Research Article

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"Literally I Grew Up" Secondary–Tertiary Transition in Mathematics for Engineering Students beyond the Purely Cognitive Aspects

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Abstract: High dropout rates in the first year of undergraduate studies are an expression of the secondary–tertiary transition problem and they seem to be particularly high in those degree programs where specialized mathematics courses are taught in the first year of study. Research shows that students' difficulties during the transition period cannot be reduced to purely cognitive factors. In this article, we address the secondary–tertiary transition problem in mathematics for engineering students. Based on a questionnaire with focus beyond the purely cognitive aspects, a comparison of the transition problem at three European mid-sized universities is carried out, to identify common challenges and difficulties, as well as differences. The questionnaire concentrates on the four dimensions (personal, organizational, content related, and social) and corresponding critical requirements for a successful transition described in Trautwein, C., & Bosse, E. (2017). The first year in higher education – critical requirements from the student perspective. *Higher Education*, *73*, 371–387. A group of 308 first-year engineering students partook in the study. In the presentation, we highlight students' perceptions regarding the transition, changes, and challenges they experienced under the above-mentioned four dimensions and discuss similarities and differences between countries.

Keywords: dropout rates, engineering education, mathematics, secondary, tertiary transition

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1 Introduction

High dropout rates in the first year of undergraduate study are an expression of the secondary–tertiary transition problem, which has received much international attention (e.g., Bergsten & Jablonka, 2015; Cheng et al., 2015; Gueudet, 2008). Dropout rates are especially high in degree programs where mathematics courses are taught in the first year of study (Heubeil, 2014; Troelsen & Laursen, 2014).

In mathematics-related subjects compared to other fields of study, the dropout rates have led research to often focus on transition on cognitive challenges resulting from the specifics of the subject (Gómez-Chacón, Griese, Rösken-Winter, & Gónzalez-Guillén, 2015). Often the intervention to improve the transition problem is "running bridging courses, lowering the level of the mathematics taught, or reducing the examination standards in order to avoid massive failure. For different reasons these reactions rarely proved to be effective" (Di Martino & Maracci, 2009, p. 401). The cognitive challenges may be far to be solved.

However, students' difficulties during the first-year of undergraduate study cannot be reduced to purely cognitive factors. According to Di Martino and Maracci (2009, p. 402) "researchers who are interested in human performance need to go beyond the purely cognitive." Clark and Lovric (2009) describe the transition as a rite of passage with three phases of separation, transition, and incorporation. They emphasize the culture shock when a person undergoes a range of strong emotions that influence her/his actions and behavior. Gueudet (2008) shows that in many theoretical works on secondary–tertiary transition perspectives as individual, social or institutional are considered; "clarification of the causes [of students' difficulties] plays a fundamental role in the building of appropriate didactical actions" (p. 251).

Cheng et al. (2015) understand transition as an "internal process in the mind, which takes place when students

undergo change and pass from the familiar to the unknown" (p. 1). Gale and Parker (2014) describe transition as "the ability to navigate change" (p. 737). Both definitions emphasize processes within the individual. Coertjens, Brahm, Trautwein, and Lindblom-Ylänne (2017) extend this by considering external circumstances that lead to the internal process. All these definitions outline change as a process individuals need to react upon. In this article, we follow Gale and Parker's (2014) understanding of transition as "becoming," thus considering major challenges of the transition process and how it may result in changes in students' self-perceptions and characteristics.

1.1 Critical Requirements for a Successful Transition

Overall, numerous models have been used to describe transition and clarify transition issues. Cheng et al. (2015) describes how all models address three different shocks (academic, social, emotional) that mathematics students undergo when entering higher education. In their qualitative study on critical requirements for a successful transition from student perspective, Trautwein and Bosse (2017) describe four different dimensions, *Personal*, *Organizational*, *Content-related*, and *Social*, that cover a range of needs students have to handle to make the secondary–tertiary transition. The four dimensions find their counterparts in the shocks (academic, social, emotional) addressed by the models depicted by Cheng et al. (2015). Underlying the academic shock are the critical requirements from the organizational dimension (e.g., coping with the quality of teaching and supervision; dealing with assessment conditions) and the content-related dimension (e.g., meeting curricular demands and pace of the courses). The critical requirements from the personal dimension are responsible for the emotional shock (e.g., balancing areas of life; managing the workload; coping with pressure to perform). The social shock finds its counterpart in the social dimension (e.g., building peer relationships; collaborating in teams or interacting with academic staff).

In line with international studies, Heubeil (2014) shows that dropout rates in mathematics and mathematics-related subjects are significantly higher than in other subjects. This has led to focus empirical research on transition problems in mathematics-related subjects mainly on the cognitive challenges and shocks arising from the nature of the discipline (e.g., Gómez-Chacón, Griese, Rösken-Winter, & Gónzalez-Guillén, 2015). The way of presenting mathematics at university is in a dense, formal, and systematic structure known as "definition-theorem-proof" (Nardi, 2008). Mathematical rigor increased abstract formalism instead of descriptiveness, and mathematical proof instead of performing calculations often poses problems to students (Gueudet, 2008). These problems are all related to the content-related dimension and contribute to the transition problem. Even though various methods of teaching mathematics using new approaches were developed in the last years, there seem to be indications that not much happened after all in practice (e.g., Melhuish, Fukawa-Connelly, Dawkins, Woods, & Weber, 2022). Moreover, even if the "student centered learning" is recognized as the "new paradigm," it seems to be a lot left to be done when applying the methods in practice (e.g., Woods & Weber, 2020).

