of three European universities: Budapest University of Technology and Economics - BME [Hungary], University of Leuven - KU Leuven [Belgium], and University of Žilina - UniZa [Slovakia].

1 THREE DIFFERENT UNIVERSITIES, THREE EDUCATIONAL CONTEXTS

For all incoming students at the three participating universities, the transition to university is a pivotal moment. However, it should be noted that there are substantial differences between these universities when characterizing this transition. In this first section, these contextual differences will be highlighted.

1.1 Transition from secondary school and entrance to university

In Flanders, Belgium (**KU Leuven**), there are no entry requirements to higher education (except for the study programmes medicine, dentistry, and arts education): when students obtain their secondary school diploma, they are allowed to enrol in whichever study programme they like. Unlike other European countries, neither national nor regional school leaving (matriculation) examinations are organised in Flanders. As a consequence, there is a large degree of heterogeneity in incoming students' levels of math and science background in most study programmes. For example, students with low math levels (i.e., less than 6 weekly hours of mathematics) or low math grades are allowed into STEM study programmes together with peers with higher math levels and grades. As a consequence, the first year at university is a considerable hurdle for a substantial number of students.

In an educational context without formal admission mechanisms, an accurate information flow between secondary schools and universities is of paramount importance. In this respect, secondary school teachers, student guidance counsellors, and university representatives at open days and student fairs are crucial stakeholders to advice candidate students and to provide them with the most accurate information on the content, difficulty level, expected competencies, and future career options of the different study programmes.

In Slovakia **(UniZa**), all students need to pass the school leaving examinations before they attend university. However, since 2008, profound reforms in the organization of these school leaving examinations took place. First, different levels of matriculation exams were abolished, that is, students can no longer choose between a medium or advanced level exam. Second, in the new system, none of the STEM subjects (i.e., math, physics and chemistry) are obligatory. Third, before the reforms, the math matriculation exam was internally organised in each school through an oral exam. Now, the math matriculation exam exists of an oral and a written part prepared by a National committee. If a students' score on the written part is above 33%, s/he can proceed to the oral part and get a final grade from 1-4 (1 is maximum). If a student scores below 25%, s/he has to retake the written exam in September. Finally, students from vocational schools can no longer participate in the matriculation exams for STEM subjects as they have to take the examination from a prescribed set of subjects.

Admissions at the Faculty of Electrical Engineering at UniZa are generally done by tender. The final mathematics and physics grades obtained in secondary school and participation in the matriculation exams for these subjects are taken into consideration. Applicants who did not participate in the math and/or physics matriculation exam and do not meet the minimal criteria for admittance (i.e., a weighted average score math and physics in secondary school below 2) are obliged to participate in a selection interview on campus. In practice, all these students are accepted because of normative funding.

In Hungary **(BME)**, the system of entrance examinations was terminated in 2005 and replaced by a new system based on admission points (i.e., entrance score). In this new system, students can apply for several science and engineering programmes ranked in accordance with their preference. Whether an applicant is admitted to the place s/he has chosen depends on (1) the *entrance score limits* defined at the given faculty and (2) the *total entrance score* achieved by the applicant (see below). The deadline of application for STEM programmes launching in September is 15th of February. So, in BME, the final choice process takes place much earlier than in Belgium and Slovakia.

The *entrance score limits* for a particular programme are a composite of (1) the total number of applicants to that programme, (2) the ranking order of the different study programs chosen by the applicants, and (3) the capacity of the given institution defined for each programme. These entrance score limits are set on the same day and at the same time for all programmes of higher education, at the end of July.

The *total entrance score* of each applicant is calculated in a system of 400+100 points. Scores are based on grades obtained in secondary school (max. 200 points), the matriculation examination points (max. 200 points), and the bonus points (max. 100 points). Bonus points are granted for successful advanced level secondary school final examination, language competence (language certificates), and results achieved at academic competitions. A student who holds at least secondary school qualification is only eligible for entry to undergraduate programmes if he or she has acquired at least 280 admission points.

Given its prestigious status, at BME the entrance score limits of the STEM programmes are generally set (much) higher than 280 points; in 2015 the entrance score limits of the programmes participating in the readySTEMgo project were: Chemical Engineering 433, Mechanical Engineering 383, Electrical Engineering 365, Civil Engineering 320, Physics 382, and Mathematics 373.

