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DOI:

[10.1016/j.ijer.2016.06.008](https://doi.org/10.1016/j.ijer.2016.06.008)

Document Version

Accepted author manuscript

[Link to publication record in Manchester Research Explorer](#)

Citation for published version (APA):

Pampaka, M., Pepin, B., & Sikko, S. A. (2016). Supporting or alienating students during their transition to Higher Education: mathematically relevant trajectories in the contexts of England and Norway. *International Journal of Educational Research*, 79, 240-257. <https://doi.org/10.1016/j.ijer.2016.06.008>

Published in:

International Journal of Educational Research

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Supporting or alienating students during their transition to Higher Education: mathematically relevant trajectories in the contexts of England and Norway

Maria Pampaka*, Birgit Pepin and Svein Arne Sikko

Abstract

Drawing on our projects of transition to mathematically demanding subjects in UK Higher Education and an extension of this work in Norway, we explore the measurement of various pedagogical and learning aspects of students' transition into Higher Education. We focus on experiences of engagement, and alienation, which we claim can offer an enhanced view on student learning experiences. Our analysis is based on longitudinal surveys of students entering different programmes in UK (N=1778), and Norwegian (N=721) universities. Validation is performed within the Rasch measurement framework, which indicated problems in establishing measurement invariance. Cross-sectional analysis of the two datasets, then, revealed consistent patterns in the process of alienation from mathematics as well as some systemic mechanisms that can help alleviate that.

Keywords: Mathematics dispositions, alienation, transmissionist teaching, Rasch analysis

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Acknowledgement/Funding: The authors would like to acknowledge the support of the ESRC projects with grant numbers RES-061-025-0538 and RES-062-23-1213. We would also like to thank Prof Julian Williams for the valuable comments throughout, and the two anonymous reviewers.

1. Introduction

It is well documented that very few students are well prepared and well disposed to continue their studies in mathematically-demanding courses in Higher Education (HE) institutions (for more details see Roberts, 2002; Smith, 2004). The aim of the TransMaths projects (www.transmaths.org), project, both in the UK and in Norway, was to understand how students can acquire a mathematical disposition and an identity that support their engagement with (mathematics in) Science, Technology, Engineering and Mathematics (STEM) courses in their pre-university and university education. In particular, we investigated how students' experiences of mathematics education practices interact with background social factors to shape students' self-identity, dispositions, learning outcomes and their decision-making in college and in transition into HE. In this paper we further explore the process of alienation through empirical quantitative evidence during students' transition. This relates to our earlier work, where we found evidence of a negative effect of transmissionist teaching on students' mathematics dispositions at the end of their pre-university courses, (Pampaka, Williams, Hutcherson, et al., 2012) which for some students meant deciding not to go into STEM subjects.

There are different reasons to support our rationale for investigating the English and Norwegian cases. Both are considered as highly-developed European countries, and 'rich' arguably due to their oil production and related industries. However, there are interesting societal and educational level differences which make such a comparison relevant. It can be argued that the UK is a relatively non-egalitarian class society, in which 'equity' is of mainly 'rhetorical' priority, but in practice schools prioritise attainment and league tables, which arguably militates against the 'priority' or equity. Norway, on the other hand, is regarded as one of the most egalitarian countries in Europe, where education is free, at all levels (including university education). It is mandatory from grades 1-10, and everybody has the right to secondary education at grades 11-13. Elementary school (grades 1-10) follows the model of 'enhetsskolen' (one school for all). This means that there is an inclusive attitude, a wish to include everybody, and that everybody should get the same educational opportunities, and hence get the same opportunities to pursue HE and suitable careers. This can be seen in the light of strong social-democratic political traditions which have dominated Norwegian politics since the 1930's, even in periods of conservative/coalition governments. Universities and university colleges are, with few exceptions, state - funded and students pay no tuition fees.

Norway is probably one of the richest countries in Europe (it was one of few countries which was able to steer free from the financial crisis in Europe in the 2000's), and it still has a growing economy with high demand for labour force, in particular in engineering and other high-skill areas, including academic careers. Students going into HE can thus feel safe that they will get a job, nearly regardless which subjects they choose to study . This is particularly true for engineering, and teacher education, with a relatively similar situation in the UK job market. In the UK, whilst mathematics graduates find it easier to find employment (than other graduates), they typically seek, and find, employment in the financial sector : many mathematics graduates go into the financial sector, to make money

as stock brokers, or work for the banks in the City (of London). From our survey it was also clear that UK students study mathematics for different reasons and purposes, and engineering was not the strongest incentive in the UK (Harris et al., 2015; Pepin, Lysø, & Sikko, 2012).

We hypothesize, thus, that the social and cultural differences between the UK and Norway will give rise to differences of perceived feeling of (support or) alienation towards mathematics learning at school and university. A free and inclusive educational system, together with a social democratic and open society, relates to a less competitive and grade focused system at school and university. This is likely to lead to a more respectful environment regarding students' independent learning, and hence to less perceived alienation in a Norwegian system, as compared to a more competitive and class divided UK system.

In this paper we focus on students who went through the respective educational processes in Norway and the UK, overcoming barriers, and managed to secure a place in HE. We aim to further investigate the role of pedagogical experiences and support on students' transition into HE, as sources of alienation from mathematics and STEM related topics (or even studying at university), as manifested through associations with disposition measures which we consider as subjective experiences of alienation. This will provide valuable insights into mechanisms for keeping students in STEM subjects, and generally in HE, and hence for students' educational and socio-economic life opportunities (Ball, Davies, David, & Raey, 2002; Boaler & Greeno, 2000). The paper starts with a short overview of the concept of 'alienation' and our conceptualisation of it within the context of this paper. We continue with our methodological and analytical framework, and subsequently present results regarding our measure validation, as well as substantive findings with the use of these measures. We conclude with a discussion of our findings and their implications.

2. The concept of *alienation*

The term 'alienation' is rooted in Marx' work and the notion of 'estranged labour' (Marx, 1844), which essentially builds on relevant concepts from Hegel. In its generic form it refers to "the process whereby people become foreign to the world they are living in"¹. The term was brought more closely into education through the work of Lave and Mc Dermott (2002) who replaced 'learning' for 'labour'. This interpretation and further implications in (mathematics) education have been extensively discussed by Williams (2015; 2012).

Because in this paper we adopt a more 'instrumental' approach, we turn to some recent conceptualisations of alienation through the lens of social psychology and disengagement, and their associations, before we return to our own operationalisations which is influenced by both perspectives.

¹ <https://www.marxists.org/glossary/terms/a/l.htm#alienation>

The notion of student alienation was used in social psychological theory in the 1960s, according to which alienation evolved under conditions that generated low self esteem and low social interest (Ziller, 1969); the growth of conceptual and practical theory on student alienation has been accompanied by assessment tools and recommended practices (e.g. Hyman et al., 2004). There has been a consensus that student alienation results in “an estrangement from the learning process and involves the subjective experience of being wrongly isolated from one or more school groups (e.g. other students, teachers, and/or administrators) or activities (e.g. class activities, ...)” (Tarquin & Cook-Cottone, 2008).

More recently, and taking another perspective, alienation has been linked to student approaches to learning (e.g. for a summary of key concepts in this perspective see Biggs, 2003), with a clear focus on cognitive aspects of student learning experience. However, these studies have been criticised for their limited focus, and scholars have suggested (e.g. Malcolm & Zukas, 2001) that insufficient care has been taken of the learner’s social and cultural context. Critics have argued that this represents the student as “an anonymous, decontextualized, degendered being whose principal distinguishing characteristics are ‘personality’, ‘learning style’ or ‘approach to learning’” (ibid, p.38). Trying to address the limitations of the approaches to learning perspective, Mann (2001) suggested an alternative approach: a focus on experiences of alienation and engagement, which appeared to provide ‘a broader and more contextualised view on the student learning experience’. Here the notion of alienation refers to a disconnection in the context of a desired or expected relationship; and this is a useful perspective in terms of analysing, and identifying potential relationships of students’ learning experiences, and subsequently of examining instances of connection/engagement, or disconnection/alienation. This view is in agreement with Marx’s definition of alienation (and recent work in maths education as mentioned earlier).

The literature is clear that the sources of student alienation are varied, including curricular, institutional, and socio-cultural factors (e.g. Brown, Higgins, & Paulsen, 2003). Alienated students feel ‘disconnected’ from curricula and unable to establish meaningful connections. They simply do not see any opportunities for doing so, which often results in apathy in the learning processes. Recent studies describe alienation in terms of student estrangement or dis-engagement from the learning process (e.g. Case, 2008). This perspective has been influenced by the work of Mann (2001) who focussed on student learning in HE, offering some theoretical perspectives which help to understand an ‘alienating experience’ by considering alienation as the result of:

- the post-modern focus on utilitarianism, functionality and competence;
- the ways in which academic discourse constructs student identity;
- the experience of being an ‘outsider’ in the academic world;
- a context which requires compliancy rather than creativity;
- disempowering assessment practices;
- assessment practices which impose power and compliance by means of examinations, learning journals, learning contracts, etc.