Students' first encounters at the university level can be considered in respect of the differences between the university and the school as educational institutions (Winsløw & Grønbæk, 2014), that is, the organizational dimension. The design of the learning process and the quality of teaching and teaching styles differ from those in schools (Clark & Lovric, 2009). This implies a need for students to become autonomous learners: "acquisition of a certain level of autonomy in learning is often seen by university teachers as the main stumbling block in the secondary tertiary passage" (De Guzmàn et al., 1998, p. 751). The strategies successfully applied to school mathematics often do not help for university studies where the teaching is more impersonal (e.g. Pampaka, Williams, & Hutcheson, 2012) and the supervision ratio is less favorable. As a result, students may not receive sufficient support from instructors when experiencing difficulties that are expected with the increased workload and academic standard (Trautwein & Bosse, 2017).

The transition to university is often accompanied by a move to a new city or to one's own apartment. As a result, the social environment in which students are situated also changes. The cohort size and the class climate at university (e.g. constantly changing classmates) differ from that at school, making it more difficult to establish strong social ties. The social shock needs to be resolved in the entry phase of the study period so that students can find their place in the new social environment. In a study with mathematics students in Sweden, Stadler, Bengmark, Thunberg, and Winberg (2013) found that as students progressed in their studies, they became less dependent on the teacher and increasingly built their knowledge with the help of other materials and especially their peers. In addition, social inclusion contributes to students' identity formation, stress management, and improved academic performance (Stadtfeld, Vörös, Elmer, Boda, & Raabe, 2019). The above issues clearly show how important the social integration of students is for their academic success.

All of the above challenges have an impact on students' feelings and emotions. For this reason, some researchers "attempted to integrate both models [socio-institutional and psychological-individual] by using psychological factors, for example, to explain the integration of students into the academic and social environment of higher education" (Hüther & Krücken, 2018, p. 187). The change in the organization of learning and teaching style may cause students to become overwhelmed with the demands and the new required working attitude (Trautwein & Bosse, 2017). The student–lecturer interactions are less personal comparing with upper secondary school and students can feel left alone and unsupported in the learning process. The lack of connectedness with peers further reinforces this tendency and can affect student's psychological and socio-emotional wellbeing (Hughes, 2016). Already burdened by difficulties and failures, the unclear role of mathematics for the career path often hinders motivation and creates negative emotions on students' side (Bergsten & Jablonka, 2015), which ultimately promotes poor academic performance and high drop-out rates.

The four dimensions (personal, organizational, content-related, and social) proposed by Trautwein and Bosse (2017) are thus also well founded from a theoretical perspective and are well suited as a starting point for empirical investigations. In the present study, we concentrate on the issues beyond the purely cognitive aspects. Based on a questionnaire, to identify common challenges and difficulties, as well as differences, an international comparison of the transition problem at three European mid-sized universities is carried out. We ask: What dimension(s) *beyond the purely cognitive aspects* influences the secondary–tertiary transition in mathematics for first year engineering students?

2 Methods

2.1 Participants

In total, 499 first year students from three European universities took part in the courses where the questionnaire was handed out. However, 191 students (39%) were excluded from the sample since they were not engineering students (e.g., prospective teachers) or due to incomplete data. This left a final sample of 308 participants for the subsequent analyses. Participants were distributed across the different countries as follows: 36 (12%) from Germany (DE), 170 (55%) from Sweden (SE), and 102 (33%) from Turkiye (TR). Sixty-six percent of participants were male (M), 33% were female (F), and 1% did not indicate their gender. Most students took the course during their first semester, but 40 of the Turkish students took the course during their second semester and 3 students from Germany took it during their second or third semester.

The German university is an institution located in the south of Bavaria. The engineering program offered is mainly computer science. The second university is a Swedish university offering a large spectrum of engineering programs on Bachelor/Master level. The third university that is part of the study is an institution located in the Anatolian region of Turkiye. It has a strong engineering program that consists of civil, industrial, computer, electric–electronic, and mechanical. In-depth mathematics courses are mandatory for the engineering students in the first semesters in all three universities. The institutions are consider mid-size universities in their specific countries.

2.2 Instrument

A questionnaire with 16 items was designed to collect information about possible transition difficulties from upper secondary school to university. Participants received the survey electronically through their emails by invitation and were asked to fill in the survey anonymously and voluntarily. The survey consists of four parts with three Likert-type questions for each part and four open-ended questions. We asked open-ended questions to be able to delve deep into the topic and give students an option of free-form answers. The data coding and analysis were carried out using the Dedoose software and IBM SPSS Statistics 27. The analysis of the external non-responses showed no systematic patterns with respect to central background variables. The analysis of internal non-responses showed no pattern indicating threats to validity in the items used.

