The secondary-tertiary transition in mathematics:
What are our current challenges and what can we do about them?

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Student transition from school-level mathematics to university-level mathematics, often referred to as the *secondary-tertiary transition* (hereafter STT) is an enduring, complicated and multi-faceted process. STT is a long-standing issue of concern, which has merited significant attention in mathematics education research and practice. In particular, STT was discussed on the pages of this Newsletter several years ago (Gueudet on behalf of the Education Committee of the EMS, 2013).

At its 2018 meeting in Cyprus, the EMS Education Committee recognized that our knowledge about successful ways of dealing with STT is still insufficient and that moving forward requires a large-scope effort on the part of all parties involved, including mathematics lecturers, school teachers, education researchers, policymakers and students in transition. As part of this effort, the Committee is conducting a survey among mathematicians. **The goal** of the survey is to collect and report to the mathematics community information needed in order to devise national and international actions that can essentially improve the state of the art with respect to STT.

Thank you very much for devoting about 15 minutes to completing the survey below.

LINK TO THE SURVEY

Additional thanks for sending this invitation to your colleagues that might be interested in taking part in the survey and thus in contributing to the EMS collaborative effort to make substantial progress in relation to the STT. The survey[1] is open until September 15, 2019.

Appendix: Background information on STT

Many university mathematics lecturers feel that teaching first-year university mathematics courses, such as real-analysis and linear algebra, is often a more difficult, frustrating and disappointing experience than they would had expected or would have liked them to be. In a recent survey of the state of the art with respect to the teaching and learning of proof, Stylianides, Stylianides, and Weber (2017) conclude that students at all levels struggle with proof writing, have difficulty translating informal reasoning into valid arguments, are often unable to validate proofs, and generally lack many of the competencies needed for proving. It is thus not surprising that many mathematicians characterize their first-year students as unprepared, unable or unwilling to cope with challenges of university-level mathematics (Nardi, 2008).

From the student side, the STT experience looks differently. For example, in a recent study on mathematics freshmen in Pisa University, Di Martino and Gregorio (2018) describe the emotional crisis experienced even by those students who had been successful mathematics learners in high school and who eventually succeeded at the university. Student testimonies show that the crisis is induced by unexpected failures in first-year mathematics courses and intensified by the realization that the strategies they developed at high school for learning mathematics, which had served them well, were failing them at the university level. As a result, many students feel helpless, ashamed and, in some cases, left alone. In brief, encounters with university mathematics require from

[1] The URL of the survey is as follows:
https://docs.google.com/forms/d/e/1FAIpQLSdcxoDW63m1h7nmdacQkhtWS8cGHH84K4a8OU-fWVnqIEuGJA/viewform

students deep reconstruction of their understanding of what mathematics is, of their attitude towards the subject, and of their perceived competences (Winsløw & Grønbæk, 2014).

Recent research tends to attribute students' difficulties during the STT to discontinuities between mathematics as experienced at school and as practiced at university rather than to inherent inability to do mathematics at a high level. The discontinuities concern for example: modes of thinking (e.g., formalization and abstraction), modes of mathematical communication (e.g., proof writing), student agency over learning (e.g., the increased requirement for independent study), teacher-student interaction, assessment and grading and curriculum misalignment (Gueudet, 2008, Jablonka, Ashjari & Bergsten, 2017). In addition, the students' first encounters with university-level mathematics are considered from the perspective of characteristics of communities the students and mathematics lecturers belong to (Biza, Jaworski & Hemmi, 2014) and by accounting for differences between the university and school as educational institutions (Winsløw & Grønbæk, 2014).

Implications of mathematics education research with regard to STT include suggestions for reducing these discontinuities at the university level and at the school level. At the university level, suggestions include "bridging" mathematics courses, resources and courses for promoting lecturers' pedagogical awareness and enriching their arsenal of teaching and assessment strategies, pedagogical methods making tacit aspects of mathematics accessible for students during lectures and tutorials, and curriculum design principles for producing better textbooks (Gueudet et al., 2016). At the school level, education researchers and math educators have called for, sought and proposed curriculum reforms and teacher development programs that would bring the mathematics that is practiced and experienced in school closer to the mathematics within the discipline (Gueudet et al., 2016). As mentioned, a small portion of the proposed changes has been realized in practice.

Are hard feelings and experiences an inherent part of learning during STT, or can they be reduced? How do lecturers and students experience STT in different universities and countries? How did these experiences change (if at all) during the last decade in light of increasing attention and efforts to addressing STT? How and to what extent have different institutions and lecturers been addressing STT? Has technology been helpful in this regard? If so, how was technology integrated in university teaching, and what have been the results of these integrations? How can successful efforts to address these challenges of STT be further disseminated? These and such questions are still open and serve as a motivation for the suggested survey and further action.

References

Biza, I., Jaworski, B., & Hemmi, K. (2014). Communities in university mathematics. *Research in Mathematics Education*, 16(2), 161-176.

Di Martino, P., & Gregorio, F. (2018). The first-time phenomenon: Successful students' mathematical crisis in secondary-tertiary transition. In E. Bergqvist, M. Österholm, C. Granberg, & L. Sumper (Eds.). Proceedings of the 42nd Conference of the International Group for the Phychology of Mathematics Education (Vol. 2, pp. 339-346). Umea, Sweden, PME.

Gueudet, G. (2008). Investigating the secondary–tertiary transition. *Educational Studies in Mathematics*, 67(3), 237-254.

Gueudet, G. on behalf of the Education Committee of the EMS (2013, December). Why is university mathematics difficult for students? Solid Findings about Secondary-Tertiary Transition. EMS Newsletter, 46-48.

Gueudet, G., Bosch, M., DiSessa, A. A., Kwon, O. N., & Verschaffel, L. (2016). *Transitions in mathematics education*. Springer International Publishing.

Jablonka, E., Ashjari, H., & Bergsten, C. (2017). "Much Palaver About Greater Than Zero and Such Stuff"–First Year Engineering Students' Recognition of University Mathematics. *International Journal of Research in Undergraduate Mathematics Education*, *3*(1), 69-107.

Nardi, E. (2008). *Amongst mathematicians*. New York, NY: Springer.

Stylianides, G. J., Stylianides, A. J., & Weber, K. (2017). Research on the teaching and learning of proof: Taking stock and moving forward. In J. Cai (Ed.) *First compendium for research in mathematics education* (pp. 237–266). Reston, VA: National Council of Teachers of Mathematics.

Winsløw, C., & Grønbæk, N. (2014). Klein's double discontinuity revisited. *Recherches en Didactique des Mathématiques*, 34(1), 59-86.