Case (2008) provided a simpler framework of alienation resulting from three categories: entering HE; fitting into HE community; staying in the HE. This suitably aligns with our empirical position in this paper, since we follow students during their transition and focus on alienating or engaging experiences of learning.

There have also been several attempts to measure student alienation with various instruments (e.g. Thorpe, 2003), amongst them approaches to assessing student alienation incorporating the *Classroom Life Instrument* (Johnson & Johnson, 1983) and its further modifications (e.g. Ghaith, 2003). An overview of the most commonly used instruments for 'HE alienation' reveals that they provide an indication of 'overall' alienation or disengagement, with a mixture of items capturing students' dispositions (and feelings).

In our more mathematically-focused work we have also previously constructed, and validated for the UK, measures related to students' experiences during their transition to HE. From this empirical perspective alienation is viewed as a process rather than an attribute associated with a student. In this way we deal with what others (e.g. Williams, 2015) classify as subjective experiences of alienation from mathematics and try to objectify these within pedagogical and institutional process that are assumed to be influencing the former. As our approach is more instrumental, while we acknowledge the distinction (i.e. between subjective and objective experiences), we stay away from this for our operationalisation. Instead, in this paper we attempt to quantify the process of alienation through students responses in surveys and subsequent statistical modelling of proxies of subjective experiences of alienation (e.g. negative dispositions towards mathematics) accounting for other (perceptions of) experiences during the process of transition to university and related to the pedagogy before and during university that might enhance or alleviate dispositions. This becomes possible with the previously developed and validated instruments (for the UK) that capture students' pedagogical experiences (e.g. experiencing transmissionist teaching), and more generic perceptions of the transitional gap and positivity towards the transitional experience in HE (Pampaka, Williams, & Hutcheson, 2012). Building on this work, and its extension to Norway, we thus ask the following research questions:

(1) How can we measure students' perceptions of alienating processes during their transition to HE, related to pedagogical and learning aspects? How can we evaluate the comparability of these measures across two different educational systems? (i.e. can we establish construct validity and ensure measurement invariance?)

(2) How are these measures linked to students' experiences of alienation, such as students' dispositions?

3. The research design and samples

We draw on data from two studies within our TransMaths agenda: the first study, which also sets the methodological framework for the other, was an ESRC funded project²

² [REDACTED]

entitled "Mathematics learning, identity and educational practice: the transition into Higher Education" and took place from 2008 to 2010 in the United Kingdom (UK). The second study, from 2010 to 2012³, aimed to replicate the established methodology and instruments, developed for the UK population, in the Norwegian educational system. Both studies were methodologically hybrid, mixed methods studies involving a longitudinal student survey (the most relevant part for this paper) and case study work. The UK TransMaths project included three data points (DPs hereafter): at or just before the beginning of students university course (DP1 @ summer/autumn of 2008), later in the first year (DP2 @ February to May 2009), and early in their second year (DP3 @ October 2009 to January 2010). The Norwegian study included only two DPs: early in the first (NDP1 @ September 2010) and second (NDP2 @ Autumn 2011) year of university studies (altogether about 15 months into HE). Surveys were complemented with multiple case studies of HE programmes and students who enrolled on them, following them as they progressed through their transition from the end of their pre-university education⁴, or start of university, until about 15 months into their HE studies.

In terms of sampling, data come from students in five UK (N=1778) and two Norwegian Universities (N=721). For the **UK sample**, we mainly drew on cohorts of students in selected STEM programmes (i.e. Mathematics, Engineering, Physics, Chemistry; exceptions being in Education, and Medicine) in five HE institutions⁵. The **Norwegian sample** comes from various courses (e.g. mathematics for engineers; for teachers; for mathematicians; for 'other' professions) at two institutions. A brief description of the samples is given in Table 1 (more details in Pampaka, Williams, & Hutcheson, 2012; Pepin et al., 2012).

Table 1: Description of the two samples

| Sample / by Gender | DP1/NDP1 | DP2 | DP3 |
|---------------------------|-------------------|------------------------|-------------------|
| UK Sample* | N=1778 (%) | N=875 (%) | N= 824 (%) |
| Female | 726 (41) | 411 (47) | 383 (46.5) |
| Male | 1052 (59) | 464 (53) | 441 (53.5) |
| Norwegian Sample** | N=721 (%) | NDP2: N=563 (%) | |
| Female | 361 (50) | 278 (49.5) | |
| Male | 359 (50) | 284 (50.5) | |

* Students are matched across the two DPs
 ** The Norwegian sample sizes should be considered as independent across DPs; matching was only possible for around 250+ students.

4. Methodological/Analytical Approach

In this paper, as in our previous work (Pampaka, Hutcheson, & Williams, 2014; Pampaka, Kleanthous, Hutcheson, & Wake, 2011; Pampaka, Williams, & Hutcheson, 2012; Pampaka et al., 2013; Pampaka, Williams, Hutcheson, et al., 2012), we have followed the common methodological/analytical framework shown in Figure 1, in order to guide our way towards responding to the research questions. In particular, the various instruments

³ An additional element from 2013 to 2016 – follows selected surveyed students from university into work

⁴ In UK, this is associated with the second year of post-secondary education (in colleges) when students get their A levels (A2) in various subjects.

⁵ One was a post-92 (former polytechnic) institution, two were 'Russell group', and two '1994 group' universities

forming our questionnaires were developed first in English, based on the theoretical background, the research literature and information collected during the projects' pilot stages. A distinctive feature of the work presented here at this stage involved the adaptation of these instruments (after they have been validated for UK) for the Norwegian context. This involved "back-and-forth" translation into Norwegian by a team consisting of both native English and Norwegian speakers fluent in both languages, and subsequent validation of the questionnaires with students in a pilot study. Validation of the relevant constructs was performed with the Rasch model, and the resulting measures were then used in further statistical analysis and modeling. These steps are detailed next.



Figure 1: Framework for building, validating and using alternative measures of teaching and learning outcomes

4.1. The Questionnaires & Instrument Development

Questionnaires, for both countries, included a mixture of structured quantifiable items measuring students' dispositions, perceptions of teaching and transitional experiences, open-ended questions, giving rise to more qualitative data, and background variables such as gender, age, previous maths qualifications (at school), as well as 'programme'-related variables (i.e. course and institution). The constructs/measures of interest for this paper are outlined next with their operationalization herein in regards to the process of alienation.

Mathematics Disposition (DP1, DP2, DP3, NPD1, NPD2): These are considered as proxies of students' subjective experience of alienation as they denote students' dispositions towards further use/study of mathematics. An example item that defines this measure is: "If I find out that any future study involves more mathematics than I thought, this would make me feel:" with response options from very happy to very unhappy. These measures have been validated and extensively used in our previous work and the details are provided elsewhere (Pampaka et al., 2011; Pampaka & Williams, 2010; Pampaka et al., 2013).

Perceived pedagogical experiences at pre-uni (DP1, NPD1) and university (DP2, NPD2) maths: The development of these two instruments capturing students' perceptions of the teaching practices they experienced before and during their university (maths relevant) studies, was based on the theoretical framework of our previous work, which detailed a measure of teacher self-reported pre-university pedagogy and its association with students' learning outcomes (Pampaka, Williams, Hutcheson, et al., 2012). For this we employed Swan's previously developed instrument (Swan, 2006), which in turn built on

the research findings of Askew and his team (Askew, Brown, Rhodes, Johnson, & Wiliam, 1997) and Ernest (Ernest, 1991): From the work of Askew and colleagues Swan derived the ‘ideal’ categories of teachers’ orientation towards each component (i.e. transmission, discovery and connectionist). In Pampaka et al. (2012) this is described in detail: using and adopting Swan’s items we constructed a unidimensional measure of transmissionism (or ‘teacher-centricism’) in teaching mathematics. For the purposes of the TransMaths projects, we reduced the original 28-item teacher survey to an 11-item instrument of students’ perceived transmissionist pedagogical experience, which we hypothesise here plays a role in the alienating process. The items, as presented to British students at DP1 are shown in Appendix 1. This instrument will be used as an indicative example of how measures were constructed, and thus the main focus of the detailed validation process presented later in the paper.

