The Transition to STEM Higher Education: Policy Recommendations

Conclusions of the readySTEMgo-Project

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Abstract—For Europe to remain at the forefront of scientific and technological development, the current shortage of persons trained in these fields at secondary and higher education has to be overcome**.** The readySTEMgo project aims to improve the retention rates of higher education STEM programmes by the identification of at-risk students in an early stage. We successfully identified a number of key skills that are essential for first-year achievement in a STEM programme. Additionally, we investigated which intervention tools can support at-risk students and evaluated their effectiveness. Based on the output of this research project four policy recommendations are formulated.

Keywords—Transition, STEM, at-risk students, key skills, interventions

1 Introduction

Engineering pedagogy is a diverse field of research with different stakeholders (students, professors, industry, society, etc.) and many different contexts. A lot of attention is spend to first-year didactical approaches. Several approaches are possible and needed since they should be context and culturally sensitive. When the results of this didactical research in Higher Education are translated into the engineering curriculum in a well-considered way, the effectivity of higher education can be increased [1].

The focus of the European project readySTEMgo was on the academic readiness of first-year students in STEM programmes (Science-Technology-Engineering-Mathematics) (see https://iiw.kuleuven.be/english/readystemgo). Led by the University of Leuven (KU Leuven), the project was carried out by Hamburg University of Technology (Germany), University of Źilina (Slovakia), Budapest University of Technology and Economics (Hungary), Aalto University (Finland), University of Birmingham (UK) and SEFI. We identified students with an increased propensity of dropping out in an early stage of the chosen STEM programme. To achieve this goal, we identified the key STEM competencies that are required to be successful in a

STEM programme (objective 1), we selected diagnostic tests and gauged their predictive power on study success in the first year in order to identify students at-risk (objective 2), and we investigated which intervention tools can support these at-risk students and we measured the effectiveness of current remediation programs (objective 3).

2 Identification of key skills and diagnostic tests

The identification of the key STEM competences is based on a literature overview [2], focus group discussions with students, a first-year survey completed online by 857 first-year students (http://online.pubhtml5.com/iiju/xkkh/#p=1), and large-scale data-collections of more than 9000 first-year students [3]. We confirmed that prior math achievement is an important predictor of student achievement in STEM programmes. In line with results of other studies, we showed that effort-related, self-regulated learning strategies (motivation/persistence, time-management, concentration, etc.) are important skills. Moreover, they are a good start to provide students with feedback on which aspects of their study behavior they need to improve in order to increase academic achievement. Additionally, we observed that the secondary school teacher board is very well capable of giving accurate advice to students who are in the middle of the decision-making process [3].

We selected different diagnostic tests and observed a systematic correlation for some scales of the LASSI-test [4], independent of the educational context [5].

3 Interventions

The increasing call for higher education accountability, drives universities towards evidence-based decision-making processes. The effectiveness of interventions should be studied in terms of costs (utility) and benefits. Academic skills and self-management-based interventions seem to be very important [6]. The readySTEMgo project focused on a diverse set of interventions [7]. The STELA-project (http://stela-project.eu) developed, in collaboration with the readySTEMgo-project, student dashboards with a central focus on actionable feedback [8]. The prime focus is to unveil information to first-year students on their personal self-regulatory skills and to stimulate a self-reflective process on their own learning behavior. At KU Leuven we also developed infographics about critical skills in order to inform young students who are in the middle of their decision-making process in a visually attractive way. At the University of Źilina a new summer course in physics was developed. Hamburg University of Technology focused predominantly on the use of tutorials (i.e., small groups of students supervised by a teaching assistant with a strong focus on the conceptual problem solving process). Aalto University evaluated the self-perceived usefulness of the ABC-introduction week at the start of the academic year and the student guilds. Budapest University of Technology and Economics studied the effectiveness of math diagnostic tests and the University of Birmingham looked at the profiles of the first-year students who visited the math support center.

4 Policy recommendations

The results of this project are brought together in four policy recommendations.