In their qualitative study on critical requirements for a successful transition from student perspective, Trautwein and Bosse (2017) discovered 32 critical requirements that can be classified into four different dimensions (see Table 1). The requirements written **boldface** are carefully addressed in our questionnaire and the ones written in regular style are only partially addressed. The requirements written in *italics* are left out due to GDPR (the General Data Protection Regulation) rules or not applicable to our study.

2.3 Focus in this Study

In the present study, we focus on the part of the questionnaire that can be categorized according to the

Table 1: Critical difficulties and requirements of transition assigned to dimensions (Trautwein & Bosse, 2017, p. 379)

Personal	Organizational	Content related	Social
Balance areas of life	**Cope with the quality of teaching and supervision**	**Meet curricular demands and pace**	**Build peer relationships**
Arranging for housing	**Deal with assessment conditions**	Clarify study choice and study interest	**Collaborate in teams**
Schedule learning activities	**Cope with the formal regulations**	**Modify initial expectations**	**Interact with academic staff**
Find mode of learning	Deal with institutional resources and restrictions	**Identify performance and assessment standards**	**Cope with the social climate**
Manage the workload	**Gain an overall orientation**	**Generate subject related career goals**	Defend study choice
Cope with pressure to perform and exam nerves	Use information and support services	**Adjust to scholarly mode**	
Handle personal and financial problems	**Handle course offer**	**Acquire academic language proficiency**	
Follow the lecture	*Manage course selection*	**Develop academic skills**	
Cope with failure	Reconcile subject areas and courses		
Assess one's own performance and capacity			

Trautwein and Bosse's (2017) personal, organizational, and social dimensions (see Table 1) and that are linked to the beyond cognitive aspects of the transition. The students were asked to assess the degree of *social integration*, *motivation*, *interest*, i*nspiration*, *eagerness*, *confidence*, *success*, and *stress when making the transition from school to university*. All these characteristics can be related to the **personal dimension** and its requirements. The students were also asked about *having problems dealing with their time in a responsible and meaningful way* and if *the time they spend on their studies has increased at university*. Other items that can be related to the **personal dimension** and the specific requirements include: *the pace of study at university compared with upper secondary school*, and the *requirements of managing the studies*.

The questions that can be related to the **organizational dimension**, and the specific requirements presented above, are focused on *the level of support from teachers concerning learning strategies*, *the feedback the students get from their teachers*, *the level of the teachers' expectations*, *the quality of the lectures at university*, and *the requirements of managing the studies*.

The questions related to **the social dimension** are focused on *the degree of easiness in socializing with other students*, *the degree of difficulty in collaborating with other students, the degree of wellbeing of students, having different classmates on different courses, and the degree of being well integrated in the student club*s.

2.4 Analysis Procedure

The study is a mixed-method design, using a "sequential exploratory design" (Robson & McCartan, 2017), containing different phases of data analyses. The open-ended questions were analyzed using qualitative content analysis (e.g., Bryman, 2004). A priori categories from Trautwein and Bosse (2017) guided the qualitative content analysis. IBM SPSS Statistics 27 was used to analyze the data statistically.

Since it is not possible to measure different aspects of the secondary–tertiary transition using one single item, two composite measures were constructed. First, we used factor analysis to extract relevant items related to personal dimension and organizational dimension respectively. We theoretically analyzed the components, and based on our analysis, we decided to collapse components 2 and 3 (see Table 2). In the next step of the analysis, we used the two composite measures to explore students' expressed emotions regarding critical difficulties and requirements of transition assigned to content-related and social dimensions.

In the first composite measure "*Coping, balancing and managing workload*," the following five items were used: the pace of study, the level of difficulty, the teacher's expectations, increasing time on studies, and requirements of managing studies. In the second composite measure "*Support, feedback and quality of teaching*," three items were used: the quality of lectures, support from

Table 2: Factor load for items related to personal dimension and organizational dimension

	Component		
	1	2	3
The pace of study at university is higher			0.75
The level of difficulty of the course content at university is higher		0.37	0.55
The teacher's expectations of me as a student are higher at university			0.74
The time I spend on my studies has increased		0.81	
The requirements of managing my studies are higher at university		0.78	
The quality of lectures at university is higher	0.66		
I receive better support from my teachers concerning learning strategies	0.82		
I receive helpful feedback from my teachers	0.78		

Extraction method: principal component analysis.
Rotation method: Varimax with Kaiser normalization.
Rotation converged in four iterations.

teachers concerning learning strategies, and feedback from teachers. When exploring the dimensionality using Principal Component Analysis, we can see that the first composite measure explains 49% of the variance and the second 57% of the variance. Then, we controlled the two dimensions using multiple correspondence model (see Figure 1). Based on the model summary, we decided to use the composite measures, even though the reliability statistics are below lower bound (see, e.g., Peterson, 1994).