Transitional experiences (DP2, NPD2): This instrument aims to capture students’ transitional experience into university, which is considered here as another indicator that affects the process/system of alienation. Appendix 2 presents the 13 items of this instrument appearing in the DP2 questionnaires. Details on the construction and validation of this instrument for the UK context has been provided elsewhere (Pampaka, Williams, & Hutcheson, 2012) along with some results using the two constructed measures: the first we called ‘perception of the transitional gap/jump’ and the other ‘degree of positive feeling about the transition’. These measures are very relevant here as they both objectify experiences of alienation: the former (gap) captures the perceived gap students perceive they experience during transition, whereas the latter indicates the degree of their positivity with this gap, thus potentially influencing the (subjective) experience of alienation from maths. The outcome of the validation process for this measurement for the Norwegian sample is also presented in this paper.

Perceived mathematical support at university (DP2 and DP3, NPD2): Finally, in order to capture students’ perceptions of the supporting mechanisms that may help them ‘survive’ their transition to university, we developed another instrument (see Appendix 3), based on pilot work and interviews conducted at the initial phase of the project. Its validation for UK is presented elsewhere (Pampaka et al., 2014) and the resulting measure for Norway is also overviewed here. This measure is called ‘quality of learning support for mathematics in transition to university’ and we consider here as capturing a potentially pulling force which could alleviate the other (subjective) alienating experiences.

4.2. Our measurement approach to validation

Our validation approach in this paper has been extensively tested and applied in various constructed measures, with results reported elsewhere (e.g. Pampaka et al., 2011; Pampaka et al., 2013). Briefly, our psychometric analysis for validation was conducted within the Rasch measurement framework, following the relevant guidelines (Wolfe & Smith Jr., 2007a, 2007b). The Rasch model was selected instead of classical test modelling approaches and other item response theory models, because it provides the means for

constructing interval measures from raw data (Wright, 1977) once certain assumptions are met, including uni-dimensionality, local independence, and common item discrimination. In its simplest form (i.e. for dichotomous responses) the model proposes a mathematical relationship between a person's 'ability', the 'difficulty' of the task, and the probability of the person succeeding on that task, facilitating the construction of simple, fit for purpose, one-dimensional measures. The dichotomous model was employed for the construction of the 'transitional gap' measure; for the rest of our analyses we used the one-parameter Rasch rating scale model (RSM), which is an extension of the simple Rasch model to rating scale observations like in most of our instruments (i.e. with ordered response categories for feelings/satisfaction: Negative, Neutral, Positive; or ordered frequency categories for the pedagogical measures). RSM establishes the relative difficulty of each item stem in recording the development of a scale from the lowest to the highest levels the instrument is able to record (Andrich, 1999; Bond & Fox, 2001; Wright & Mok, 2000). Validity evidence, under this framework, is thus based on statistical indices, from which we focus on **item fit statistics** (as indicators of construct validity and unidimensionality), **category statistics** (for the appropriateness of the Likert scale used), and **person-item maps** (for substantive, content and external validity) (Wolfe & Smith Jr., 2007b). Further investigation of dimensionality issues was also performed by exploring the results of principal component analysis of the residuals after the Rasch model was fitted (Linacre, 1998). Particularly relevant for this analysis and the comparability between UK and Norway measures is **Differential Item Functioning (DIF)**. DIF tests for group invariance in the item calibrations, when an instrument is used with different groups of persons; only when group invariance is established, meaningful comparisons of person measures can be secured (Thissen, Steinberg, & Wainer, 1993; Wright & Masters, 1982). Analysis for this paper was performed with the Winsteps software (Linacre, 2014); some calibrations reported for earlier work were performed with FACETS (Linacre, 2003).

5. Results

In this section we focus on the measurement results for the 'reduced' pedagogy instrument (Pampaka, Williams, Hutcheson, et al., 2012) into the two measures of students' perceived pedagogical experience before and during their first year at university in UK and Norway. We then summarise the measurement outcomes of the other relevant measures, and we move on to use these measures to map students transitional experiences and find explanations of potential alienation and its resolution.

5.1 Validation Results: Students' Perceived Pedagogical Experiences in two systems

The 11 items of the shortened instrument about students perceptions of the pedagogical experiences they encountered in their maths classes before and during university (Appendix 1) were analysed with the Rasch RSM as this is the most appropriate model for the case of items that share the same response options. For easier interpretation of the measures and in order for higher scores to indicate transmissionist teaching (for consistency with our previous results) the coding of items 2-8 was reversed. Analysis was performed initially with both DPs together but these results did not support time

invariance of the measures (i.e. the two instruments could not be considered equivalent), so independent analysis was considered more valid. We limit the detailed presentation of results here to the instrument relevant to the pre-university mathematics experience.

We first explore the Rasch item **fit statistics**, which provide evidence for construct validity and in case of inconsistent data (with the model) they might suggest the existence of new dimensions in the data, or may flag items to which responses are overly predictable (overfits), an indication that they somehow depend on other items and might be candidates for deletion (Bowles, 2003; Wright, 1994). At this point we acknowledge the debate around cut-off points for acceptable ranges for fit statistics (Linacre, 2002; Smith, Schumacker, & Busch, 1998), and considering existing recommendations we take 1.3 as a value for infit and outfit mean squares that suggests cause of concern. Items with fit statistics higher than 1.3 will be considered as 'misfits' and will be further investigated (qualitatively as well). Items with value below 1 will not be explored in detail since they are not considered as a threat to the measure's validity. Finally, we endorse the recommendation of Bohlig et al. (1998) who state that 'less than pleasing fit statistics say "think again", not "throw it out"' (p. 607), and hence we seek explanations and interpretations for the high fit values.

The fit statistics and item measures for the pre-university experience for both UK and Norway were first pooled together for a preliminary analysis. This indicated one highly misfitting item, namely Item 10: "The teacher was encouraging us to work more quickly". We interpreted this departure from ideal fit as a possible misinterpretation of the item by the students or simply denoting a practice that can be mutually present in various levels of transmissionist classrooms. This item also seems to be problematic for the perceived university pedagogy measure (DP2) and is one that causes huge problems with time invariance. The item, also presented large DIF size when UK and Norway measures were compared. Based on all presented evidence it was thus decided to exclude this item from subsequent analysis.

We then recalibrated the remaining 10 items with the pooled data and fit statistics were within acceptable ranges⁶. DIF analysis however was still problematic as shown with Figure 2: in fact this indicates that more than half of the items present significant DIF. In brief we could say that practices where the UK point is on the happen less frequently compared to Norwegian pre-university math courses. The largest distance observed with Item 7 ("We were working collaboratively in pairs") which appears to happen significantly more frequently in the UK: our experience with the Norwegian system is also in agreement with this observation as students are more used to working in groups of three or four rather than pairs.

.Given this DIF and the potential problems it might cause on directly comparing these groups we decided to proceed with separate calibration for each national group.

⁶ Give the volume of results related to the validation of the measures and the limited space we provide more details for the interested reader in www.teleprism.com/ijer2016.