1. *Promote data-driven reflection about the transition to higher education (orientation)*. It is easier to convince policy makers, practitioners and students about important variables associated with achievement, when attractive visualisations are developed based on institution-specific data.
2. *Engage in closer cooperation different educational levels (communication)*. It is worth investing in projects that involve stakeholders from both secondary and higher education. This enables the early and structural implementation of remedial initiatives before students enroll into higher education.
3. *Invest in developing transversal study skills (interventions)*. Interventions aimed at at-risk students should entail a dual complementary focus on academic and non-academic content. Based on representative data, students can be encouraged to reflect on their learning and study skills. This self-reflective process is a key facilitator for the development of transversal skills in later stages.
4. *Explore international best practices (inspiration)*. There are many types of approaches to teaching, developed within different educational contexts. International collaborations focusing on effective interventions and teacher training, are needed. The potential for transfer to implement these interventions in other educational contexts should be an essential element of the application criteria of educational projects.

5 Future research

These policy recommendations highlight the importance of sharing and discussing the results of this type of research with policymakers, educational researchers, and practitioners of secondary and higher education. This complex process with many stakeholders is time-consuming, but has great potential for increasing achievement in higher education. Through data-driven research, focusing on application and valorization, institutions can make evidence-based decisions. Consequently, teachers can be trained in effective teaching methods and obtain the skills to implement efficient interventions. Time and incentives for planning and preparing initiatives are essential.

Moreover, this multidisciplinary research offers opportunities to develop new instruments and interventions, such as student dashboards based on learning analytics. These developments can be implemented in many other programmes outside of the STEMfield. A university-wide implementation increases the return on investment.

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7 References

[1] Schneider, M. and Preckel, F. (2017). Variables associated with achievement in Higher Education: a systematic review of meta-analyses. *Psychological Bulletin*. Advance online publication https://doi.org/10.1037/bul0000098

[2] Pinxten, M., De Laet, T., Van Soom, C., 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 (art.nr. 54365) (pp. 1-8).

[3] Pinxten M., Van Soom C., Peeters C., De Laet T., Langie G. (2017). At-risk at the gate: Prediction of study success of first-year science and engineering students in an open-admission university in Flanders. Any incremental validity of study strategies?. *European Journal of Psychology of Education, 33* pp 1-22 https://doi.org/10.1007/s10212-017-0361-x

[4] Weinstein, C.E., & Palmer, D.R. (2002). *Learning and Study Strategies Inventory 2nd Edition*. Clearwater, FL: H&H Publishing Company.

[5] Pinxten, M., Van Soom, C., Peeters, C., De Laet, T., Pacher, P., Hockicko, P., Langie, G. (2016). Learning and study strategies of incoming science and engineering students. A comparative study between three institutions in Belgium, Slovakia, and Hungary. *Proceedings of the 44rd Annual SEFI Conference*. Annual Conference of European Society for Engineering Education (SEFI). Tampere (Finland), 12-15 September 2016 (art.nr. 10) (pp. 1-8).

[6] Robbins, S. B., Oh, I., O., Le, H. and Button, C. (2009). Intervention effects on college performance and retention as mediated by motivational, emotional, and social control factors: integrated meta-analytic path analyses. *Journal of Applied Psychology, 94*, 1163-1184. https://doi.org/10.1037/a0015738

[7] Pinxten M., De Laet T., Van Soom C., Peeters C., Kautz C., Hockicko P., Pacher P., Nordström K., Hawwash K., Langie G. (2017). Approaches to the Identification of STEM Key Competencies in European University systems. *Proceedings of the 45th Annual SEFI Conference*. Annual Conference of European Society for Engineering Education (SEFI). Azores Islands (Portugal), 18-21 September 2017 (art.nr. 51) (pp. 1-8).

[8] Broos, T., Verbert, K., Van Soom, C., Langie, G., De Laet, T. (2018). Small data as a conversation starter for learning analytics: exam results dashboard for first-year students in higher education. *Journal of Research in Innovative Teaching & Learning, 1-14*.

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