Ethical considerations: The study underwent ethical reviews at the involved universities. The following long and proven tradition of intervention research in the education sector was followed. All the relevant national regulations, institutional policies, in accordance the tenets of the Helsinki Declaration, have been followed. The study has been approved by the authors' institutional review board or equivalent committee at each university. The participating researchers did not process any sensitive personal data and the study in itself was not a major intervention in the participants' lives. The study was based on *voluntary participation* (the participants were free to opt in or out of the study at any point in time), *informed consent* (participants knew the purpose, benefits, and risks before they agree or decline to join), and *anonymity* (the identities of the participants was not known and personally identifiable data was not collected).

Model Summary

Dimension	Cronbach's Alpha	Variance Accounted For: Total (Eigenvalue)	Variance Accounted For: Inertia
1	.733	2.868	.319
2	.628	2.262	.251
Total		5.129	.570
Mean	.686[a]	2.565	.285

a. Mean Cronbach's Alpha is based on the mean Eigenvalue.

Figure 1: Model summary of multiple correspondence model.

3 Results

In the personal dimension, Trautwein and Bosse (2017) put forward balance of life; managing the workload and scheduling one's own learning activities. When asked about their workload, 38% (118/308) of the students agreed to a large extent having problems dealing with their time in a responsible and meaningful way. In addition, 84% (258/308) answered that the time they spend on their studies had increased at university. There are, however, some differences between the groups. About half of the Turkish students marked having problems managing their time, the ratio for the German and Swedish students was about one-third. Furthermore, a higher proportion of Turkish students (91%) and Swedish students (83%) noted that their workload had increased at university level. One-third of the German students agreed upon this.

Table 3 shows the distribution of three content-related aspects of managing the workload and scheduling one's own learning activities. We then asked about the requirements of managing their university studies, 39% (121/308) marked higher requirements than at upper secondary school, and 82% (252/308) agreed upon a higher pace of study at the university. Regarding the notion of higher pace, the groups differed a lot. 94%

Table 3: Distribution of answers regarding content-related aspects of managing the workload and scheduling one's own learning activities: *requirements of managing university studies, pace, and difficulty of course content at university* [Germany (DE), Sweden (SE), Turkiye (TR)]

	Strongly agree or agree			Neither agree nor disagree			Disagree or strongly disagree			
	DE	**SE**	**TR**	**DE**	**SE**	**TR**	**DE**	**SE**	**TR**	**Total**
I find the requirements of managing my studies are higher at university.	17	62	42	15	66	37	4	40	23	
		Total	*121*		*Total*	*118*		*Total*	*67*	*306*
I find the pace of study at university higher.	34	154	64	2	11	21	0	5	17	
		Total	*252*		*Total*	*34*		*Total*	*22*	*308*
I find the difficulty of the course content at university higher.	32	142	91	3	21	6	1	5	5	
		Total	*265*		*Total*	*30*		*Total*	*11*	*306*

(34/36) of the German students and 92% (154/170) of the Swedish students marked higher pace, but only 41% (64/102) the Turkish students agreed to a large degree upon this question. As expected, most students (87%, 265/306) agreed or strongly agreed that the difficulty of the course content at university is higher than in upper secondary school.

To examine how the students' cope with pressure to perform, their coping with failure, and assessing one's own performance and capacity, the students were asked to assess the level of different emotions that they have observed in their transition from school to university. Figure 2 shows the results on group level, and different patterns are revealed.

Many of the German students (80%, 29/36) and Swedish students (62%, 105/168) are feeling highly stressed comparing with the Turkish students (16%, 17/102). When looking to the level of success: 33% (30/102) of the Turkish students feel high level of success compared with less than 3% (1/36) in Germany and 5% (9/168) in Sweden. However, the students from Sweden (55%, 93/168) and Germany (44%, 16/36) seem to be more looking forward for their studies than the Turkish ones (19%, 20/102). Similar results we find when asking about the motivation where only 25% (26/102) of the Turkish students are highly motivated, compared with 50% (18/36) of the German students and 64% (109/168) of the Swedish students feeling motivated. Furthermore, when looking to the results concerning students' confidence, we find that only 20% (21/102) of the Turkish students are feeling confident, with a better percentage in the other two countries: 38% (14/36) in Germany and 36% (61/168) in Sweden. Similar differences we can see when looking to the levels of interest and feeling inspired. The Turkish students show lowest levels of interest (15%, 16/102) and feeling inspired (11%, 12/102). The German and Swedish students show feelings that are more similar: interest (83%, 30/36 versus 74%, 125/168) and feeling inspired (44%, 16/36 versus 55%, 94/168). When looking into the social integration, 23% (24/102) of the Turkish students feel that they managed to integrate, compared with 33% (12/36) German students and 39% (67/168) Swedish students.

In the organizational dimension, Trautwein and Bosse (2017) put forward aspects such as students coping with the quality of teaching and the formal regulations, dealing with assessment conditions. Table 4 shows the distribution of answers on items related to this dimension. With slightly small differences between countries, 45% of the students (140/306) agreed that the teaching styles of instructors are more difficult to handle at the university than previous school level. In the same time, 51% of them (158/308) agreed that the quality of the lectures at university is higher. No big differences between the universities were noted. When asking about the support from teachers concerning learning strategies, we found similar situations in the three universities with a third part of the students feeling that they get such support; 32% (99/308) of the them feel that they do not get such support. When asked if they received helpful feedback from their teachers, there were no big differences and 39% of the students (121/308) agreed that hey received helpful feedback from teachers. A large amount of the students 77% (237/308) (with slightly small differences between countries) perceived the teachers' expectations to be higher compared to upper secondary school.

In the social dimension, Trautwein and Bosse (2017) focus on students' ability to build peer relationships. Table 5 shows the distribution of answers on items related to this dimension. When asked about the level of easiness

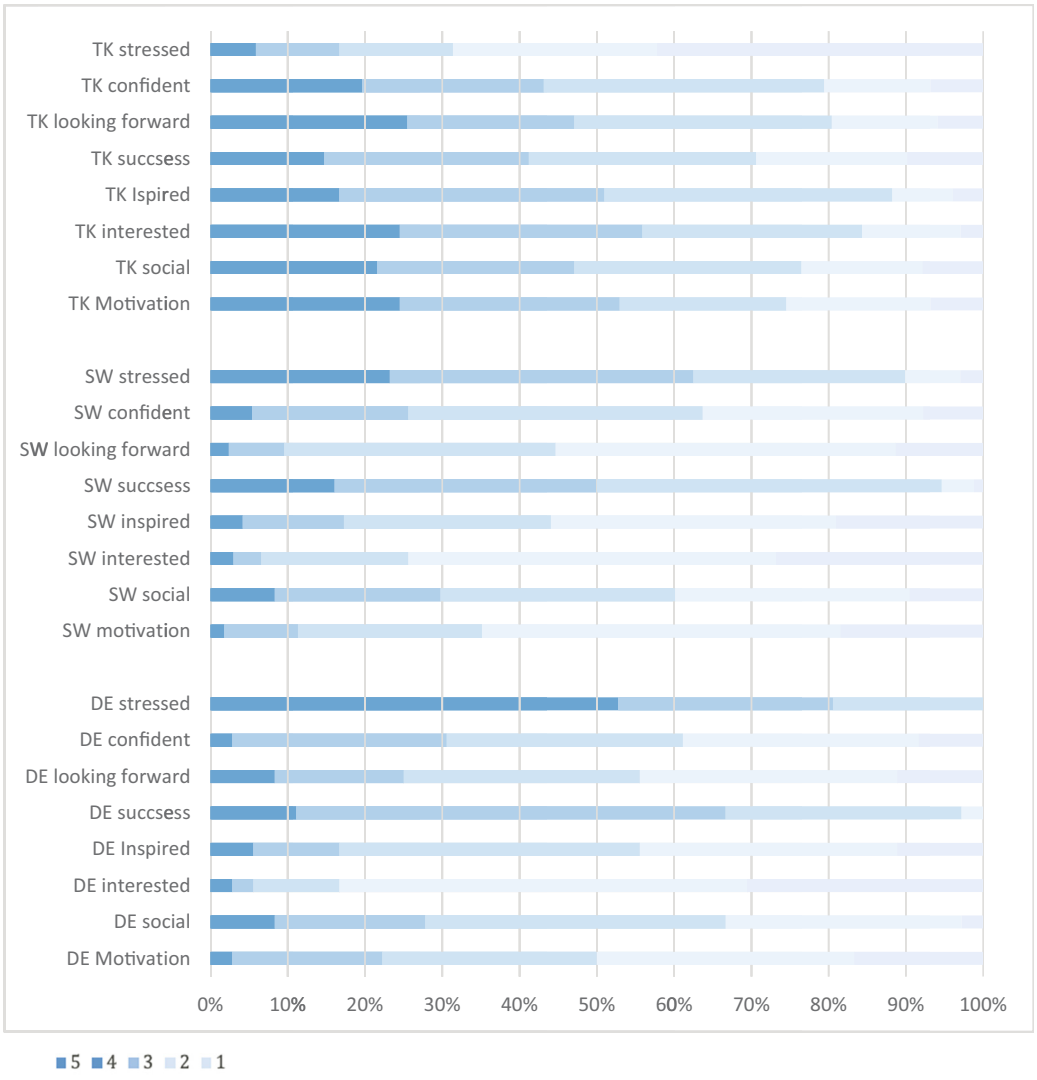

Figure 2: Levels of students' expressed emotions. Likert scale definitely (5), partially (4), neutral (3), partially not (2), and definitely not (1) [Germany (DE), Sweden (SE), Turkiye (TR)].

in socializing with other students, 70% (72/102) of the Turkish students found easy to socialize, while only 35% (60/168) of the Swedish students, respectively, and only 22% (8/36) of the German students feel the same. Considering the collaboration in teams, only 19% (32/168) of the Swedish students found difficult to collaborate with other students. Similarly, 27% (28/102) of the Turkish students find the collaboration difficult. The exception here are the German students that answer in 53% (19/36) strongly agree or agree to this question. Trying to find out how the students cope with the social climate, we asked about how they feel having different classmates on different courses and how well are they integrated in the student clubs. To the first question, the answers look similar in the three universities showing that many of the students are positive (82% (84/102) of the Turkish students, 72% (26/36) of the German students, and 61% (104/168) of the Swedish students) for having different classmates in different courses. A big amount (58%, 59/102) of the Turkish students are well integrated in the student clubs, while only 38% (58/168) of the Swedish students and 33% (12/36) of the German students feel the same.