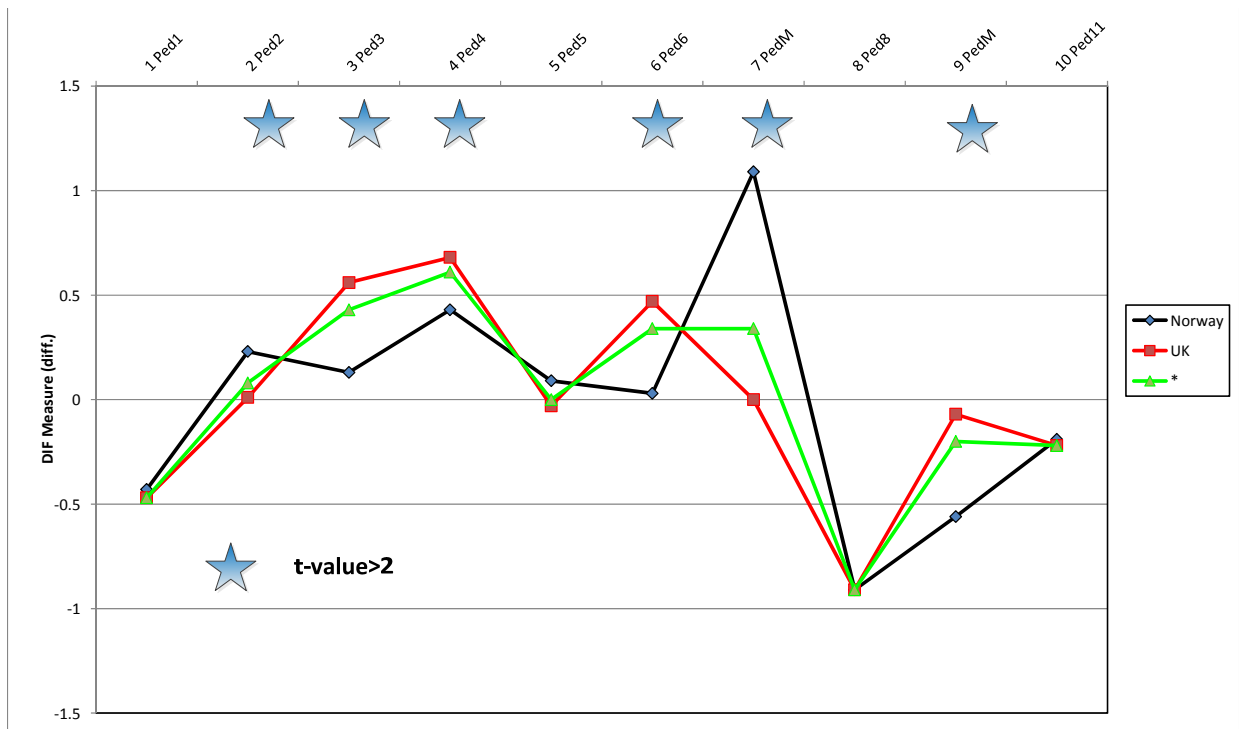


Figure 2: DIF analysis for 'perception of a transmissionist pedagogy in pre-university maths experience' scale

The 'cleaned' recalibrated results, for the pre-university measures are shown in Table 3 for both samples. As shown, the fit is now acceptable for all the items and thus we can claim that they work well together to define the measure called 'students' perception of a transmissionist pedagogy in pre-university maths experience'.

Table3: Item statistics for the revised scale students' perception of a transmissionist pedagogy in pre-university maths experience': UK and Norway

| Item Entry No | UK | | | | | | | | Norway | | | | | | | | |
|-----------------------------------|--------------|----------------|---------|-----|------------|------|-------------|------|-----------------------------------|----------------|---------|-----|------------|------|-------------|------|--|
| | Raw Score | Observed Count | Measure | SE | Infit MNSQ | ZSTD | Outfit MNSQ | ZSTD | Raw Score | Observed Count | Measure | SE | Infit MNSQ | ZSTD | Outfit MNSQ | ZSTD | |
| item1 | 4590 | 1507 | -.50 | .04 | .91 | -2.5 | .96 | -1.0 | 2316 | 701 | -.44 | .06 | 1.06 | 1.2 | 1.19 | 3.0 | |
| item2 | 4129 | 1489 | .01 | .03 | .94 | -1.7 | .95 | -1.5 | 2104 | 703 | .24 | .05 | 1.07 | 1.4 | 1.07 | 1.3 | |
| item3 | 3672 | 1495 | .57 | .03 | .83 | -5.6 | .83 | -5.3 | 2114 | 696 | .14 | .05 | .77 | -4.9 | .78 | -4.5 | |
| item4 | 3532 | 1480 | .69 | .03 | .98 | -6 | 1.00 | .0 | 1958 | 680 | .46 | .05 | .85 | -3.1 | .89 | -2.1 | |
| item5 | 4184 | 1494 | -.03 | .03 | .99 | -3 | .97 | -8 | 2154 | 704 | .11 | .05 | 1.16 | 2.9 | 1.12 | 2.1 | |
| item6 | 3754 | 1495 | .47 | .03 | .86 | -4.6 | .84 | -4.9 | 2177 | 703 | .04 | .05 | .94 | -1.1 | .90 | -1.9 | |
| item7 | 4154 | 1494 | .00 | .03 | 1.08 | 2.4 | 1.11 | 3.1 | 1772 | 705 | 1.14 | .05 | 1.19 | 3.8 | 1.19 | 3.6 | |
| item8 | 4829 | 1487 | -.92 | .04 | 1.09 | 2.3 | 1.01 | .3 | 2439 | 698 | -.94 | .07 | .98 | -3 | .91 | -1.4 | |
| item9 | 4199 | 1490 | -.06 | .03 | 1.10 | 2.8 | 1.09 | 2.5 | 2372 | 706 | -.57 | .06 | 1.04 | .7 | 1.06 | 1.0 | |
| item11 | 4298 | 1476 | -.24 | .04 | 1.25 | 6.8 | 1.30 | 7.6 | 2162 | 676 | -.19 | .06 | .93 | -1.2 | .94 | -1.0 | |
| | Mean: | | .00 | .04 | 1.0 | -0.1 | 1.01 | 0.0 | Mean: | | .00 | .06 | 1.0 | -0.1 | 1.0 | 0.0 | |
| | SD: | | .47 | .00 | 0.12 | 3.6 | 0.13 | 3.6 | SD: | | .55 | .00 | 0.12 | 2.5 | 0.13 | 2.5 | |
| PERSON: REAL SEP.: 1.57 REL.: .71 | | | | | | | | | PERSON: REAL SEP.: 1.43 REL.: .67 | | | | | | | | |
| ITEM: REAL SEP.: 12.84 REL.: .99 | | | | | | | | | ITEM: REAL SEP.: 9.54 REL.: .99 | | | | | | | | |

The dimensionality of these two scales is further explored with the results of the principal component analysis of the residuals (Table 4). According to this 'test of dimensionality' the Rasch model explains 35.4% of the variance for both samples (UK and Norway). As

suggested by relevant guidelines⁷ (Linacre, 2014) important lines to check regard the contrasts – in our case the eigenvalue for the first contrast is marginal according to guidelines (i.e. if the first contrast is much larger than the size of an eigenvalue expected by chance, usually less than 2), and it is advised to inspect the ‘contrasting content of the items which produce this large off dimensional component in the data: in our case these were items 5 to 7 (and 8 for UK) which were those reversed and indicating more student-centered practices. So even though the results may be suggestive of a secondary dimension this is not considered sufficiently strong as to threaten the validity of this overall measure.

Table 4: Principal components analysis of the residuals

| | UK | | | | Norway | | | |
|------------------------------------|------------|--------------|---------|-------|-----------|--------------|---------|-------|
| | Empirical* | | Modeled | | Empirical | | Modeled | |
| Total raw variance in observations | 15.5 | 100% | | 100% | 15.5 | 100% | | 100% |
| Raw variance explained by measures | 5.5 | 35.4% | | 35.4% | 5.5 | 35.4% | | 35.7% |
| Raw variance explained by persons | 2.2 | 14.2% | | 14.2% | 2.4 | 15.2% | | 15.3% |
| Raw Variance explained by items | 3.3 | 21.2% | | 21.2% | 3.1 | 20.2% | | 20.4% |
| Raw unexplained variance (total) | 10 | 64.6% | 100% | 64.6% | 10 | 64.6% | 100% | 64.3% |
| Unexplned variance in 1st contrast | 2 | 13.1% | 20.3% | | 2 | 13% | 20.2% | |
| Unexplned variance in 2nd contrast | 1.4 | 8.8% | 13.6% | | 1.5 | 9.9% | 15.4% | |
| Unexplned variance in 3rd contrast | 1.3 | 8.6% | 13.2% | | 1.2 | 8% | 12.5% | |
| Unexplned variance in 4th contrast | 1.3 | 8.1% | 12.5% | | 1.2 | 7.9% | 12.3% | |
| Unexplned variance in 5th contrast | 1 | 6.6% | 10.2% | | 0.9 | 5.8% | 9% | |

*The first column presents variance rescaled in eigenvalue units so as to match the number of items.

Another indicator of a well functioning scale when using the RSM involves the examination of the **category statistics** to ensure the appropriateness of the Likert scale used and its interpretation by the respondents. The results for both measures (UK and Norway) provided evidence of well functioning scales (see www.teleprism.com/ijer2016).

Once validity is established at item and category level, the resulting common measurement scales (in logits as shown with the arrow in the middle) are presented in the form of **item-person maps**, as shown in Figure 3 for both UK and Norway. At the right side of each plot, the distribution of the students on this measure is shown with a histogram. The higher the place of the “practice”, the more transmissionist (or teacher-centered) the student perceived their pre-university math courses. The item distribution is also shown on the left hand side of the scales: items at the bottom of the scale (e.g. ‘we don’t invent our own methods’) are items easier to report higher frequency of occurrence, thus ‘easier’ for the measurement of ‘transmissionist’ teaching practice.

