The Secondary-Tertiary Transition in Mathematics
Successful Students in Crisis

Francesca Gregorio (HEP Vaud, Lausanne, Switzerland and LDAR, Université Paris Diderot, France), Pietro Di Martino (Università di Pisa, Italy) and Paola Iannone (Loughborough University, UK)

Introduction

The transition from secondary school into university mathematics – also referred to as secondary-tertiary transition (STT) – is a sensitive moment for many students, also for those who have achieved high marks at the end of their schooling and are considered excellent in mathematics in the school context.

For this reason, the EMS Education Committee identified STT to be one major issue for mathematics departments across Europe and their students, as explained in the last EMS newsletter (Koichu & Pinto, 2019). In order to shed some light onto this process and to support mathematics departments in implementing appropriate measures to help students overcome the difficulties connected to the move into university mathematics, the EMS has recently designed and distributed a survey for mathematicians across Europe. The EMS Education Committee's interest reveals the concern of the mathematics community for the experiences of students joining degree courses in mathematics and the will to understand this phenomenon in order to alleviate some of the problems connected to this transition. Indeed, the STT has been of interest to mathematics educators for a while now, and many empirical studies have been carried out to better understand all aspects of this transition. Gueudet (2008) highlights three aspects of this transition: a cognitive aspect, which focuses on the increased cognitive difficulties of university mathematics and its increased formalism and rigour (e.g. Tall, 1991); a social aspect, which focuses on the social changes that students face when moving to university, where they receive less support than in school and where they often experience living away from their families for the first time (e.g. Pampaka, Williams and Hutcheson, 2012); and an affective aspect, linked to the feelings and emotions that students experience during the STT. The first aspect – the cognitive one – has interested researchers since the late seventies, but the interest in the other two aspects is growing, as research reveals just how important social and emotional experiences are for students moving into university. Recently we have investigated the emotional aspect further and we will report here on some of our findings (Di Martino & Gregorio, 2018) underlying the necessary developments.

The STT can be seen as a real rite of passage (Clark and Lovric, 2008) characterised by three stages:

- separation stage (from secondary school – when students leave behind the context in which they have been successful mathematics learners),
- liminal stage (from secondary school to university – where students join the new context, but they are still relative novices in the practices and norms of this new context) and
- incorporation stage (when students become full participants of the practices of university mathematics).

Each stage of this passage is often associated with a period of crisis caused by the need to reorganise well-established mathematical routines and negotiate new methods of interaction with the subject, the peers and the instructors in the new context. Difficulties in reaching the incorporation stage of this passage may cause students to drop out from their courses.

In line with a general movement in mathematics education, we have dedicated more attention to a holistic approach to the STT, focusing on the affective factors that shape this crisis and to this extent we developed a research study at the University of Pisa, in Italy (Di Martino & Gregorio, 2018). Students at this university are usually considered excellent in mathematics at the end of their schooling: more than 65% of the students in the first year of the bachelor in mathematics in Pisa achieve a final mark at secondary school between 90/100 and 100/100, but despite the high results these students face many difficulties during their bachelor's degree, and more than 22% of them drop out at the end of the first year (in line with the average Italian dropout rates for the bachelor in mathematics).

Our research was organised into two phases: the first phase consisted of the design and administration of a questionnaire, the second phase involved interviews with volunteering students. We included in the questionnaire and interviews both successful students and those who had dropped out of their course so that we could collect both experiences of success and failure. We chose mainly qualitative methods and open-ended questions in order to stimulate students to compose narratives related to facts and emotions that they themselves recognised as significant, using the words they consider more appropriate for their memories. Therefore, our research has been intentionally student-centred. As part of this study we collected and analysed 137 questionnaires and 37 interviews.

Results

From the qualitative data collected emerges that students joining the bachelor in mathematics are generally high achievers and strongly motivated in their academic choice. Nevertheless, they often experience their first failure in mathematics. For the first time, some successful students have to come to terms with difficulties in establishing effective studying routines, obtaining poor marks for their work and not being the best in mathematics amongst their peers. This is a big change for them, and they have to learn to manage this change from a cognitive as well as an emotional point of view.

We are interested in describing and understanding this change. From our data, this shift is usually unexpected, and this surprise makes students' negative reactions even more powerful: their mathematical identity as a successful student is suddenly questioned. In most cases, students start associating negative emotions to their university experience and to mathematics; shame, anxiety, insecurity, sadness and frustration are the emotions more often mentioned in our data. Moreover, students begin to question their own self-image as mathematicians: switching from feeling highly competent to feeling inadequate for the task can be a hard change. The university experience also elicits an awareness of the difference between secondary school mathematics and university mathematics, questioning the theories of success in mathematics developed during the school experience. Students recognise secondary school mathematics as a procedural subject – that requires performing calculations following standard steps – compared with university mathematics, a formal and abstract subject that consists of definitions and theorems and deals for the most part with abstract objects. Most students like this new version of their subject, but they find it hard to come to terms with it at the start of their studies, where so many other aspects of their lives are changing.

The big differences in teaching methods between secondary school and university do not help students in their STT; relatively small mathematics classes are replaced by large lectures where students may feel lost, and studying strategies which worked at school level suddenly become ineffective at university level. Students then become stuck in this first impression of failure and they do not know how to change the situation. In addition, despite the increasing efforts made by the institution to help students during tertiary transition, some struggling students believe that they have to smoothly adapt to the new context and materials. This attitude exacerbates the difference with the secondary school experience of mathematics. To sum up, students feel a sense of impotence, in the conviction that they cannot gain control of the situation of failure which then becomes unavoidable and unchangeable for them.

Facing failure for the first time and the change of their perceived competence in mathematics makes students feel ashamed. Students become afraid of disappointing people close to them and are afraid of being compared to their peers. This attitude supports the misconception that students often have of being the worst of their year and the only one experiencing difficulties, with important consequences to their self-esteem. The same sense of shame often leads students to close within themselves and to avoid sharing their difficulties with peers and university teachers, an attitude which in turn precludes the possibility of improvement and isolates these students. Our data suggests this point is really important and the main difference in behaviour between dropout students and students who successfully progress in their studies. Successful students manage to overcome the isolation caused by early failures and difficult experiences, while students who drop out of their studies remain isolated until their situation is so unbearable that dropping out seems to them to be the only solution. Indeed, we see in our data that overcoming shame and sharing difficulties reduces the emotional charge experienced by the students, enabling them to perceive these difficulties as surmountable and to focus on the new cognitive demands of learning mathematics at university level. Therefore, we believe that the university experience in mathematics requires a deep reconstruction of the students' perception of mathematics, of the disposition towards the subject, and of their perceived competences. Emotional factors should be taken into account to make the STT easier, for example by promoting reflection on the change in the context, on the acceptance of the difficulties and of a possible new mathematical identity.

Our study is ongoing, and the next objective is to investigate the role of the higher educational context (and therefore also the role of cultural factors) in this transition. We have started to collect the data following the methodology of the Italian study in two other countries with very different higher educational systems: Switzerland and the U.K. We ask in this new part of the study what the institutional features that facilitate and hinder this transition are, whether the experiences of students in very different educational systems can be compared and whether these experiences have common features.

Bibliography

Clark, M. & Lovric, M. (2008). Suggestion for a Theoretical Model for secondary-tertiary transition in mathematics. *Mathematics Education Research Journal*, 20(2), 25–37.

Di Martino, P. & Gregorio, F. (2018). The mathematical crisis in secondary-tertiary transition. *International Journal of Science and Mathematics Education*, 17(4), pp 825–843.

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

Koichu, B. & Pinto, A. (2019). The Secondary-Tertiary Transition in Mathematics. What are our current challenges and what can we do about them?. *EMS Newsletter*, 6(112), 34–35.

Tall, D. (1991). *Advanced Mathematical Thinking*. Dordrecht: Kluwer.

Pampaka, M., Williams, J., & Hutcheson, G. (2012). Measuring students' transition into university and its association with learning outcomes. *British Educational Research Journal*, 38(6), 1041–1071.

Francesca Gregorio [francesca.gregorio@hepl.ch] is a PhD student and teaching assistant at the HEP Vaud (Switzerland) and the lab LDAR of the Paris Diderot University (France). Her research focuses are on STT transition and on mathematical learning disorders. She is a teacher trainer for primary and secondary pre-service teachers.

Pietro Di Martino [pietro.dimartino@unipi.it] is an associate professor in mathematics education at the University of Pisa (Italy). He is the president of the Italian Committee for Mathematics Teaching (CIIM). His main research interests concern the role of the affective factors in the processes of mathematics teaching and learning, the difficulties in the STT transition and the main aspects involved in problem solving at the primary school level.

Paola Iannone [p.iannone@lboro.ac.uk] is senior lecturer in mathematics education at Loughborough University (UK). Her main research interests concern mathematical reasoning and students' proof production, students' note-taking habits at university level and the summative assessment of mathematics at university.