1.2 Differences in science and engineering programmes offered in the first year

There is also an important difference in engineering programmes offered at the different universities. The most notable difference is between Belgium and the other countries involved. At most partner institutions, students can choose between different engineering specializations from the start of their academic career (e.g., Electrical Engineering, Civil Engineering, Mechanical Engineering, Security Engineering, etc.). By contrast, at KU Leuven, new students can only choose between three different engineering programmes (Bio-Science Engineering, Engineering Science, and Engineering Technology). Only after the third or fourth semester, students are allowed to make specific choices regarding different engineering disciplines (Electrical, Mechanical, Chemical engineering, Food Technology, Biotechnology, etc.). Before that time, students are offered a common programme with a broad range of general engineering courses.

Also regarding the science programmes offered at the different universities there are substantial difference. At KU Leuven, students from a wide range of science programmes were included in this study (i.e., Mathematics, Informatics, Physics, Biology, Biochemistry, Chemistry, Geography, and Geology). At BME, only students from the Mathematics and Physics programme were included whereas at UniZa, the only science programme that is offered is Management Science and Informatics.

2 GOAL OF THE PRESENT PAPER

In this paper, differences in learning and study skills of incoming STEM-students between the three participating universities will be explored. More specifically, the level of motivation, self-regulatory skills (e.g., concentration, time-management), performance anxiety, and study skills of the three populations of incoming students will be determined. In this respect, special attention will be given to gender differences and prior effort exerted in secondary school.

3 DATA AND METHOD

3.1 Sample

During the first two weeks of the academic year 2015-2016, first-year science and engineering students at the participating universities were invited to fill in an extensive questionnaire regarding their prior educational background and study behavior in secondary school. Overall, a large number of students participated in this questionnaire in the three partner institutions: KU Leuven (N= 1,521); UniZa (N=880); and BME (N=990). In sum, we have a large database of background characteristics of 3,391 students providing us with a detailed profile of each student:

- Information on the choice process regarding the selected study programme
- Prior grades in math and science subjects in secondary school (grades and matriculation results) & math level (basic – medium – advanced)
- Effort expenditure in secondary school
- Levels of motivation, attitude and performance anxiety in secondary school
- Learning and study strategies used in secondary school

3.2 The Learning and Study Strategies Inventory (LASSI)

In order to measure first-year students' learning strategies, the Learning and Study Strategies Inventory (LASSI) was administered to all students mentioned above at the different institutions (in a translated version). This scientifically validated instrument contains 77 items regarding students' learning and study skills. Since students did not experience university education at this stage, they were instructed to rate each item with respect to their study behavior in secondary school.

The LASSI instrument contains the following ten scales:

1. **Attitude** (the importance of going to university and academic success in a students' life)
2. **Motivation** (a students' persistence when confronted with challenging tasks)
3. **Time management Skills** (a students' tendency to procrastinate and ability to meet deadlines)
4. **Anxiety** (anxiety levels that keep students from performing at the maximum level)
5. **Concentration** (a students' concentration level when in class or studying)
6. **Information Processing** (deep versus surface learning)
7. **Selecting Main Ideas** (a student's ability to select the key message from a text)
8. **Study Aids** (a students' ability to use and create techniques for meaningful learning)
9. **Self-testing** (the degree to which students monitor their progress when studying)
10. **Test Strategies** (a students' techniques for preparing for and taking tests)

Based on norm research at KU Leuven [4], cut-off values were determined for five norm groups for each of the ten LASSI scales (very weak, weak, average, good, very good). We used the same cut-off values for all universities.

4 RESULTS

4.1 Differences LASSI scales

As shown in Table 1, there are significant differences between the three universities regarding the level of learning strategies of their incoming students. In the paragraphs below the most salient findings will be discussed.