⁷ See also: www.winsteps.com/winnman/table_23_0.htm

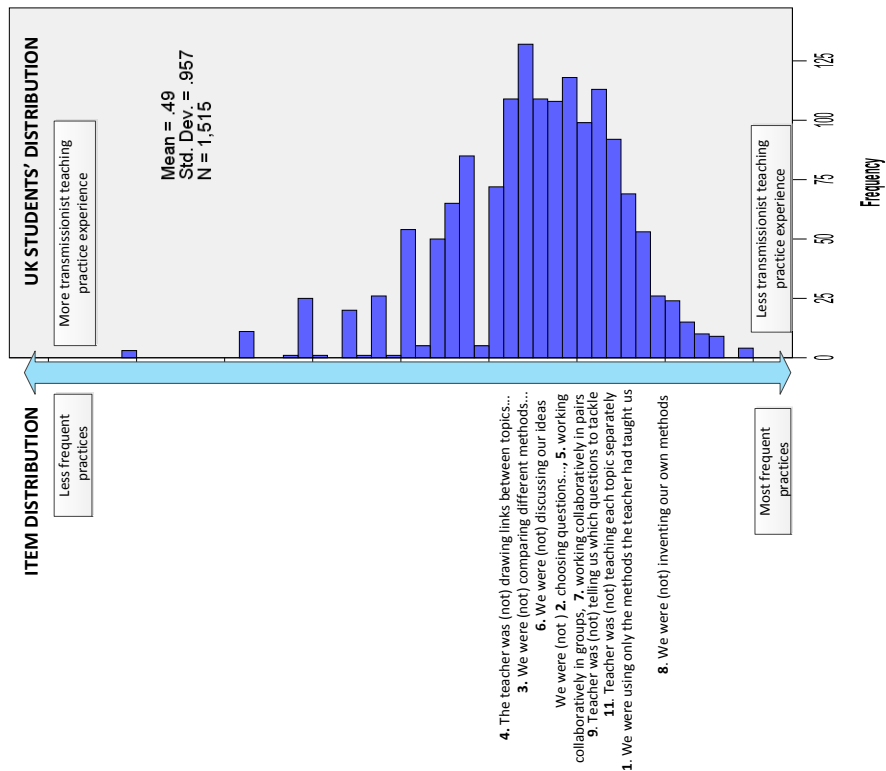
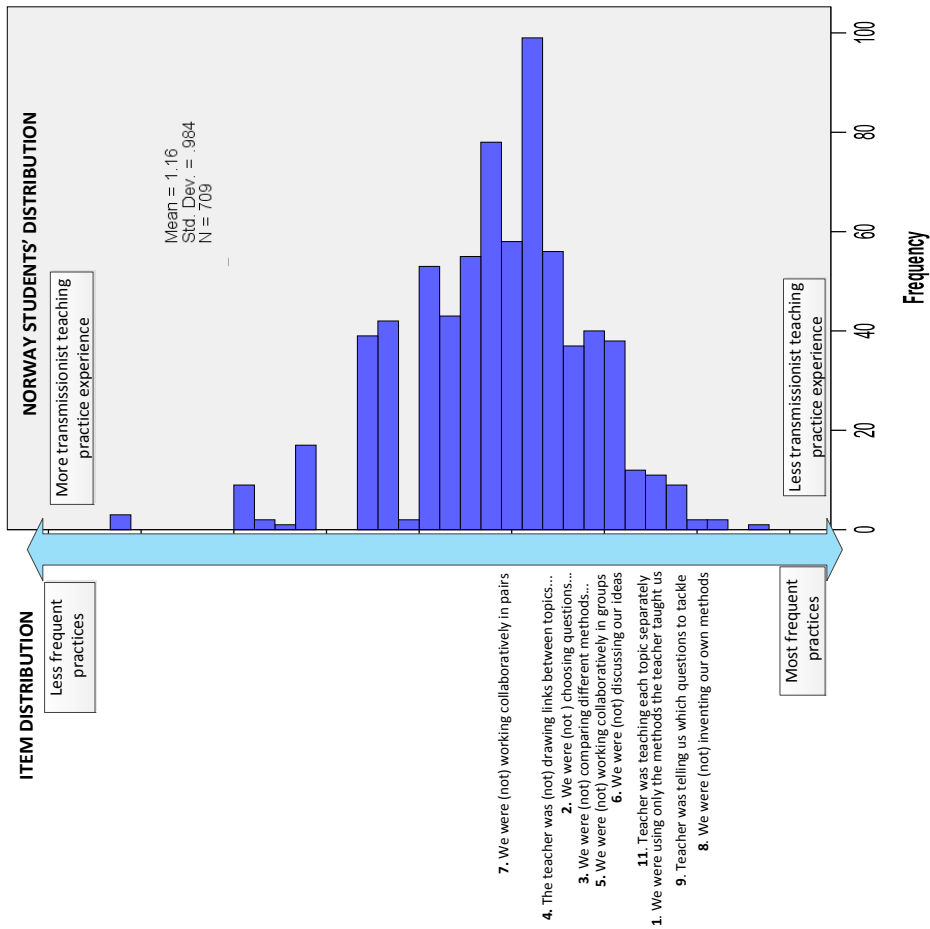


Figure 3: The item-person map with the hierarchy of students' perception of a transmissionist pedagogy in pre-university maths experience (UK and Norway)

Looking comparatively at the two plots one can note similarities and differences. For instance the same items appear at the bottom of both scales (which define the most frequent practices, e.g. students (not) working on their own methods). Moreover, overall the same items appear at similar location: e.g. between 0 and -1 logits we can observe items 8,1,9 and 11 for both, even though their ordering is different. Similarly item 4 is at about the same location, and within the same range, and likewise items 2 and 5. The biggest disparities appear for items 6, 7 and 3 and 9 (as also suggested by the DIF analysis reported previously).

In sum, and on face validity the scales appear equivalent in meaning but there are some differences in the operationalisation of this construct in the two cultures as will be discussed later as well.

Employing this approach allowed us to construct and consequently add to our datasets two measures of perceived pedagogical experience for each country: one for students' pre-university courses and one for their first year university (maths) courses. The higher the students' score on these measures the more teacher-centered or transmissionist the teaching they perceived (before or during university).

5.2 Overview of other relevant validated measures

The same methodology was employed for the other measures as summarised in Table 5; for the UK validation details are presented elsewhere (Pampaka et al., 2014; Pampaka, Williams, & Hutcheson, 2012).

Table 5: Psychometric overview of other validated measures

| Measures Dimensionality Information | Model | Item N | | Infit | | outfit | | Item | | Person | |
|---|-------|--------|--------------------------|----------------------------|--------------------------|-----------------------------|--------------------------|------------|-------------|------------|-------------|
| | | | | MNSQ | Zstd | MNSQ | Zstd | Separation | Reliability | Separation | Reliability |
| Pedagogy@Uni (UK) Note: Analysis was run with Facets, therefore dimensionality tests are not available | RSM | 10 | Mean SD Max Min | 1 0.2 1.4 0.8 | 0.1 3.7 6 -4 | 1 0.2 1.4 0.9 | 0.1 3.7 7 -5 | 9.51 | 0.99 | 1.46 | 0.68 |
| Pedagogy@Uni (Norway) Eigenvalue of 1 st contrast: 2.5 Raw variance explained by measures: 39% | RSM | 10 | Mean SD Max Min | .99 .21 1.46 .77 | -3 3.4 6.9 -4.5 | 1.01 .22 1.47 .78 | -1 3.5 6.7 -3.9 | 9.38 | 0.99 | 1.51 | 0.70 |
| Transitional Gap (UK) Note: Analysis was run with Facets | Dich | 12 | Mean SD Max Min | 1 0 1.1 1 | 0 0.8 1 -1 | 1 0 1.1 0.9 | 0 0.7 1 -1 | 7.66 | 0.98 | 0.55 | 0.23 |
| Transitional Gap (Norway) Eigenvalue of 1 st contrast: 2 Raw variance explained by measures: 59.2% | Dich | 12 | Mean SD Max Min | .95 .10 1.12 .84 | -2 1.0 1.1 -2.8 | 1.68 2.53 9.90 .18 | .4 3.2 9.9 -2.9 | 8.31 | 0.99 | 0.38 | 0.13 |
| Positivity towards transition (UK) Note: Analysis was run with Facets | Dich | 12 | Mean SD Max Min | 1 0.1 1.4 0.8 | -0.0 2.9 6 -4 | 1 0.1 1.3 0.8 | -0.1 1.8 3 -3 | 13.66 | 0.99 | 1.87 | 0.78 |
| Positivity towards transition (Norway) Eigenvalue of 1 st contrast: 1.9 Raw variance explained by measures: 33.5% | RSM | 12 | Mean SD Max Min | 1.00 .23 1.57 .71 | -2 3.9 8.6 -5.7 | .99 .25 1.65 .69 | -3 3.6 8.8 -5.3 | 8.34 | 0.99 | 1.56 | .71 |
| Perception of Support (UK) Eigenvalue of 1 st contrast: 1.9 Raw variance explained by measures: 42.8% | RSM | 9 | Mean SD Max Min | 1.02 .19 1.21 .69 | -3 5.1 5.2 -8.9 | 1.01 .19 1.20 .68 | -4 4.9 4.9 -9.0 | 8.66 | 0.99 | 1.4 | 0.66 |
| Perception of Support (N) Eigenvalue of 1 st contrast: 2.6 Raw variance explained by measures: 58.1% | RSM | 9 | Mean SD Max Min | 1.03 .21 1.36 .77 | 2 3.3 5.0 -4.4 | 1.03 .21 1.34 .75 | .1 3.3 4.8 -4.8 | 18.94 | 1 | 1.22 | 0.60 |