When analyzing the results using the composite measures, we can see no significant correlation between *Support, feedback and quality of teaching* and students' expressed emotions regarding confidence, stress levels, or feelings of being overwhelmed or underchallenged. However, when it comes to *Coping, balancing and managing workload*, we notice a correlation to the level of confidence (see Table 6). The results indicate that the more confident a

Table 4: Distribution of answers regarding items related to the organizational dimension [Germany (DE), Sweden (SE), Turkiye (TR)]

	Strongly agree or agree			Neither agree nor disagree			Disagree or strongly disagree			
	DE	SE	TR	DE	SE	TR	DE	SE	TR	Total
The teaching styles of instructors more difficult to handle at university	14	72	54	15	52	30	7	44	18	
	Total		*140*	*Total*		*97*	*Total*		*69*	*306*
Teachers provide better support on learning strategies	5	53	32	17	64	36	14	51	34	
	Total		*90*	*Total*		*117*	*Total*		*99*	*306*
Receive helpful feedback from teachers	17	62	42	15	66	37	4	40	23	
	Total		*121*	*Total*		*118*	*Total*		*67*	*306*
Teachers' expectations are higher at university	31	134	72	4	26	16	1	8	14	
	Total		*237*	*Total*		*46*	*Total*		*23*	
The quality of lectures at university is higher	19	78	61	14	52	27	3	38	14	
	Total		*158*	*Total*		*93*	*Total*		*55*	*306*

student is, s/he express higher level of handling expectations and managing the workload. Furthermore, the results indicate a correlation between expressed confidence and feelings regarding if one is socially integrated or lonely; the more confident the more socially integrated, and the more uncertain/doubtful the lonelier. Note, we do not have data to show causality.

Table 6 also shows a correlation between stress levels and feelings of being overwhelmed or underchallenged. The results show a moderate correlation between feelings of being overwhelmed and stress, which is expected. However, the results also imply a correlation between feelings of being underchallenged and being relaxed. This result suggests the existence of a group of students that are not coming to their full potential, that is, if the mathematics taught is not challenging enough, the students may not make enough effort to progress in their learning.

3.1 Results from Analysis of Open-Ended Questions

Looking into the responses to open-ended questions may be the bridge to understand the personal, social, and

Table 5: Distribution of answers regarding items related to the social dimension [Germany (DE), Sweden (SE), Turkiye (TR)]

	Strongly agree or agree			Neither agree nor disagree			Disagree or strongly disagree			
	DE	SE	TR	DE	SE	TR	DE	SE	TR	Total
At university, I find it easier to socialize with other students.	8	60	72	11	59	21	17	49	11	
	Total		*140*	*Total*		*91*	*Total*		*77*	*308*
At university, I find it more difficult to collaborate with other students.	19	32	28	6	47	38	11	89	36	
	Total		*79*	*Total*		*91*	*Total*		*136*	*308*
At university, I think it is good that one can have different classmates on different courses.	26	104	84	8	58	10	2	6	8	
	Total		*214*	*Total*		*76*	*Total*		*306*	*308*
At university, I am well integrated in the student clubs.	12	58	59	13	53	22	11	57	22	
	Total		*129*	*Total*		*88*	*Total*		*90*	*308*

Table 6: Correlation between composite measures (*Support, feedback and quality of teaching; Coping, balancing and managing workload*) and students' expressed emotions

		Support, feedback, quality	**Socially integrated (1)–lonely (5)**	**Confident (1)–uncertain/ doubtful (5)**	**Stressed (1)–relaxed (5)**	**overwhelmed (1)–underchallenged (5)**	**Coping, balancing, managing**
Support, feedback, quality	Pearson correlation	1	−0.109	−0.001	0.007	−0.097	0.013
	Sig. (2-tailed)		0.057	0.982	0.902	0.090	0.819
	N	308	308	308	308	308	308
Socially integrated (1)–lonely (5)	Pearson correlation	−0.109	1	**0.381****	0.085	**0.243****	0.042
	Sig. (2-tailed)	0.057		<0.001	0.137	<0.001	0.464
	N	308	308	308	308	308	308
Confident (1) –uncertain/ doubtful (5)	Pearson correlation	−0.001	**0.381****	1	−0.015	**0.242****	**−0.155****
	Sig. (2-tailed)	0.982	<0.001		0.797	<0.001	0.006
	N	308	308	308	308	308	308
Stressed (1)–relaxed (5)	Pearson correlation	0.007	0.085	−0.015	1	**0.381****	0.077
	Sig. (2-tailed)	0.902	0.137	0.797		<0.001	0.178
	N	308	308	308	308	308	308
Overwhelmed (1)–underchallenged (5)	Pearson correlation	−0.097	**0.243****	**0.242****	**0.381****	1	0.036
	Sig. (2-tailed)	0.090	<0.001	<0.001	<0.001		0.525
	N	308	308	308	308	308	308
Coping, balancing, managing	Pearson correlation	0.013	0.042	**−0.155****	0.077	0.036	1
	Sig. (2-tailed)	0.819	0.464	0.006	0.178	0.525	
	N	308	308	308	308	308	308