Table 1. *Mean scores on the 10 LASSI scales for the three universities*

	Attitude	Motivation	Time Manag.	Anxiety	Concen-tration	Inform. Proces.	Main Ideas	Study Aids	Self Testing	Test Strat.
BME	32.36	28.37	26.21	26.88	28.47	30.49	19.60	22.16	25.98	32.00
KUL	31.46	28.33	24.35	27.28	27.10	28.32	17.92	24.12	25.32	29.56
UniZa	28.67	25.62	25.14	24.17	25.43	29.03	17.65	23.44	24.23	28.13
Total	**31.05**	**27.68**	**25.09**	**26.4**	**27.09**	**29.13**	**18.35**	**23.39**	**25.25**	**29.93**
N	3,233	3,233	3,228	3,239	3,247	3,225	3,263	3,220	3,246	3,229
St. Dev.	4.15	4.65	4.88	5.82	5.22	4.66	3.01	4.78	4.55	4.42

Note. *All scales except for Main Ideas: Minimum score = 8; Maximum score = 40; Statistical differences between universities were tested using ANOVA analysis. Attitude:* $F(2, 3230) = 208.05$, $p < .001$*; Motivation:* $F(2, 3230) = 109.93$, $p < .001$*; Time management:* $F(2, 3225) = 43.22$, $p < .001$*; Anxiety:* $F(2, 3236) = 82.10$, $p < .001$*; Concentration:* $F(2, 3244) = 76.53$, $p < .001$*; Information processing:* $F(2, 3222) = 65.84$, $p < .001$*; Selecting main ideas:* $F(2, 3260) = 129{,}48$, $p < .001$*; Study Aids:* $F(2, 3217) = 50.07$, $p < .001$*; Self-testing:* $F(2, 3217) = 32.84$, $p < .001$*; Test strategies:* $F(2, 3226) = 196.16$, $p < .001$.

As shown in Figure 1, the proportion of students with very weak attitudes when entering university is substantially higher at UniZa (36%) compared to KU Leuven and BME (12% and 11% respectively). Apparently, for more than one third of the first-year UniZa students going to university does not play an important role in their life. By contrast, at BME there is a large proportion of students with a very high score on the attitude scale (31%): for about one third of the student, going to university plays a very important role in their lives. A potential explanation could be that for the latter group of students, being allowed into a prestigious university increases the value they attach to going to university and to academic success.

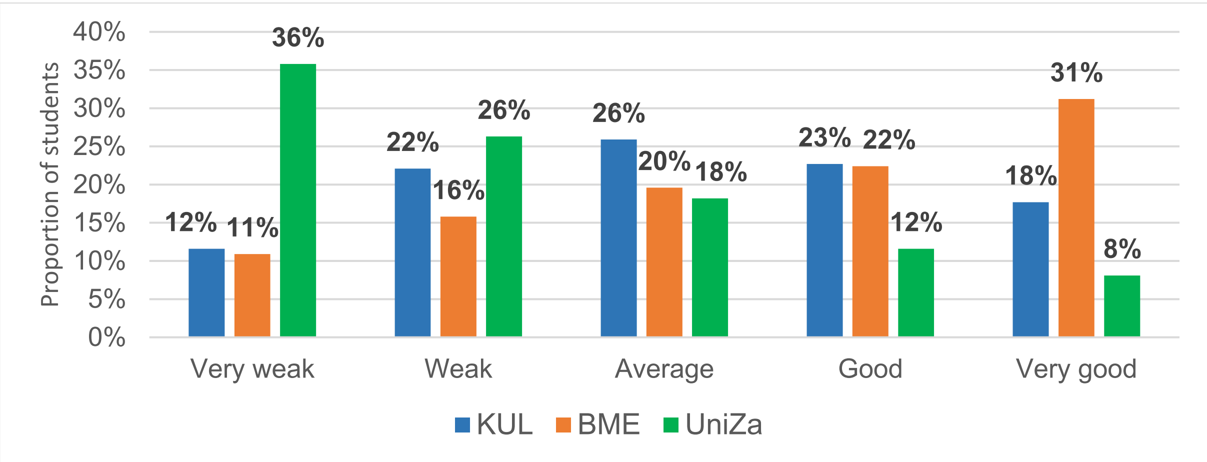

Fig. 1 Proportions for each of the 5 norm groups for the Attitude Scale for the three universities

A similar pattern was observed with respect to incoming students' levels of motivation (Figure 2). As outlined above, this variable measures students' diligence, self-discipline, and their capacity to persist when confronted with challenging tasks.

Compared to the other two universities, 31% of UniZa students indicate having a very weak motivation at the start of the academic year. This could be problematic in science and engineering study programmes wherein students are regularly presented with challenging problems they need to solve.

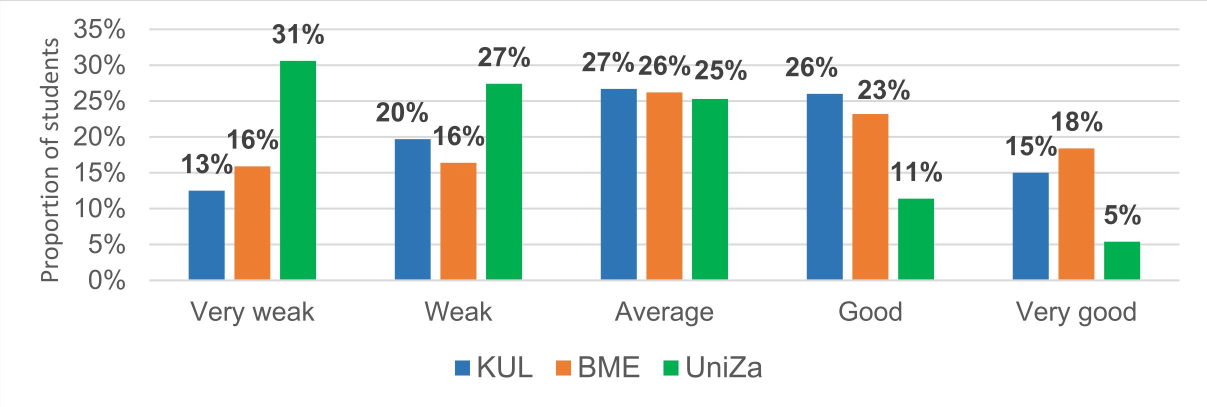

Fig. 2 Proportions for each of the 5 norm groups for the Motivation Scale for the three universities

Also at the Test strategies scale, students at BME score significantly higher than the other two universities. This suggests that incoming students at BME use more effective test-taking strategies and more efficient techniques for preparing for tests.

4.2 Gender differences

In general, the proportion of female students is considerably lower than male students at each university: KU Leuven (27%), BME (20%) and UniZa (22%).

Except for the Information Processing and Selecting Main Ideas scales, there are significant differences between male and female students regarding the LASSI scales. In general, female students display higher levels of attitudes, motivation, time management, and other study strategies. The most notable differences between female and male students is on the Study Aids scale ($F(1, 3217) = 282.80$, $p<.001$). Thus, female students more frequently use meaningful learning techniques, such as underlining, using italic text, and making simple graphs when studying, compared to male students. It should be noted, however, that girls display significant higher levels of performance anxiety ($F(1, 3217) = 57.44$, $p<.001$). It should be noted that all statistical significant differences were observed at the different universities.

4.3 Effort exerted in secondary school

Students were asked how hard they had to study for their obtained grades in secondary school. Over the three universities, 33% of the students reported low levels of effort exerted in secondary school whereas 44% and 22% reported medium and high levels of effort exerted in secondary school, respectively. As shown in Table 2, there are significant differences between the three different effort levels regarding a number of LASSI scales (e.g., motivation, time management, and performance anxiety).

Table 2. *Mean LASSI scores as a function of effort levels in secondary school (generalized over institutions)*

	Attitude	Motivation	Time Mgt	Anxiety	Concen-tration	Inform. Proces.	Main Ideas	Study Aids	Self Testing	Test Strat.
LOW (33%)	30.83	26.12	23.38	28.06	26.63	29.48	18.71	22.32	24.44	30.22
MEDIUM (44%)	31.24	28.22	25.54	26.20	27.30	28.87	18.28	23.72	25.37	29.98
HIGH (22%)	31.29	29.23	26.65	24.66	27.46	29.26	18.12	24.38	26.36	29.73
Total	**31.11**	**27.74**	**25.07**	**26.47**	**27.11**	**29.16**	**18.39**	**23.4**	**25,29**	**30.01**
N	3,109	3,109	3,101	3,113	3,121	3,100	3,136	3,095	3,119	3,104
St. Dev.	4.14	4.65	4.89	5.80	5.22	4.61	3.00	4.77	4.55	4.38

***Note**. All scales except for Main Ideas: Minimum score = 8; Maximum score = 40. Statistical differences were tested using ANOVA analysis. Attitude: F (2, 3106) = 3.78, p = .02; Motivation: F (2, 3106) = 113.55, p < .001; Time management: F (2, 3098) = 112.04, p < .001; Anxiety: F (2, 3110) = 78.01, p < .001; Concentration: F (2, 3118) = 6.93, p = .001; Information processing: F (2, 3097) = 5.43, p = .04; Selecting main ideas: F (2, 3133) = 9.87, p < .001; Study Aids: F (2, 3092) = 45.24, p < .001; Self-testing: F (2, 3116) = 38.78, p < .001; Test strategies: F (2, 3101) = 2.58, p = .08.*

Students who reported low levels of exerted effort in secondary school show significantly lower motivation and time management scores. Thus, students who did not study hard in secondary school display substantial lower levels of self-regulatory skills when entering university. Additionally, low effort students report significantly lower levels of study aids and self-testing strategies. As such, low effort students less frequently use techniques that enable meaningful learning (e.g., underlining, using italic text when studying, etc.) and less frequently monitor their progress while studying (e.g., by asking themselves relevant exam questions) compared to students who report average or high levels of exerted effort in secondary school.

5 CONCLUSIONS AND DISCUSSION

In summary, the levels of attitudes, motivation and test strategies of incoming first-year students in three European universities differ significantly. The different educational context, including differences in admission criteria at these universities, might partially explain these differences. For example, incoming students at BME, a prestigious engineering institution in Hungary, enter university with more desirable attitude and motivation levels compared to students from UniZa. Going to university clearly plays a more important role in the lives of BME students compared to their Slovak colleagues. From a gender perspective, female students outperform male students on most of the LASSI scales. In this respect, female students seem to be better equipped with the right learning tools to cope with the academic challenges ahead. The results also demonstrate that the amount of effort exerted in secondary school is related to the level of learning and study skills of incoming students. Students who put less effort in their school work in secondary school display lower levels of persistence, time management skills, and study techniques such as underlining and making simple graphs. All of these skills are important in an academic environment wherein students (1) are regularly stimulated with challenging problems, (2) are confronted with a large amount of course content, and (3) are no longer externally triggered to keep track of their study progress. In conclusion, these low effort students might be at risk when confronted with the high demands that a university environment imposes on them.

5.1 Directions for future research

An important direction for future research is to link a students' individual score on each of the LASSI scales with their actual exam results in order to gauge the predictive power of the LASSI scales for first-year study success. We are particularly interested in the added value of the LASSI scales on students' prior grades. Preliminary analyses at the three universities show that especially a student's self-regulatory skills (e.g., time management, concentration, and persistence/motivation) have a positive relation with the student's grades after the first exams in January. This finding is important given that it enables us to identify students with a lack of self-regulatory skills in a very early stage of their university education career. Targeted interventions aimed at providing these students with the right tools to cope with the university course content can support these students.

5.2 Challenges ahead

The joint analysis of data of different institutions confronts us with important challenges. Any attempt to combine the LASSI scales with students' educational background data (prior math grades and math level in secondary school and study programme in secondary school) is statistically challenging since the latter group of variables are not measured on a common metric. For example, grading practices differ substantially between European countries. In Belgium, percentages are calculated for each subject whereas in other countries subject grades range between 1 and 4 (or 5). Also, there is a high degree of diversity regarding the study programmes in secondary school prior to entering a science or engineering study programme at university. Unfortunately, statistically it is not feasible to correct for this diversity or rescale it to a common metric.

REFERENCES

[1] Ackerman, P.L., Kanfer, R. and Beier, M.E. (2013), Trait complex, cognitive ability, and domain knowledge predictors of baccalaureate success, STEM persistence, and gender differences, *Journal of Educational Psychology, Vol. 105, No. 3*, pp. 911-927.

[2] Pinxten, M., De Laet, T., Van Soom, C., and Langie, G. (2015), Fighting increasing drop-out rates in the STEM field: The European readySTEMgo Project, *Proceedings of the 43rd Annual SEFI Conference*. Annual Conference of European Society for Engineering Education (SEFI). Orléans, France, 1-3 July 2015, pp. 1-8.

[3] Vanderoost, J., Callens, R., Vandewalle, J., and De Laet, T. (2014), Engineering positioning test in Flanders: a powerful predictor for study success, *Proceedings of the 42nd Annual Conference*. Annual Conference of European Society for Engineering Education (SEFI). Birmingham, UK, 15 - 19 September 2014, pp. 1-8.

[4] Olivier, I., Lacante, M., and Briers, V. (2015). A re-calibration of the LASSI norm scores for a Flemish educational context (Unpublished master thesis). Katholieke Universiteit Leuven, Leuven, Belgium