In sum two more measures were validated for the Norwegian sample, based on analysis of the items regarding the transitional gap (Appendix 2). The first, defined as ‘perception of transitional gap’, was derived from analysis of the 13 statement stems denoting changes between pre-university and university experiences, replicating the results presented in (Pampaka, Williams, & Hutcheson, 2012) for UK with the help of the dichotomous model (as the ratings were recoded so as 0 indicates no change, and 1 change in either direction).

Results indicated a very good fit to the model, but very poor person separation (similar to the UK): The resulting students’ distribution on this measure is shown on the left histogram in Figure 4 and actually contextualises the low separation: in fact as most students have reported differences between the two systems (pre-Uni and Uni) there is some skewness in their measures towards the positive side and low discrimination between these scores. The histogram on the right presents the distribution of students’ ‘positivity towards transition’ which resulted from the ‘feelings’ column of the items in Appendix 2 (for his analysis we preserved an ordered level of ‘positive feeling’ to the change by coding Negative = 1, Neutral = 2 and Positive = 3, and consequently applied the RSM). As can be observed the picture here is much better and indicates good psychometric properties; similarly the measure of “quality of learning support for mathematics”, based on analysis of the items in Appendix 3 (after excluding item 6 which was not contributing towards the underlying construct) also shows appropriate measurement properties as shown in Table 5.

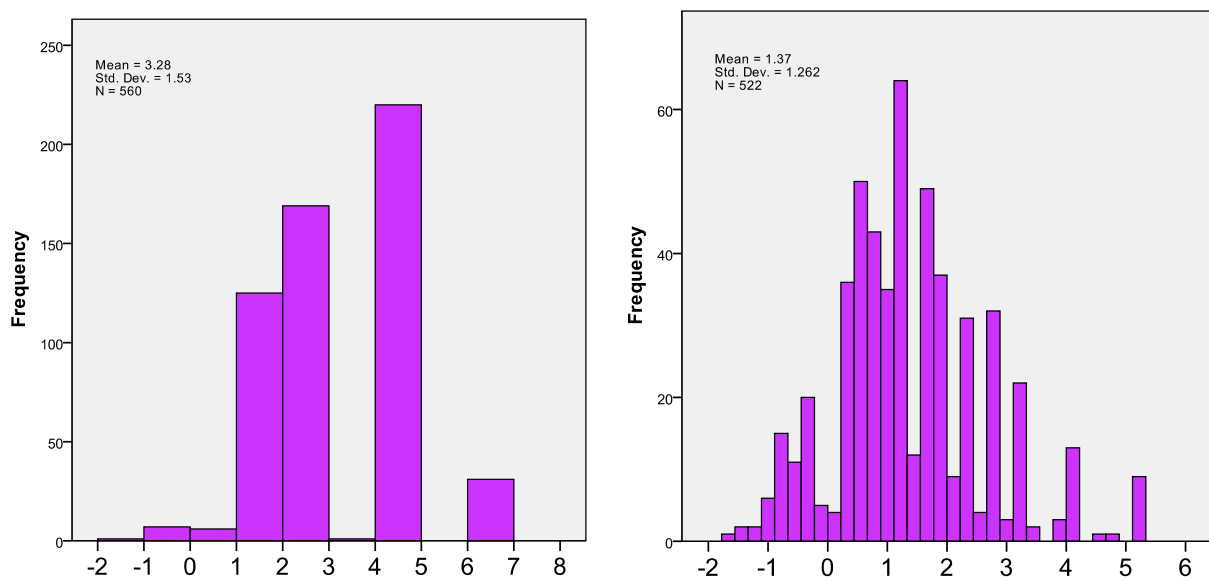


Figure 4: Norwegian students’ distribution on the measure of ‘perceived transitional gap’ (left) and ‘positivity towards transition’ (right)

As a concluding point for the measures validation, we note our decision to treat the results from the two groups separately for most of the consequent analysis: this is mainly because of the complexity in the interpretations of DIF results, with most of the items falling outside the confidence intervals for measure invariance. For further analysis in this paper

we treat the samples as separate, thus we do not violate any analytical assumptions of comparability.

5.3 Substantive Results: Dispositions, Teaching and Learning in Transition and Alienation

We have thus far in this paper and elsewhere established the validity of measures related to students' dispositions, perceptions of teaching and learning aspects of their transitional experiences and the quality of support in place to help their transition. In the remaining we explore how these are related with each other and other measures.

Associations of measures involved during transition

The measures we have constructed can be either considered as subjective experiences of students' alienation (e.g. maths disposition) or indicators of experiences that influence the process of alienation during (and/or after) the transition of students into HE (e.g. perceptions of pedagogy, transitional gap, positivity towards transition). In this section we explore the relationship between these proxies of alienating experiences via separate correlation analyses for UK and Norway, and we then focus on the context of the differences and similarities in the associations. Table 6 shows these associations (Pearson correlations and their significance) for the UK sample. All measures are in logits thus the variables are continuous.

Table 6: Associations between variables in UK sample

| Pearson Correlations (p-values) | Pre-Uni Pedagogy | Uni-Pedagogy | Perception of transitional gap | Positivity towards transition |
|--|-----------------------------|--------------------------|---|--|
| Math Dispositions DP1 | -0.30 (<0.001) | 0.03 (0.48) | 0.05 (0.21) | -0.10 (0.01) |
| Math Dispositions DP2 | -0.22 (<0.001) | -0.007 (0.86) | 0.02 (0.67) | 0.04 (0.22) |
| Perceived support at uni | -0.22 (<0.001) | -0.26 (<0.001) | 0.19 (<0.001) | 0.24 (<0.001) |
| Pre-uni Pedagogy | | 0.22 (<0.001) | -0.006 (0.88) | 0.06 (0.16) |
| Uni pedagogy | | | -0.04 (0.29) | -0.18 (<0.001) |
| Perception of transitional gap | | | | -0.07 (0.06) |

There appear to be (statistically significant) negative associations of students' perception of pre-university transmissionist pedagogy with maths disposition at both data points. These suggest that the more transmissionist the teaching students' experienced before HE, the lower their maths dispositions are before and during the first year of their university studies. In contrast, students' perception of pedagogy at university, does not seem to correlate significantly with these dispositional measures. Perceptions of transmissionist pedagogy (both pre and at-university) are also associated negatively with students' "perception of quality of maths support" they received (i.e. perceived support at uni, in the table for simplicity): It appears that the more transmissionist the teaching the lower the perception of quality of support at uni.

In regards to students' perceptions of the transitional gap this was not found to be statistically related to mathematics dispositions or perceptions of pedagogy measures but is positively associated with students' perception of the quality of the support they receive during their first year maths courses. That is, the more students are aware of the transitional gap, the higher they perceive the quality (or not) of the support they receive at uni. It can be argued that students who perceived a higher transitional gap might be more in need of support, and aware of its potential benefits, which in turn might act as a mechanism against alienation. Students' positivity towards transition (a proxy of a less alienating experience) appears to be negatively correlated with maths disposition at DP1 only (i.e. the less disposed they are to continue studying maths when arriving at uni, the more positive they feel about the transition). This is also positively associated with students' perception of the quality of support they receive with their mathematics during the first year: the more positive they are about transition, the more efficient they perceive the support they have received with mathematics. Hence, it can be argued that the support they received steered them away from getting alienated towards their studies of mathematically demanding subject/s. Positivity towards transition is, finally, negatively associated with students' perception of the extent of transmissionist pedagogy they experienced at university: the less transmissionist the teaching, the more they tended to be content with their transition.

A similar analysis was performed for the Norwegian sample (Table 7). We should note that because of samples differences between NDP1 and NDP2 the sample size for associations between variables across data points is limited to about 250 students, whereas associations with variables measured at NDP2 are based on a larger sample (N=563).

