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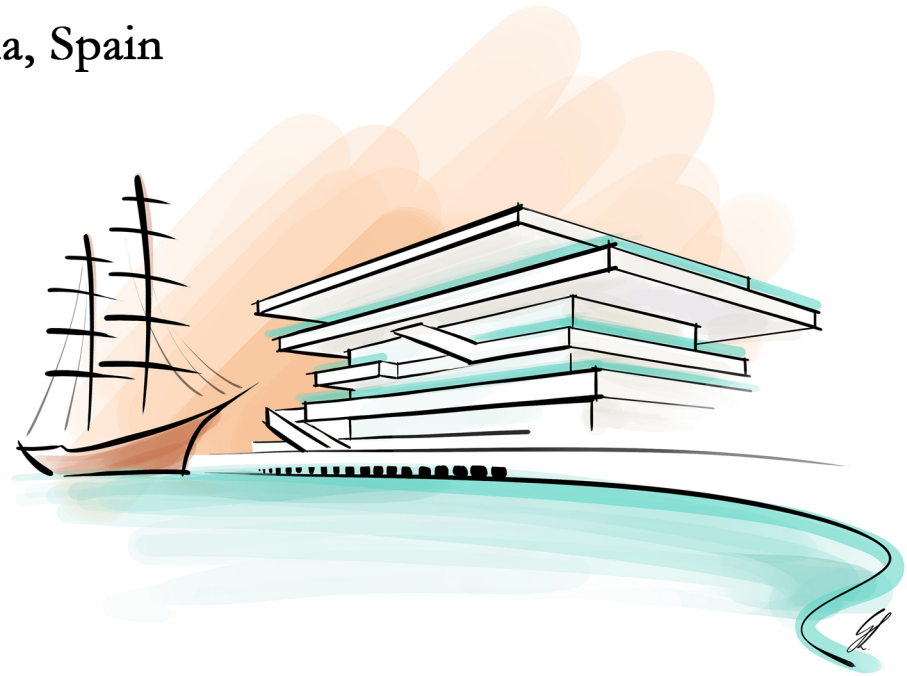

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The secondary-tertiary transition in mathematics: insight through personal journals in a math class

Giulia Bernardi[1], Domenico Brunetto[1], Gaia Turconi[2]

[1]Mathematics Department, Politecnico di Milano, Italy, [2]Department of Human Sciences, Università Telematica Pegaso, Italy.

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Abstract

This study delves into the transition from secondary to tertiary mathematics education, a pivotal moment impacting cognitive, social, and cultural domains. Through personal journal analysis and using the theoretical framework of the "rite of passage", it investigates the experiences of first-year Architecture students at Politecnico di Milano. Text analysis confirms five prevalent themes described in the literature: instrumental/relational mathematics, structural differences between university and high school, adjustment process of self-regulation strategies, the development of a new identity as mathematicians, and social integration with peers. This research contributes to ongoing efforts in mathematics education, aiming to improve the overall transition experience and academic success of tertiary education students. In particular, the study sheds light on the complexities involved and shows as the journal practice can provide a deeper understanding of student challenges, perceptions, and adjustment processes.

Keywords: *Tertiary transition; journaling; mathematics; rite of passage; STEM.*

1. Introduction

The transition phase from secondary to tertiary (STT) mathematics education is that moment in which students enroll at university, entering a new world from a cognitive, social, and cultural point of view, and it's considered one of the major issues in mathematics education (Gueudet, 2008). The decreasing number of college students in the STEM area seems to be strongly influenced by the presence of at least one mathematics course, and, on the other hand, these courses also affect the percentage of dropouts and delays in obtaining the qualification (Gueudet, 2023). This leads to the inclusion of fewer and fewer scientific professionals in the working environment, thus also resulting in a social problem (OECD, 2022), as well as an educational and pedagogical one. Optimizing the success and adaptation of first-year students

during the challenging transition from secondary to tertiary education requires a comprehensive focus on metacognitive factors, such as self-regulation (Zimmerman, 2000); these elements prove to be just as important, if not more, than addressing disciplinary gaps (Di Martino & Maracci, 2009). The phenomenon of STT education in mathematics is complex and multifaceted, and as such requires numerous theoretical lenses in order to be explored in its entirety (Di Martino et al., 2023).

The theory of the "rite of passage", brought into the field of mathematics education by Clark and Lovric (2008), highlights well how this passage is a real crisis, a shock that involves the whole person, cognitively, socially, emotionally, and culturally. From a cognitive point of view, one shock is certainly due to the different degree of depth required by university study compared to high school: there is a shift from instrumental to relational mathematics (Skemp, 1978). A change also occurs in the level of difficulty of the contents offered and in the time devoted to each one: entering the university world, in fact, also entails changing the cultural institution of reference (Artigue, 2004), and, consequently, certain paradigms that functioned in high school are not useful anymore, such as the learning methods and the organization of one's autonomous work (De Guzmán et al., 1998). The emotions that accompany this transition are powerful and sometimes all-embracing (Clark & Lovric, 2008). From a social point of view, integration into a new community with new people and new interpersonal interaction rules adds further uncertainty and fragility to a delicate period (*ibidem*).

Although the transition from secondary school to university is an area with many contributions and many testimonies of fruitful teaching experiences, still little work concerns the context of bachelor courses where mathematics is not the core discipline. This reality could show differences from all the aspects described before compared to studies conducted on "specialized" students (Di Martino et al., 2023). Often coming into contact with "non-specialized" students, the topic of transition to undergraduate mathematics education is of great interest to us; wanting to investigate more deeply this phase experienced by our students in the Architecture course at Politecnico di Milano, we decided to use a tool known in pedagogy for its metacognitive and self-reflection potential: the personal journal.

Journals are the repositories of thoughts and ideas, processed and clarified through writing or recording one's experiences (Killion, 1999). As technology has become pervasive in everyone's daily lives, journaling is often transposed to the digital realm in education (e.g., Morando et al., 2023), making writing and filing more accessible and easier for teachers to reference. However, in mathematics education journaling is not often used, probably because of the stereotype associated with "advanced" mathematics as predominantly instrumental (Skemp, 1978), neglecting the emotional and linguistic aspects that influence learning even in this discipline (Bardelle & Di Martino, 2012).

The primary aim of this article is to investigate the nuanced facets of the transition phase from secondary to tertiary education in our university students, employing the method of journaling, in particular analyzing the words used and their context. By delving into the reflective insights provided by students through journaling, we seek to gain a deeper understanding of their experiences, challenges, and perceptions during this crucial phase. This exploration aims to shed light on the complexities of these changes and provide valuable insights for educators and institutions to enhance support mechanisms and improve the overall transition experience for our students.

2. Methods and Research Contest

Our work focuses on the mathematics course held during the initial semester for first-year Architecture students at Politecnico di Milano. In addition to the basic mathematical concepts essential for their academic progression, the course also aims to introduce the logical rigor necessary for the training of an architect. This year the course was divided into two segments, each consisting of two modules, culminating in brief assessment tests. Before these tests, a deadline was set for submitting a personal journal, consisting of any type of written digital file about reflections on the lectures, for a total of four deliveries. We decided to use the Journal as a tool that serves a dual purpose: fostering metacognitive development among students and gaining insights into their experiences during the transition from secondary to tertiary education within an architectural mathematics classroom.

The course enrolled approximately 180 students, of whom 104 submitted at least one journal. To encourage participation, we made some of the learning objectives of this activity explicit (reviewing what was done in class, reflecting on their own difficulties and strategies to overcome them), and also offered extra points on the final grade. In order to avoid any sense of fear of being judged by their teachers, we assured the students that their contributions would be accessible only to a tutor (the third author) who would report the main demands and difficulties to the course lecturers anonymously. The lecturers, based on the reports received, had the opportunity to comment on what the students had written in their journals, intending to advise the students, suggesting additional or different teaching materials, or modifying certain aspects of the course such as the timing of the tests.

2.1. Text Analysis

We opted to use AntConc (Antony, 2023), a free corpus analysis toolkit designed for text analysis, to conduct an initial exploration of the content submitted by students. For this purpose, we decided to select only the contribution of those who handed in all four assignments, totaling 61 students. To facilitate the software's identification of each term, we found it necessary to exclude certain entries from the initial pool of the diaries: those handwritten by tablet and those

composed of photos of handwritten pages, resulting in a refined dataset with 216 journals turned in by 54 students. We systematically organized these contents into four distinct files, each including contributions corresponding to a specific assignment. This procedural arrangement facilitated the extraction of words that were present across all four files, thereby capturing the temporal evolution of language usage throughout the course.

After selecting a stop list of words to exclude – such as articles, conjunctions, etc. –, AntConc's "Word" function allowed us to sort the words according to their frequency. By configuring the "Range" parameter to 4, we were able to effectively isolate the words used in all four files created. This allowed us to choose the ones students used throughout the course and thus was representative of themes across the disciplinary topics covered in the lectures. Subsequently, more than 500 words were identified. We proceeded to select approximately 100 words with the highest frequency and another 100 with the lowest frequency. The seemingly unconventional choice of examining both high and low-frequency words was deliberate: our goals were, first, to discern typical STT themes within students' narratives, analyzing how they were declined in this environment, and second, to identify any new themes specific to the class group. This comprehensive approach facilitated exploring significant themes and identifying potential distinctive nuances conveyed by less frequently used terms. It provided a more comprehensive understanding of the students' narratives, allowing us to capture subtleties and unique perspectives embedded in the less common vocabulary choices.

To refine our focus, we found it necessary to exclude terms that, while longitudinally present throughout the course, were implicitly linked to assignment requirements (e.g., "*journal*"), as well as words from mathematics closely related to the course content (e.g., "*theorem*"). To identify the setting associated with the selected terms more accurately, we wanted to have an overview of the context of use as well; therefore, we used software features such as Collocate and KWIC, which select other terms related to the one under consideration or report the original sentences in which the word was so that the context can be deduced from reading them (Antony, 2023). This approach allowed us to exclude non-significative words such as "*mathematics*", which was frequently used even without deep insight. A low-frequency word that can serve as an example for understanding our selection process at this stage is "*to fill in*", which in Italian is often associated with the term "*gaps*"[1]; the latter term proved to be decidedly more interesting, and so the analysis of the term "*to fill in*" coincided, essentially, with that of the term "*gaps*".

Finally, we analyzed the remaining words in light of the STT themes, assigning - where possible - a category to each word. Among the various themes identified and studied in the literature, we selected five of them: the instrumental/relational mathematics view, the structural differences

[1] In Italian, "colmare" e "lacune".

between high school and university, the new self-regulation strategies needed to cope with new learning methods, the emotional aspect of acquiring a new identity as a university student, and the social aspect of integration with the peer group. The labels used were: "Instrumental/Relational" (I/R), "Structural differences" (SD), "Self-regulation" (S-R), "Identity" (Id), and "Social integration" (SI). It is important to emphasize that, obviously, such a categorization is in itself limiting and functional only to a preliminary analysis of the contents of the journals. It is worth noticing, our analysis allows that some words belong to more than one category. Those, even contextualized, seem to express messages belonging to different themes of transition depending on the kind of nuances the reader can grasp. For example, the sentence "I am *happy* that I did well on the test" can be interpreted as both "I am *happy* because I thought I was incapable and could not achieve such a result" (concerning more the theme "Id") but also "I am *happy* because I studied hard and my efforts paid off" (concerning more the theme "S-R"). Of course, these two interpretations are exaggerations, but they help us understand the wide range of the interpretive spectrum in which each term can be placed.

3. Data analysis

At the end of the first data cleansing, we selected 102 high-frequency words (min 37 - max 622), and 108 low-frequency words (min 4 - max 7). Then we employed the qualitative analysis described in the previous section to 155 words. Among these, 81% were removed because they were not significant terms (e.g., "*journal*", "*theorem*", "*mathematics*"). Finally, we employed the qualitative analysis of 28 words. We report in Figure 1 the selected words labeled according to STT themes with their frequency (in brackets).

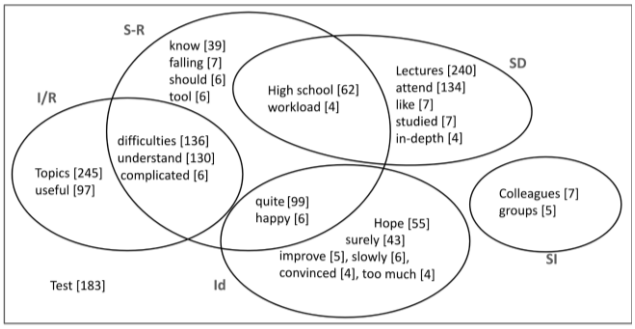

Figure 1. Classification of the selected words.

At first look, we can observe that the theme social integration (SI) is the least populated, while the most populated is the S-R one with 11 terms, some of which are in common with other themes. For clarity, in the following, we report a deep analysis of a few terms. If we take an analysis of the term "*useful*" (*u.*) and its context of use, we notice that for students it is associated only with practice moments during classes: "I find the practical session more *u.* than the

theoretical lectures", "we should do more exercises *u.* for passing the exam". This highlights how the view of mathematics is mainly instrumental: practice and repetition seem to be, for students, more relevant to pass the exam than theoretical explanations of concepts and methods. As a consequence, the term "*useful*" belongs to the theme I/R. The differentiation between hours devoted more to theory and others more to practice is typical of college mathematics but not of high schools, and this is one of the differences between the two cultural institutions that emerge: "the university *workload* is more demanding", "the *workload* of the course is more than what was done in *high school* and in less time", "I never covered this topic *in depth* in *high school*, I can't understand it". Therefore, "*workload*" is labeled both as S-R and SD. These changes seem to cause a negative atmosphere for some students: "I've *fallen* behind, I *should* practice more", "I *should* start studying as hard as my classmates if I want to pass the exam", which concerns the S-R theme. Other students mentioned the "*hope*" that the effort will pay off because they feel their journey is going ("*quite*") "*well*". As a result, these latter terms belong to the Id themes.

The only word that did not find a main category of reference was "*test*", a term that students used to talk about their experiences related to assessment. This moment is cross-cutting: if you have an instrumental view, the amount of exercise done in the short time before the test affects your confidence. The first university exam brings with it many anxieties because it is the first encounter with a new assessment method and the comparison with high school grades is still strong.

The theme that is certainly less represented is what we have called Social Integration, which indicates the process of settling and adjusting to a new peer group with new relational dynamics. This lack of representation, however, is quite justified when we think about a university lesson: we asked students to talk about the math course, and although they were "allowed" to express anything related to it – even their emotional and experiential world – occasions for socializing in class are rare, even if (we hope) students socialize with each other during breaks and outside. From the words analyzed, we can also see how some students independently create moments of discussion with *colleagues* ("I had a *c.* explain it to me"), sometimes through study groups ("We solved the exercise as a *g.* and confronted each other").

4. Discussion and conclusion

This work aims to help educators and institutions understand the complexities of this transition better: we saw how students include the themes that characterize STT in their texts (Clark & Lovric, 2008; Artigue, 2004; De Guzmán et al., 1998), a signal that these are still relevant and present even in students "not specialized" in mathematics (Di Martino et al., 2023). At a preliminary analysis such as the one we have presented here, no different themes seem to emerge from those already present in the literature, but this may be caused by a bias in our observation of the data: behind some of the terms may lie unexplored themes that are not identifiable through

this type of tool. The personal journal, however, turned out to be a great instrument for gaining insights into the students' academic journey overall, to understand in part what this new experience is for them and the emotional and social world it entails (Morando et al., 2023; Bardelle & Di Martino, 2012). Moreover, our study confirms and extends the previous research. Indeed, a tool like this makes it possible to create a partially informal communication channel with the class group, which, when it is as large as it is in university classrooms, itself guarantees a kind of "anonymity": the professor will most likely never associate my name with my face among the hundred-plus people in the classroom, and this makes me feel freer to express my opinions, feelings, and ideas. And we, as educators, can benefit from this to know in a more "real" way what our students are experiencing.

References

Anthony, L. (2023). AntConc (Version 4.2.4) [Computer Software]. Tokyo, Japan: Waseda University. Available from https://www.laurenceanthony.net/software

Artigue, M. (2004*). Le défi de la transition secondaire-supérieur. Que peuvent nous apporter les recherches en didactique des mathématiques?*. Paper presented at the first French-Canadian Congress of Mathematical Sciences, Toulouse. https://doi.org/10.3406/dsedu.2002.1010

Bardelle, C., & Di Martino, P. (2012). *E-learning in secondary–tertiary transition in mathematics: For what purpose?* ZDM, 44(6), 787–800. https://doi.org/10.1007/s11858-012-0417-y

Clark, M., & Lovric, M. (2008). Suggestion for a theoretical model for secondary-tertiary transition in mathematics. *Mathematics Education Research Journal*, *20*(2), 25-37. https://doi.org/10.1007/BF03217475

De Guzmán, M., Hodgson, B. R., Robert, A., & Villani, V. (1998). Difficulties in the passage from secondary to tertiary education. In *Proceedings of the International Congress of Mathematicians*, 3, pp. 747-762. Berlin: Documenta Mathematica.

Di Martino, P., Gregorio, F., & Iannone, P. (2023). The transition from school to university in mathematics education research: New trends and ideas from a systematic literature review. *Educational Studies in Mathematics*, *113*(1), 7-34. https://doi.org/10.1007/s10649-022-10194-w

Di Martino, P., & Maracci, M. (2009). The secondary-tertiary transition: beyond the purely cognitive. In *Proceedings of 33rd Conference of the International Group for the Psychology of Mathematics Education*, pp. 401-408.

Gueudet, G. (2008). Investigating the secondary–tertiary transition. *Educational studies in mathematics*, *67*(3), 237-254. https://doi.org/10.1007/s10649-007-9100-6

Gueudet, G. (2023). New insights about the secondary–tertiary transition in mathematics. *Educational Studies in Mathematics*, *113*(1), 165-179. https://doi.org/10.1007/s10649-023-10223-2

Killion, J. (1999). Journaling. *Journal of Staff Development*, *20*(3), 36-37.

Morando, P., Spreafico, M. L., Turconi, G. (2023) ARE YOU OFF TO A GOOD START? THE "JOURNAL OF THE DAY" EXPERIENCE, *EDULEARN23 Proceedings*, pp. 2063-2071. https://doi.org/10.21125/edulearn.2023.0626

OECD. (2022). Education at a glance 2022: OECD Indicators. *OECD Publishing*. https://doi.org/10.1787/3197152b-en

Skemp, R. R. (1978). Relational understanding and instrumental understanding. *The arithmetic teacher*, *26*(3), 9-15. http://www.jstor.org/stable/41187667

Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In *Handbook of self-regulation*, pp. 13-39. Academic press. https://doi.org/10.1016/B978-012109890-2/50031-7