** Correlation is significant at the 0.01 level (2-tailed).

organizational dimensions in more depth. The analysis shows that students' struggle balancing the different areas of life, coping with the formal regulations and the quality of teaching. Several students point to the aspects of adulthood: "literally I grew up" writes one of the Turkish male (TRM) students, and a Swedish female (SEF) student express: "I feel that a little extra self-discipline is required, otherwise it only works if you put in the time required". The aspects of loneliness are underscored by some students, here an excerpt from a German male (DEM) student:

> In the first semester, it is basically already a very big change from school to university for me. You have to invest a lot more time because you only know a few people who can help you or with whom you can review certain content. Overall, it is very difficult for me to get started, especially in such demanding lectures like Lin Alg 1, because I am very much on my own.

Students also highlight the importance of building peer relationships, as a male student from Sweden said, "haven't really got any study group which is sad. Sits mostly alone in studies but it would be good to have someone to brainstorm ideas with." Students mentioned the importance of collaborating in teams and having more space to interact with academic staff, as one Turkish student said, "It was more difficult to ask questions to teachers in upper secondary school. On the other hand, teachers at university are insisting us to ask questions" (TRF). On the contrary, a student from Sweden said "almost no contact with the teacher at all. Gets more boring and less motivating when you have no personal contact in my opinion" (SEM).

When it comes to coping with social climate of university, a Swedish student said, "At the university, there is a much larger community and even though Corona has been affected so we cannot hang out with so many, you still get to know each other in a different way than in upper secondary school." One female and one male Turkish students also highlight the opportunities that universities provide, respectively, "university has many more socializing options and different groups of people. It's easier to find groups of friends" (TRF) and "we have more opportunities to socialize at the university. People are more social and mature" (TRM). Another Turkish student added their views from a different perspective, "there was a friendlier atmosphere in upper secondary school, but we cannot find this at university. At university it is more like a workplace. When you make a mistake, there is absolutely no return."

We also see students' struggling with how to handle the course offer. As one of the Turkish female students describe: "Our lessons are harder and we need more social life. It is very difficult to have both a social life and academic life and I do not know how to manage it." Also, students from Germany and Sweden outline similar experiences:

> The way you study is completely different from upper secondary school because I have much more personal responsibility and there is no support to seek from the teachers now, as in the same way as upper secondary school (SEF).

> The biggest difference between upper secondary school (or, Adult Education in my case), is that at university there is less time with lectures/reviews than at upper secondary school, and consequently less time with the teacher. Learning at the university is more dependent on being able to study for knowledge in course literature and online, in upper secondary school you get, as I said above, much more oral teaching (SEF).

> It sucks not understanding things right away and then sometimes you have doubts about your own competence and intelligence (DEM).

One of the organizational aspects that differ between the universities is if the tutoring is held in the main language or not. In the Turkish university, the lectures are held in English:

> While English is already a difficult language, trying to learn all these math terms can take time. Like in upper secondary school, at university our aim is not only to pass the class, but able to use what we have learned in professional life and for that, we must work harder. Unfortunately, it can be difficult to know this and work accordingly (TRF).

There are also many students that are pleased with the situation. They put forward both the quality of teaching: "We had a higher degree of quality in the lectures than in upper secondary school. Very good and well-planned lectures" (SEF), and some of them highlight the importance of good study environment: "Much nicer work environment from both teachers and other students. Nice study places at the university as well" (SEM).

4 Summary

The results from the statistical analysis put together with the conclusions after analyzing the open-ended questions show how different aspects of the Trautwein and Bosse (2017) dimensions seems to influence the secondary–tertiary transition in mathematics for first year engineering students *beyond the purely cognitive aspects* (see Figure 3). Feelings of confidence correlate with

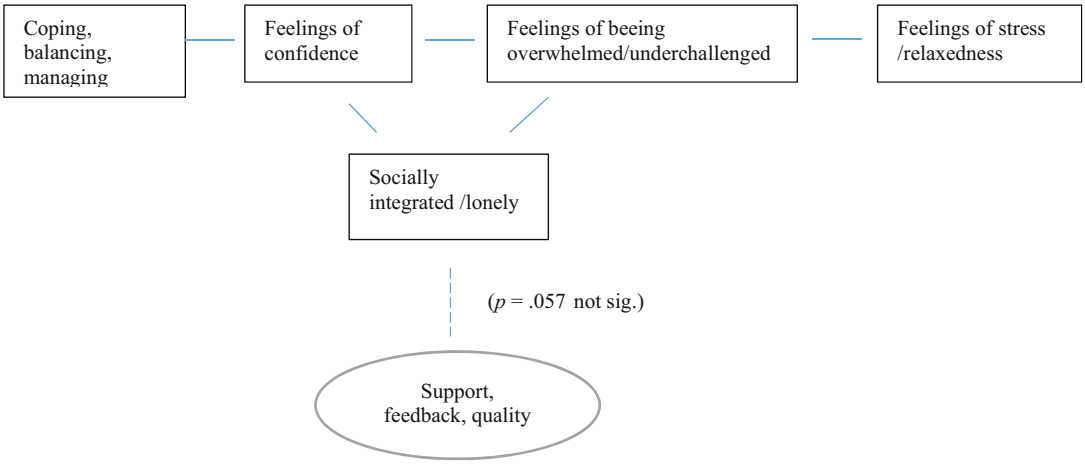

Figure 3: Different aspects beyond the purely cognitive that seems to influence the secondary–tertiary transition in mathematics for first year engineering students.

both feelings of being overwhelmed or underchallenged and feelings of being socially integrated or lonely. The results show that aspects of the personal dimension (e.g., coping, balancing and managing the workload) relate with this triad.

Furthermore, the results indicate a relation between aspects of the organizational dimension (e.g., support, feedback, and quality of teaching) and feelings of being socially integrated or lonely. There is no significant measure conveying this. Still, many of the open-ended questions uncover potential connections between difficulties and requirements of transition assigned to personal, organizational, and social dimensions. However, differences and similarities can be observed across the different countries.

5 Discussion

Our analysis, in line with Trautwein and Bosse (2017), suggests that personal, organizational, and social dimensions influence secondary–tertiary transition beyond the purely cognitive aspects. Still, we cannot conclude which one is more crucial. Nevertheless, there seems to be a triad of confidence, overwhelmed/underchallenged, and level of socially integration that need more attention in future research and course development.

The results can be understood in relation to the academic, social, and emotional shocks (Cheng et al., 2015). That is, how the first-year mathematics are organized, and to what extent, the students are prepared for, or get support in, balancing areas of life, managing workload, etc. Entering the university is for the student a way of maturing and growing up. This internal process in the secondary–tertiary transition is hence to undergo a change from familiar to the unknown (Cheng et al., 2015). Here, the students need to develop their abilities to navigate in a new educational setting and "becoming" a university student (cf. Gale & Parker's, 2014 definition of transition); the students' self-perceptions and characteristics will change. Inevitably, this kind of transition activates aspects related to the triad of confidence, overwhelmed/underchallenged, and level of socially integration as detected in this study. The transition is hence both connected to the cognitive aspects of studying first year engineering mathematics, as well as going beyond such aspects. It can be said that students' success not only depends on subject knowledge but also "the ability to have healthy interpersonal relationships off and on campus" (Kuh & Love, 2000 as it was quoted from Aypay et al., 2012, p. 93).

Our aim in this study was to find out which dimension(s) influences the secondary–tertiary transition in mathematics for first year engineering students. By looking into the data and responses to open-ended questions, it can be said that the transition is influenced by these dimensions (personal, organizational, and social). However, we cannot conclude if one is more important than the other since they are all interrelated. Even though we have done our best to compartmentalize the dimensions, it can be also seen from the students' quotes that these dimensions are all linked.

The results show a moderate correlation between feelings of being overwhelmed and stress, which is expected. However, differences and similarities can be observed across the different countries. For instance, on group level, the Turkish students are more relaxed, more motivated, and eager to study mathematics than their peers in Germany and Sweden. Even though Turkish students indicate

the challenges of studying Math in English, they also emphasized the supportive nature of the organization. Furthermore, the results imply a moderate correlation between feelings of being underchallenged and being relaxed. This result suggests that there is a group of students not coming to their full potential. This result is important to recognize; even though not completely unexpected, it still not universal acknowledged. The phenomenon is due to the fact that first year engineering students usually read in large students groups with a large spectrum of pre-knowledge and it is difficult or better said unusual to implement student-centered teaching and learning in such courses. This type of courses was the courses included in our study. The essential work focusing on the causes for high dropout rates (e.g., Gómez-Chacón et al., 2015; Heubeil, 2014; Nardi, 2008) might hinder course development aiming for supporting highly able students (see, e.g., Vinerean et al., 2021).

5.1 Limitations

The data collection was during the COVID-19 lock down. We know that the COVID-19 has had an impact on all of students and teachers (Nilsberth, Liljekvist, Olin-Scheller, Samuelsson, & Hallquist, 2021; Teke-Lloyd, Türk, & Bengü, 2022). We cannot overrule its importance regarding crucial parts in the transition problems, i.e., the shocks (academic, social, emotional) addressed by the models depicted by Cheng et al. (2015). There were differences in how the universities handled remote teaching. How the situation (COVID-19) affected the transition is not examined in this study.

6 Conclusions and Future Directions of Research

The study was done across different educational systems; it was valuable to work from a theoretical framework both regarding design and analysis to detect differences and similarities across our different universities. This is promising for future work when making in-depth analysis of both the qualitative and quantitative data collected in different educational systems.

The secondary–tertiary transition is influenced by the personal, organizational, and social dimensions beyond the purely cognitive aspects. There seems to be a triad of feelings related to being confident, overwhelmed or underchallenged, and feelings regarding the level of being socially integrated that need more attention in future research and course development.

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