Table 7: Associations between variables in matched Norwegian sample

| Pearson Correlations (p-values) | Pre-Uni Pedagogy | Uni-Pedagogy | Perception of transitional gap | Positivity towards transition |
|--|-----------------------------|--------------------------|---|--|
| Math Dispositions DP1 | -0.2 (0.001) | 0.18 (0.004) | 0.07 (0.093) | 0.10 (0.113) |
| Math Dispositions DP2 | -0.13 (0.042) | -0.13 (0.002) | -0.01 (0.918) | 0.21 (<0.001) |
| Perceived support at uni | -0.04 (0.514) | -0.29 (<0.001) | 0.19 (<0.001) | 0.30 (<0.001) |
| Pre-uni Pedagogy | | | -0.01 (0.835) | 0.03 (0.685) |
| Uni pedagogy | | | -0.11 (0.078) | -0.10 (0.018) |
| Perception of transitional gap | | | | 0.32 (<0.001) |

The results from the Norwegian sample also show (statistically significant) negative associations of pre-university transmissionist pedagogy with disposition measures at both data points: the more transmissionist the teaching, the less disposed the students were. This association seemed to be weakening as students moved further into university, but it was still statistically significant. Perception of transmissionist pedagogy at uni seemed to be positively related with mathematics disposition at the start of uni. What was more interesting about this measure was its negative association with the measure of perceived quality of the support they received. The perception of uni-pedagogy was also found to be

negatively associated with positivity towards transition: the more transmissionist they found teaching at uni, the less positive they felt about the transition.

Another statistically significant association was found between the transitional gap and students' perception of the quality of support they received: The higher they perceived the gap during the transition, the more efficient they perceived the support they received. Positivity towards the transition is positively related to the perception of transitional gap: the bigger the gap, the more positive the students are! This is new and we did not find this correlation in the UK study (even though not significant, the relationship was negative). Positivity towards transition is also positively correlated with mathematics disposition at DP2.

Modeling Engagement over time to objectify the process of alienation

In previous work (Pampaka, Williams, & Hutcheson, 2012) we reported a model of maths (dropping) dispositions at the second year at Uni (DP3, which is equivalent to the Norwegian DP2) and found a positive effect of early mathematics disposition as well as the measure of students' positivity towards transition (and measures of students confidence and 'expertise' with mathematics). Here we model the same outcome for the also dropping Norwegian students' mathematics dispositions, and for comparative purposes we also replicate the final model (after a theoretically driven step wise process) for the UK. Table 8 presents the results of linear regression models⁸ of mathematics dispositions during second year at university (NDP2 and DP3), taking into account dispositions at start of Uni (DP1), perceived support at uni, their perception of transitional gap, while controlling for gender and university.

Table 8: A Regression Model for HE maths-disposition at second Year at Uni (NPD2 Norway and DP3 UK)

| | Norway | | | | UK | | | |
|--------------------------------|--------|------|--------|--------|--------|------|--------|--------|
| | Coef B | s.e. | t | P | Coef B | s.e. | t | P |
| (Constant) | 0.516 | 0.42 | 1.227 | 0.221 | -0.588 | 0.30 | -1.946 | 0.052 |
| HE Maths Disposition DP1 | 0.469 | 0.06 | 7.747 | <0.001 | 0.627 | 0.03 | 18.345 | <0.001 |
| Gender (Ref: Female*) | 0.238 | 0.22 | 1.077 | 0.283 | 0.31 | 0.12 | 2.543 | 0.01 |
| Quality of Math Support at Uni | 0.818 | 0.15 | 5.372 | <0.001 | 0.305 | 0.06 | 5.484 | <0.001 |
| Perception of Transitional Gap | -0.121 | 0.07 | -1.837 | 0.067 | -0.055 | 0.07 | -0.727 | 0.468 |

*Female is the reference category; The coefficients, thus, denote the effect of the other category(i.e. male) compared to the reference. For instance, according to this model the outcome variable is expected to increase by 0.2385 units (logits) on average when we change from female to male students for the Norwegian sample
 Both models control for University (as another dummy variable)- the coefficients are omitted.
 Norway: $F(5, 273) = 25.74, p < 0.001, R^2 = 0.32$ (Adjusted $R^2 = 0.308$)
 UK: $F(9, 414) = 75.24, p < 0.001, R^2 = 0.621$ (Adjusted $R^2 = 0.612$)

As expected, the previous disposition had a strong positive significant effect for both models. What is more interesting, however, is the effect of the proxies of subjective

⁸ The details of our approach are presented in previous work and omitted from here due to space limitations

alienating experiences: Norwegian students' perception of the transitional gap seemed to have a damaging effect on students' dispositions (negative estimate, $p=0.067$), but at the same time the supporting mechanisms in place had a stronger and positive effect. For the UK the effect of transitional gap perception seems to be fully alleviated as it is negligible and non significant.

5. Discussion/Conclusions

In this paper alienation has been conceptualised with the construction of selected measures that denote either (subjective) alienating experiences or other aspects of the alienating process that can help explain how the 'system' functions. As examples of such procedural indicators are students' perceptions of the transitional gap and their associated feelings regarding the transition. We also consider mathematics dispositions as a proxy of subjective alienating experience, especially with the noted drop of these dispositions. More interestingly though, measuring students' perceptions of teaching and learning aspects of their transitional experience, such as pre- and at-uni transmissionist practices, allows us to shed some light onto potential sources of alienation for these students.

One of the primary tasks of this paper has been to introduce these measures, which we believe add substantially to the existing literature on relevant existing scales (e.g. Ghaith, 2003; Thorpe, 2003) and the comparability of measures across different contexts. In regards to the latter, as expected, our psychometric approach revealed some issues regarding measurement invariance when converting instruments from one academic context to another (Millsap, 2011; Pepin, 2000). Our resolution in this paper was to proceed with 'safe' separate analysis and focus on commonalities and differences in the resulting associations.

Further, we expect that other practices central to the PRE- and AT-uni experience are important to shape engagement, and as such could be considered as sources of potential alienation. This provides another significant starting point in this paper, with the aim of exploring the potential effect of teaching practices on students' transition and progression in HE, and building on previous work, which found evidence of a negative effect on transmissionist teaching on students developing maths disposition at their pre-university experiences (Pampaka, Williams, Hutcheson, et al., 2012). This is where our measures of students' perception of pre-uni and uni transmissionist pedagogy are coming into play. We present how we developed and validated these measures for the two educational systems in this study. Our psychometric analysis revealed some problems in regards to the comparability of the measures, which is common when instruments are used in multiple cultures/systems (Thissen et al., 1993).

Having these measures at hand, we then examine various relationships to help us identify factors that increase disengagement, or to phrase it more positively, that ease the transition and thus reduce the chances for alienation. So, essentially we deal here with the two categories of factors related to alienation as defined by Case (2008): experiences of

entry; and fitting into HE. It is worth summarising here the most important commonalities and differences of these relationships in the two educational contexts.

With regards to differences, it appears that there is evidence for a negative association between the quality of support at uni and pre-university transmissionist pedagogy for UK, whereas for Norway perceived support at uni is negatively associated with the perceived transmissionist pedagogy at university. Positivity towards transition is positively related to the perception of the transitional gap: the biggest the gap, the more positive the students are! This is new and we did not find evidence of it in the UK contexts. This is consistent, however, with more qualitative evidence. In particular, in the open statements of the questionnaires, and during interviews, Norwegian students told us that the biggest difference they experienced between upper secondary school and university was that at university they have to take more responsibility for their own learning (see also Pepin, Lysø, & Sikko, 2012). The majority of students found this to be an interesting and necessary move, and they had mainly positive feelings about it, whilst at the same time they saw it as a challenge. This can also be interpreted in the sense that the students were happy to move away from the more transmissionist system they encountered at school. Another difference we found in the associations, was the negative correlation between maths disposition at DP1 and positivity towards transition, only found in the UK, i.e. the less disposed they were to continue studying maths, the happier they were with the transition. This was also supported by our earlier findings, where maths students appeared to be the “unhappiest group” in transition (followed by the engineering students) (Pampaka, Williams, & Hutcheson, 2012). Hence, mathematics students in the UK experienced a bigger transitional gap, and felt more alienated at university than other students, whereas Norwegian mathematics students felt less alienated at university, because they appreciated the responsibility that came with the freedom of being a university student compared to high school student learning.

Further, what is interesting, when comparing the associations in the two systems, is the commonalities in the findings in regards to the effect of pre-university pedagogy and the various measures of dispositions, which we take as potential indicators of alienation from maths/STEM HE. As shown, pre-university transmissionist pedagogy was consistently found to be negatively associated with students disposition to study maths. This was particularly strong for DP1 measures, but also significant for DP2, even though weaker. What we could conclude with this is that the teaching experiences of students before they enter HE seem to influence their decisions and progression in HE. The associations found for the measure of uni-pedagogy, on the other hand, were not as consistent: these could probably be explained by some of the reasons discussed earlier.

Finally, the model of developing students dispositions for Norway and UK presented in Table 8 suggests that, even though there is an almost significant negative effect of students perception of the transitional gap in their developing (dropping) Maths dispositions, at the same time there is a significant and stronger positive effect of their perception of quality of support they receive at university. This highlights the significance of supporting

mechanisms to be in place at university to facilitate students' transitions and thus minimise the probability of alienation and potential dropout.

In conclusion, and with reference to general HE literature (e.g. Case 2008; Mann 2001), we contend that construing students' experiences of learning mathematics in HE in terms of alienation and engagement is an alternative, perhaps more suitable, approach that may give further insight, and add to more traditional 'approaches to learning' (e.g. *surface* or *deep learning*), which are often taken as the dominant perspectives in student learning research. It also helps us to understand student learning experiences/issues in higher education mathematics in a broader context, and hence helps for different issues to emerge as potential reasons for alienation, than were identified in earlier studies (e.g. Biggs 2003). In this paper we have provided quantified evidence of the process of alienation, verifying in a way the theoretical framework suggested by others (e.g. Williams, 2015) but also provided support to resilience mechanisms

A broader perspective on learning mathematics which focuses on alienation and engagement shows not only that 'a wide range of aspects of student life all have a crucial bearing on the quality of learning that they are able to experience' (p. 330, Case 2008), but also explains, to some extent, the astonishing differences between the UK and Norway findings: in our Norwegian cases, a positive disposition (and expectation) towards taking on responsibility for one's own learning (in addition to particular support structures) had a stronger influence on students' experiences of learning mathematics in HE, than the challenges they faced with the subject learning and the (for them perhaps difficult) pedagogic practices in HE (e.g. lectures). Another related dimension with these differences is the job security Norwegian students had once they completed their studies which could potentially act as a catalyst in taking responsibility for own learning as a proxy of the next step – the new independent life. Such finding thus, highlight the rewards of rigorous comparative work.

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Appendix 1 – The Instruments used for this paper

Appendix 1: Measuring students' perception of university (maths) pedagogical experience

DP1

C. Mathematics Experience and Expectations

33. How often did you do the following in your last year of mathematics lessons (IB, GCSE, AS or A2 level or other)? [Please tick as appropriate: GCSE, AS, A2, IB, other]

[Circle 1, 2, 3 or 4, or tick the box if you don't know]

| | Almost never | Some of the time | Most of the time | Almost always | DON'T KNOW |
|--|--------------|------------------|------------------|---------------|------------|
| 1. We (students) were using only the methods the teacher had taught us. | 1 | 2 | 3 | 4 | |
| 2. We were choosing which questions to tackle. | 1 | 2 | 3 | 4 | |
| 3. We were comparing different methods for doing questions. | 1 | 2 | 3 | 4 | |
| 4. The teacher was drawing links between topics and moved back and forth between topics. | 1 | 2 | 3 | 4 | |
| 5. We were working collaboratively in small groups. | 1 | 2 | 3 | 4 | |
| 6. We (students) were discussing our ideas. | 1 | 2 | 3 | 4 | |
| 7. We were working collaboratively in pairs. | 1 | 2 | 3 | 4 | |
| 8. We were inventing our own methods. | 1 | 2 | 3 | 4 | |
| 9. The teacher was telling us which questions to tackle. | 1 | 2 | 3 | 4 | |
| 10. The teacher was encouraging us to work more quickly. | 1 | 2 | 3 | 4 | |
| 11. The teacher was teaching each topic separately. | 1 | 2 | 3 | 4 | |

DP2: If relevant please say how often you have done the following in your maths learning overall this year.

| 0. This is not relevant to me as I haven't learnt or studied mathematics this year. <input type="checkbox"/> | | | | | |
|--|--------------------------|--------------------------|--------------------------|--------------------------|------------|
| | Almost never | Some of the time | Most of the time | Almost always | DON'T KNOW |
| 1. We (students) use only the methods the lecturer teaches us. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 2. We choose which questions to tackle. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 3. We compare different methods for doing questions. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 4. The lecturer draws links between topics and moves back and forth between topics. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 5. We work collaboratively in small groups. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 6. We discuss our ideas. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 7. We work collaboratively in pairs. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 8. We invent our own methods. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 9. The lecturer tells us which questions to tackle. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 10. The lecturer encourages us to work more quickly. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 11. The lecturer teaches each topic separately. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |

Appendix 2: Measuring transitional experience

Please tick the appropriate box for each statement in the table below so as to indicate the way in which your experience at university is different from your experience at school/college. Then choose the appropriate emoticon to show your feelings about each change, or the 'don't know' column.

| What is different between university and school/previous experience? <i>[Please tick the appropriate box to indicate what you find different]</i> | How do you feel about it? <i>[Tick appropriate 'face']</i> | | | |
|---|---|-------|----------|------------|
| | Negative | Mixed | Positive | DON'T KNOW |
| I have to do <i>more</i> <input type="checkbox"/> / <i>less</i> <input type="checkbox"/> / <i>about the same amount of</i> <input type="checkbox"/> private study at university. | | | | |
| I am treated <i>more</i> <input type="checkbox"/> / <i>less</i> <input type="checkbox"/> / <i>equally</i> <input type="checkbox"/> like an adult at university. | | | | |
| I have <i>more</i> <input type="checkbox"/> / <i>less</i> <input type="checkbox"/> / <i>about the same amount of</i> <input type="checkbox"/> responsibility for my own learning at university. | | | | |
| The work is <i>harder</i> <input type="checkbox"/> / <i>easier</i> <input type="checkbox"/> / <i>about the same</i> <input type="checkbox"/> at university. | | | | |
| I have access to <i>better</i> <input type="checkbox"/> / <i>worse</i> <input type="checkbox"/> / <i>about the same</i> <input type="checkbox"/> quality of resources/equipment at university. | | | | |
| The pace of the course is <i>faster</i> <input type="checkbox"/> / <i>slower</i> <input type="checkbox"/> / <i>about the same</i> <input type="checkbox"/> at university. | | | | |
| Learning is <i>more</i> <input type="checkbox"/> / <i>less</i> <input type="checkbox"/> / <i>about equally</i> <input type="checkbox"/> 'in depth' at university. | | | | |
| Teachers have <i>more</i> <input type="checkbox"/> / <i>less</i> <input type="checkbox"/> / <i>about the same</i> <input type="checkbox"/> control over my work at university. | | | | |
| I have <i>more</i> <input type="checkbox"/> / <i>less</i> <input type="checkbox"/> / <i>about the same</i> <input type="checkbox"/> opportunity to ask questions at university. | | | | |
| I have <i>more</i> <input type="checkbox"/> / <i>less</i> <input type="checkbox"/> / <i>about the same</i> <input type="checkbox"/> opportunity to discuss ideas and problems at university. | | | | |
| The language used is <i>more</i> <input type="checkbox"/> / <i>less</i> <input type="checkbox"/> / <i>about equally</i> <input type="checkbox"/> formal at university. | | | | |
| Teaching is <i>more</i> <input type="checkbox"/> / <i>less</i> <input type="checkbox"/> / <i>about equally</i> <input type="checkbox"/> personal at university. | | | | |
| I have a <i>more active</i> <input type="checkbox"/> / <i>less active</i> <input type="checkbox"/> / <i>about the same</i> <input type="checkbox"/> social life at university. | | | | |

Appendix 3: Measuring perceived mathematical support at university

Please tell us what you think of the support you received for learning mathematics in your course/programme last year, by selecting how much you agree with the following statements.

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree | DON'T KNOW - N/A |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|------------------|
| 1. I have learnt a lot from working with my fellow students on the maths for my course. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 2. I can follow the maths in most of my lectures. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 3. I find that the teachers generally respond to my needs in the maths teaching I have received. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 4. I have learnt a lot from using technology for maths during my course. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 5. I have learnt a lot from using on-line support for maths during my course. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 6. I preferred the school/pre-university teaching in maths to the teaching last year at university. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 7. I have benefitted a lot from maths lectures. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 8. I have benefitted a lot from maths tutorials. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 9. I have learnt a lot from working with my own informal group of colleagues outside of organised classes/tutorials/workshops. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 10. I have learnt a lot from special provision provided for my particular maths needs: | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |