

Mathematics teachers' and students' perceptions of transmissionist teaching and its association with students' dispositions

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This article builds on previous results of the Transmaths studies concerning transmissionist teaching practices—and especially adds the significance of students' perceptions of these practices—in their association with students' declining dispositions for studying mathematics. It addresses a gap in this work, and the literature in general, regarding the relationship between teachers' and students' perceptions of pedagogy. Drawing on data analyses from a recent, large survey of teaching and learning mathematics in secondary schools, the article: (a) demonstrates and validates two new measures of perceptions of transmissionist practices, as experienced from students' and teachers' perspectives, (b) investigates the comparability of these two measures, and (c) identifies their associations with students' dispositions to study mathematics. Analysis draws on measures of students in Years 7 to 11 (involving 13,000+ students) and from 132 of their mathematics teachers, and shows low correlation at class level and negligible correlation at student level. Results of regression analysis confirm previous work with older students, i.e. that teachers' self-reported transmissionism is negatively associated with learners' dispositions, but adds that students' perceptions of transmissionism are much more strongly negatively associated with these dispositions, and largely mediate the effect of teachers' (self-reported) transmissionism. Further, the differences between year groups and gender show how girls and older learners suffer significantly larger negative effects. The article concludes with a brief discussion of these complexities and some implications for students' trajectories and transitions into (and out of) mathematics.

I. Introduction—Setting the scene within the previous Transmaths and the wider literature

As with other papers in this special issue, this work builds on Transmaths as well as its antecedent TLRP project, where emphasis was placed on students' learning outcomes (including dispositions) because of their potential influences on students' choices and decision-making. This article brings together and extends our work on transmissionism over the last decade to measure and establish the significance of students' perceptions of transmissionism and its effects.

The UK ESRC-TLRP funded project ‘Keeping Open the Door to Mathematically Demanding Programmes in Further and Higher Education’ followed students during their post-compulsory (post-16) maths choices in a longitudinal study involving questionnaires and interviews with students and teachers and lesson observations. With this work we saw differences in pedagogies and learner experiences afforded by an innovative programme (i.e. AS Use of Mathematics, UoM), which encouraged modelling and applications, use of new technology and coursework assessment. However, we also saw some quite traditional teaching on this innovative programme, and found some quite innovative teaching on the traditional programme. We, thus, felt the need to measure ‘pedagogy’ and towards this end we constructed a teacher self-report questionnaire and validated a measure of ‘transmissionist’ or ‘teacher-centred’ pedagogic practice. Using this measure, we demonstrated a negative effect of transmissionist teaching on students’ dispositions (i.e. their dispositions to study the subject in future), and showed how some institutional and pedagogic practices can encourage reduction of the learning of mathematics to the instrumental level only, thus limiting future educational opportunities (Pampaka *et al.*, 2012b). Comparative analysis of teachers’ discourses also revealed conflicts in their ‘valuing’ of pedagogic efficacy between their pre-eminent need to help the students score high grades in approaching exams (‘exchange value’) versus the need to develop understanding (use value), or even pleasure. (See www.transmaths.org for more details, research briefs and references Williams *et al.*, (2008).)

During the ESRC TransMaths projects which followed students’ transition from compulsory education to sixth form and Further Education Colleges (6fFEC), and from schools and 6fFEC to university, we further extended the work measuring maths pedagogies and learning outcomes. Analysis of students’ perceptions of teaching revealed that students who reported higher levels of transmissionist pedagogy at their university (maths) courses tended to be less positive about their transition to university (Pampaka *et al.*, 2012a).

An obvious gap in this work is the lack of evidence about the comparability of these measures of students’ perceptions (focal in the university transition study) and teachers’ perceptions. Previous work in the literature suggests that in fact students’ perceptions of teaching are important (e.g. Beausaert *et al.*, 2013) but also that they may vary dramatically within the same class, and are not consistently aligned to that of teachers.¹ In this article, we draw on our previous work and findings, and present additional results from a recent study, entitled ‘Teaching and Learning Practices in Secondary Mathematics’ (Teleprism²), which aimed to map secondary school students’ learning outcomes, attitudes and choices and produced comparable data from students and their teachers (see, for example, Pampaka & Wo (2014) for measurement of attitudes including the disposition measure used here). We thus ask:

- How can we measure (i) teachers’ and (ii) students’ perceptions of transmissionism in year 7–12?
- What is the relationship between these measures of pedagogic perceptions, and how do these vary across a diverse learner population, e.g. by year groups and gender? and,
- How are these measures associated with students’ dispositions to study mathematics?

2. Conceptualizing and measuring teaching practices

A very common categorization in the literature around teaching practices is that between ‘teacher-centred’ and ‘learner-centred’ instruction. The first, according to Schuh (2004), is usually associated with ‘transmission’ models of teaching where teacher and instruction are the focus, whereas

¹ See e.g. http://www.maa.org/sites/default/files/pdf/cspcc/Ellis_etal.pdf

² See www.teleprism.com

'learner-centred' practices move the focus to students and learning. There is also an extensive list of approaches presented as 'opposites' to the transmission model of teaching we call 'transmissionism', usually as part of studies contrasting reform teaching with the dominant traditional practice: e.g. 'guided discovery', or 'connectionist', 'dialogic' or interactive teaching, etc. For mathematics, an important goal of instruction is enhancing metacognition, interests and beliefs that are important for self-regulated learning and problem solving (De Corte, 2004). Many have argued that formative assessment and more dialogical pedagogies are required for conceptual, metacognitive and affective outcomes (e.g. Black & Wiliam, 1998, Ryan & Williams, 2007). Following from this, our framework for conceptualizing teaching practices also built on the concepts of 'connectionist', 'discovery' and 'transmissionist' practices, as developed by Swan (2006) in the sixth form and Further Education College context (see Pampaka *et al.*, 2012b). From this perspective effective mathematics teaching should be connectionist in two ways: (a) connecting teaching to students' mathematical understandings, and productions (hence student-centred, but also involving formative assessment, dialogic and discussion-based communicative mathematics); and (b) connecting teaching and learning across mathematics' topics, and between mathematics and other (e.g. everyday) knowledge.

From the students' perspective, research on classroom learning environments has evolved to consider the intertwining of teaching and learning into 'a single entity' (Shuell, 1993, Vermunt & Verloop, 1999), and found moderate positive associations between the learning environment and students' attitudes to mathematics. Student approaches to learning (strategic, surface/deep, etc.) have also been related to teaching approaches in previous literature (see Beattie *et al.* (1997) for a review). Procedural rule-following is often associated with short-term test passing in a surface approach to learning (Marton & Booth, 1997). A recent Dutch study (Beausaert *et al.*, 2013) provided evidence that a 'teacher-centred approach predicts a surface approach to learning and a student-centered approach predicts a deep approach to learning' (p. 1).

In fact Beausaert and colleagues (2013) also mentioned that there is no evidence that the teacher's perceptions of their teaching approaches will match students' experience. Referring to other studies (e.g. Nijhuis *et al.*, 2005), they conclude that it is important and relevant to measure students' perceptions of the teachers' approaches to teaching instead of using teachers' self-reports and call for more research on students' perceptions. When one attempts to look for studies involving both perspectives, evidence is scarce. These two identified gaps will thus be addressed here.

3. Methodology

Instruments: The students' questionnaires were designed as adaptations of previous TLRP/Transmaths instruments (e.g. Pampaka *et al.*, 2012a, 2013) but with different versions to reflect the maturity of these students. The various sections of the questionnaire included 'Dispositions for mathematics' (Pampaka *et al.*, 2013), students' 'perception of transmissionism' (Fraser, 1998, Pampaka *et al.*, 2012b), background variables and measures of students' attainment.

The teachers' questionnaire was largely influenced by the already validated version of the teacher instrument that gives a measure of 'transmissionist' teaching of mathematics (Pampaka *et al.*, 2012b). Items of that instrument were selected, revised (when needed) accordingly and complemented with items from other instruments (e.g. Harwood *et al.*, 2006, Kember & Gow, 1994 Harwood *et al.*, 2006) in order to reflect teaching practices found in secondary classrooms. Teachers were asked to complete a separate Teacher's survey for each of the classes of survey students they taught, by stating the frequency of certain practices given the question 'About how often do you do each of the following in your mathematics instruction in this class?'

Sample(s): The analysis presented here draws mainly on the first two data points (hereafter DP1: start of the academic year and DP2: end of the academic year 2011–2012) of our longitudinal survey of students and their mathematics teachers, covering one academic year (2011–2012). The initial sample (i.e. DP1) of 13,643 students were in Year 7 (3926), Year 8 (3039), Year 9 (2716), Year 10 (2127) or Year 11 (1835) and along with all the available responses on subsequent DPs, this sample was used for the calibration of students' measures. Validation of the teachers' measure of transmissionism was based on the 360 available 'teaching cases'—that is, the 132 teachers' reports of practice for the various classes they were teaching. Further comparisons with the constructed measures then draw on the more limited, matched data set restricted to only those students whose teachers completed a questionnaire for their class. To avoid further complications due to sample attrition descriptive results are limited to DP1 only (Year 7, 1523; Year 8, 1338; Year 9, 944; Year 10, 715; Year 11, 603), whereas regression modelling employs the cross sectional data within the whole academic year (including thus another 1744 cases from DP2: Year 7, 425; Year 8, 387; Year 9, 262; Year 10, 454; and Year 11, 216).

4. Analytical approach

Measure Construction and Validation: This first step of our analytical approach is based on the assumption that there are latent constructs underlying the items in the questionnaires, such as 'perception of transmissionism' and 'disposition to study mathematics'. Using the teachers' and students' responses to the relevant questions, validation then involves analysing whether fit-for-purpose 'measures' can be scaled. The validation process, i.e. the accumulation of evidence to support validity arguments, was performed within the Rasch unified analytic measurement framework as in our previous work (e.g. Pampaka *et al.*, 2012a,b), employing mainly the Rasch rating scale model (RSM). Decisions about the validity of the measures are based on different statistical indices, such as item fit statistics, category statistics, differential item functioning and person-item maps (Bond & Fox, 2001).

Further Statistical Modelling: Once the measures' validity is established, the derived scores (i.e. teachers' and students' measures) are appended to the original data sets along the other responses to the questionnaires and background variables. The matched scores are compared/correlated in order to check for alignment. Further descriptive analysis aims to explore how these perceptions of teaching practice vary between year groups, and by gender. Finally the association of these measures with learning outcomes such as maths dispositions is modelled with linear regression following approaches detailed elsewhere (e.g. see Pampaka *et al.*, 2012b, for more details).

5. Validation results: Measuring perceptions of teaching practice

In this section, we briefly exemplify the validation procedures with the teachers' self-report measure of transmissionism, noting that similar validation was conducted with the other measures. These results use the Rasch RSM analysis of the 360 teaching cases as reported by the 132 teachers during both DP1 and DP2. In order to establish a meaningful unidimensional model and maintain the direction of the measures' intensity the reversal of the original coding of some items was necessary: these items are denoted with brackets in Fig. 1 and their reversed scoring must be considered for the interpretation of the constructed scale.

Item fit statistics are initially checked to provide an indication of data fit to the model. Inconsistent data may suggest new dimensions, non-fulfilment of the unidimensionality assumption in a worst case scenario, or they could simply become a source of further inquiry. Bohlig *et al.*'s (1998)

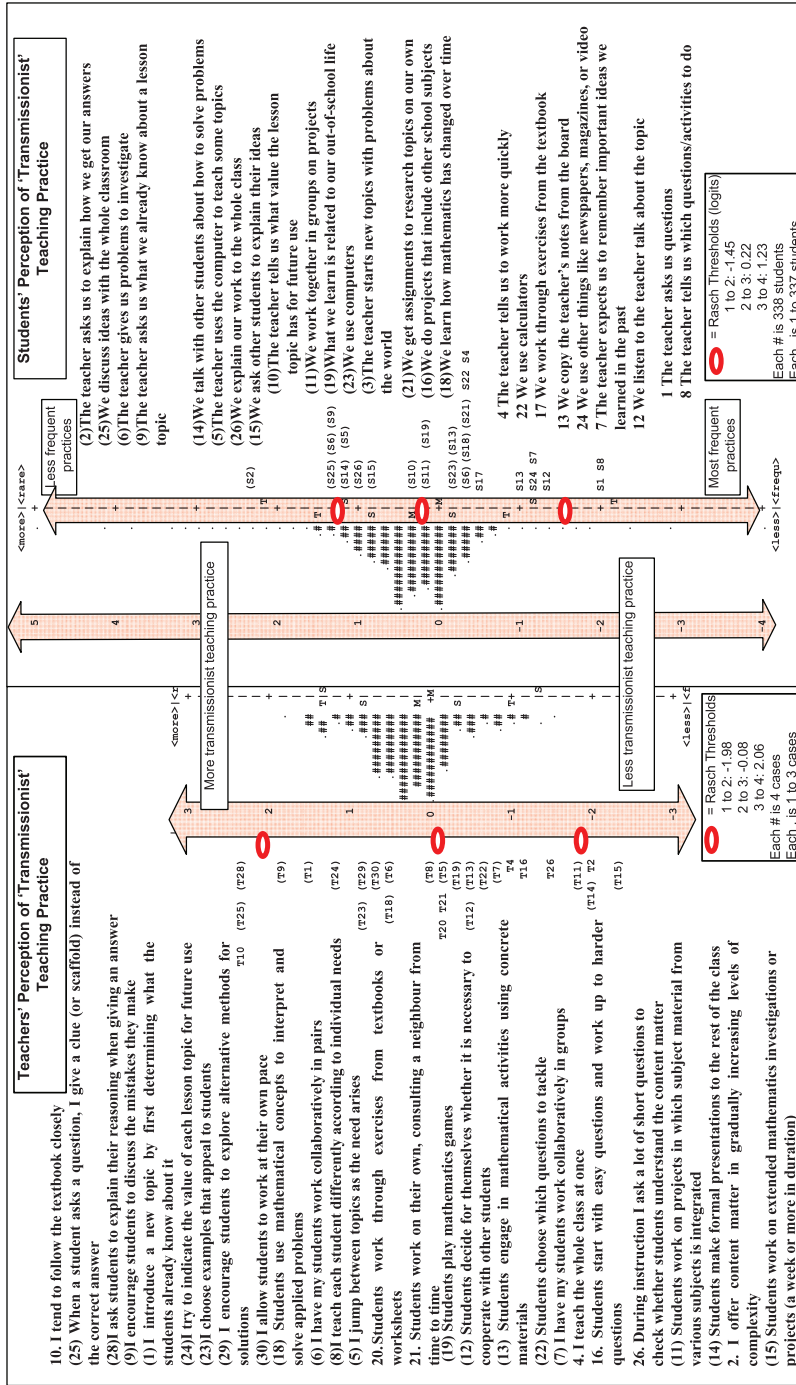


Fig. 1. The person-item maps of teachers and students' perceptions of 'transmissionism' scales.

recommendation that ‘less than pleasing fit statistics say “think again”, not “throw it out”’ (p. 607), is endorsed, and hence explanations and interpretations are sought for the high misfit values; misfit items are only removed from the scales if there is a good reason, usually involving face validity. Preliminary calibrations indicated problems with some of the initial 30 items and after face validity checks three items (T3, T17 and T27) were removed.

The Rasch analysis of the remaining 27 items showed acceptable fit and this supports the assumption of the existence of a unidimensional scale.³ Items T10 and T12 showed some misfit values (with infit above 1.4) but due to their face value and location on scale it was decided to keep them. T10 (‘I tend to follow the textbook closely’), for example, was also the most difficult item to endorse (see also Fig. 1) and such items do tend to produce higher misfit values. Response category statistics and differential item functioning by DP were also acceptable, but details are omitted due to space limitation (see footnote 3).

The resulting teachers’ measurement scale is presented by a teacher-item map (Fig. 1, left-hand site): it plots both items’ and teachers’ parameters on a common scale. The unit for this scale is the logit (shown with the arrows) and the items for the teachers’ perceptions are listed on the left⁴ (with the reverse-scored items shown in brackets) ranging from those easiest to endorse as frequent (bottom) to the most difficult to endorse being frequent. The distribution of the teachers’ transmissionism measures is also shown as a histogram: the higher the place on the histogram, the more transmissionist the teacher perceived their pedagogy. Teachers that perceived their pedagogy as less transmissionist are nearer the bottom.

Students’ perceptions: A similar procedure was followed for the student sample using a set of items more relevant to students of that age, but with similar items and with a similar underlying construct in mind. Students were asked ‘Please tell us, how often does the following happen in your maths lessons’ given 26 items and the response options ‘never’, ‘rarely’, ‘sometimes’ and ‘always’. For comparative purposes, Fig. 1 (right-hand side) presents the equivalent scale for students’ perceptions of pedagogy.

In order to read and interpret the students’ perception scale in Fig. 1, we look at the item ‘S13: We copy the teachers notes from the board’ and notice that almost all the students are plotted higher up the scale, indicating that they find it easy to agree that this happens relatively often (i.e. ‘sometimes or always’) in their classrooms. However, the important thing is that students with higher scores on this scale are more likely to agree this happens always than students with lower scores, and so agreeing that ‘copying notes from the board’ is commonplace provides an indicator that the students’ classroom is perceived as transmissionist. This makes sense to us and agrees with the kind of practice we saw happening often in teacher-centred, transmissionist classrooms. The fact that this item is quite low on the scale means that even students in the relatively *least* transmissionist classrooms (as perceived by the students here) do agree that this happens in their class, just ‘rarely’. The same sort of interpretation can be made for all the positively scaled items in the scale, (that is, those without brackets round their names in the Figure). These include practices like ‘listening to the teacher’, ‘working through exercises from the textbook’, doing the questions ‘the teacher tells us’ and ‘memorising’.

The negatively scored items (those in brackets, mostly in the top half of the students’ scale) are reversely scored because agreement that they happen often is understood (and statistically confirmed) as being indicative of lack of (perceived) transmissionism: thus ‘explaining our answers/our work’, ‘discussing ideas’ ‘asking what we already know’ or ‘investigating’ occur often in these classes. Many of these items appear very high on the scale, indicating that many students agree they happen

³ Detailed results from Rasch Analysis can be seen at <http://www.teleprism.com/teamat016>

⁴ Note that this is an edited output in order to also accommodate the stems of the items on the left; a more representative output (unedited) for the presentation of person-item map is the one with students’ perceptions on the right.

'sometimes' or 'always', but such responses contribute only zero or one to their 'transmissionism score': that is, disagreement that these things happen relatively often is what contributes to the transmissionism score, as one would expect. Less easy to endorse negative items like 'we do projects' and 'we learn how mathematics has changed over time' are items that fewer students say they do often, but still those who say this happens relatively often score less on the transmissionism scale from these items than those who say they happen rarely (because of the negative scoring). So all the bracketed items reflect practices perceived by the students as less transmissionist (in our terms, not theirs of course).

On the left of Fig. 1 can be seen items from the teachers' self-reported transmissionism scale (again negative in brackets) that correspond quite well with the students' items even in their scale positions, supporting the notion that there is some shared understanding of this construct between students, teachers and ourselves. Positively worded items that correspond with the students include doing 'exercises from the text book' (T20) and negatively worded items include 'explaining reasoning' (T28) and working collaboratively' (T7). Some items (e.g. about teachers' sequencing materials and questions graduating in difficulty) were not considered appropriate for students, which suggests some independence of the teachers' construct.

We argue that the underlying character of the transmissionist practices being perceived is similar for students' and teachers', (from looking at the content of the item stems and the order of their locations), and that the scales essentially measure the distinct perceptions of the same transmissionism practice, which itself is similar to that presented in previous work with older students and/or their teachers (Pampaka *et al.*, 2012b).

With the student data and the same validation procedures, other measures of attitudinal learning outcomes have been constructed. One of them, which extends from the previous work, used for further modelling in this article is 'disposition to study mathematics' (Pampaka & Wo, 2014), which is a measure related to expressions of behavioural intention for future engagement with mathematics (the higher the score the more disposed the student is towards further study or engagement with mathematics, essentially the same as that used in Pampaka *et al.* (2012b, 2013): logit scores were again estimated based on students' responses to a series of items indicating their current and future 'attitudes' with mathematics). This will allow us to investigate the previous findings of a negative association of transmissionism with learners' disposition, but add the dimension of students' perceptions.

6. Results: relating the measures of perceptions of transmissionism and dispositions

6.1. Investigating the 'agreement' between teachers and students scores

Analysis was performed both at the individual level as well as at class level. Within the *student-level analysis*, each student was allocated the scores of their teacher on the perception of transmissionism scale in addition to their own perceptions. Pearson correlations for each time point were: DP1 ($N=5123$) 0.119 ($p < 0.001$), DP2 ($N=1734$) 0.088 ($p < 0.001$). Correlations were also calculated at class level, i.e. between teachers' score and the average of students' scores (on the perceptions of transmissionism scale) for each class: DP1 ($N=230$) 0.228 ($p < 0.001$), DP2 ($N=84$) 0.154 ($p=0.162$). The results overall suggest weak, even negligible alignment of teachers' and students' perceptions.

Even though expected, this result needs further investigation. We start by providing evidence of the variation within these classes; looking at the standard deviations (SDs) of the class distributions of student scores, the mean of these SD scores is about half a logit (0.46) with minimum of 0.14 and maximum of 1.45. This indicates that students' perceptions of the transmissionism within the same

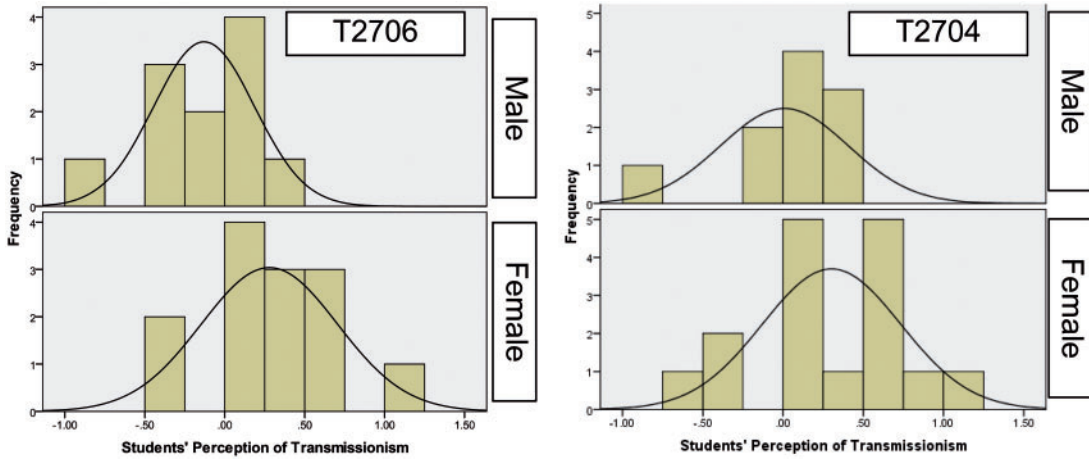


FIG. 2. Distribution of boys' and girls' perceptions of transmissionism for a Year 8 (left) and a Year 9 (right) class.

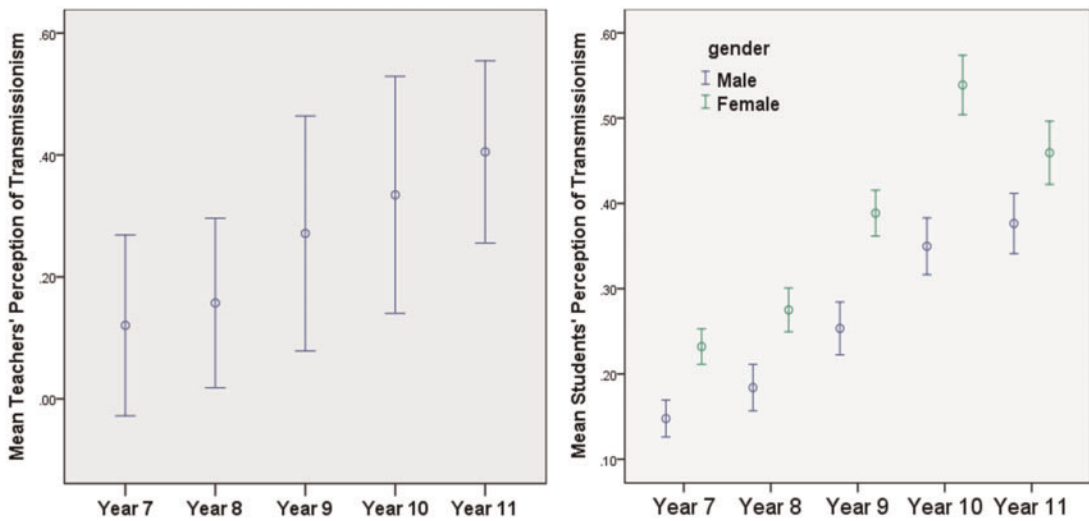


FIG. 3. Plot of means (with confidence intervals) of teachers (left) and students' (right) perception of transmissionism by Year group and gender (only for students).

class varies greatly as also shown with the histograms of two examples of Year 8 and Year 9 with two teachers in one of our case study schools (see Fig. 2).

6.2. Group differences and association of teaching practices with learning outcomes

Given the above results, and the weak correlations of the two measures, it is worth exploring potential differences between year groups and gender further. Figure 3 (right) shows how the mean students' measure of perception of transmissionist teaching is increasing with age in Secondary school, and the differences between girls and boys perceptions. The jump in their scores from Year 9 to 10 is

TABLE 1. Regression models for mathematics disposition as an outcome variable

Explanatory variables:	Model 1	Model 2	Model 3	Model 4	Model 5
constant	0.25 (0.02)**	0.47 (0.03) **	0.7 (0.03)**	0.75 (0.04)**	0.99 (0.04)**
DP (Ref: DP1)	-0.08 (0.05)	0.03 (0.04)	0.01 (0.04)	0.05 (0.04)	0.04 (0.04)
Teacher's TP	-0.14 (0.03) **	-0.06 (0.03)	-0.09 (0.03)*	-0.02 (0.03)	-0.05 (0.03)
Students' TP		-0.77 (0.04)**	-0.72 (0.04)**	-0.69 (0.04)**	-0.65 (0.04)**
Gender (Ref: Male)			-0.41 (0.04)**		-0.41 (0.04) **
Year group (Ref: Year 7)					
Year 8				-0.253(0.05) **	-0.25 (0.05) **
Year 9				-0.61 (0.06) **	-0.59 (0.06) **
Year 10				-0.48 (0.06) **	-0.49 (0.06) **
Year 11				-0.64 (0.07) **	-0.67 (0.04) **

The cells present: Coefficients (standard error)— ** $p < 0.001$, * $p < 0.01$.

Bold was used in order to emphasise significant effect within the two variables of interest (Students and Teachers TP).

Model 1: $F(2,6856)=9.31$ ($p < 0.001$), $R^2=0.0027$ (Adjusted $R^2=0.0024$).

Model 2: $F(3,6859)=163.76$ ($p < 0.001$), $R^2=0.0669$ (Adjusted $R^2=0.0665$).

Model 3: $F(4,6748)=152.24$ ($p < 0.001$), $R^2=0.0828$ (Adjusted $R^2=0.0822$).

Model 4: $F(7,6849)=96.42$ ($p < 0.001$), $R^2=0.0897$ (Adjusted $R^2=0.0888$).

Model 5: $F(8,6743)=99.66$ ($p < 0.001$), $R^2=0.1057$ (Adjusted $R^2=0.1047$).

considerably bigger than the previous years' increases at DP1, and there is also a noticeable/stability (or even small decrease for girls) from Year 10 to 11—however, the mean for Year 11 is still higher than that of the KS3 year groups (i.e. Years 7–9). The differences even though small in magnitude, are statistically significant overall (as indicated by ANOVA: $F(4, 5118)=64.28$, $p < 0.001$) with exceptions noted with overlapping confidence intervals on Fig. 3 (right). Perhaps more interesting in the same figure is the consistently higher scores of girls compared to boys. From the teachers' point of view there is still evidence of an increasing pattern by year group (Fig. 3, left), but the differences were not statistically significant.

The final question to explore regards the association of the measures of these perceptions with the measure of mathematics dispositions with the aid of linear regression modelling. As noted earlier, mathematics disposition was constructed with the Rasch model, and within the matched data set we are using for this analysis with the measure range -5.85 to 6.24 logits (with mean of 0.2 and SD of 1.6 logits). Variable selection was based on procedures with the emphasis on selecting 'useful' models that incorporated theoretical judgements as well as statistical criteria applied to the sample data. A stepwise approach with cross sectional data (e.g. including responses to both DP1 and DP2) was deemed useful for this analysis, and therefore all models controlled for DP. Exploratory variables then entered into the model in the following sequence, in order to compare with previous results and investigate emergent patterns in their effect (the resulting models are presented in Table 1):

- Step 1: Teachers' perception of transmissionism (Teachers PT) to compare with previous models (Model 1)
- Step 2: Students' Perceptions of transmissionism (Students PT) (Model 2)
- Step 3: Year Group and Gender (Model 3 and 4 independently and Model 5 together)

There are some interesting findings when looking at the results of the models in Table 1. Model 1 aimed to replicate previous findings for older students, and shows a small, statistically significant negative association between teachers' perception of their Transmissionism and students' mathematics dispositions (even though the explanatory power of this model is very low as indicated by the R-square at the bottom of the table). The judgement that this value (0.14) is 'small' is based on the average

'effect' of a change in transmissionism from -1 logit to $+1$ logit (from low to quite high scores in the teachers' histogram on the left side of the scale in Fig. 1) giving rise to 2×0.14 which is only 0.28 logits change in students disposition scores. An effect size change of this size on average is considered quite educationally significant in educational research terms, but not as significant as those found in our previous work.

Interestingly, once the students' perception of transmissionism enters the modelling (Model 2), the model shows a much stronger negative significant association between students' perception of transmissionism and their mathematical disposition, and at the same time attenuates the association of teachers' perceptions with those dispositions (one could argue the 'effect' of students' perceptions is to mediate some of the 'effect' of teachers perceptions).

Further complexities in these associations are observed in Models 3–5, when gender and Year group are introduced as explanatory variables. Gender and year group both have significantly negative associations with disposition, both statistically significant and arguably educationally significant. On average, girls score 0.4 logits lower than boys (Models 3 and 5), while decline in dispositions from Year 7 to Year 11 is even greater (assuming all other variables are the same in Models 4 and 5). The gender and year group of the student also mediate some (though a minor part) of the association of the students' perceptions on their disposition. In other words, one can say that because the students' perception of teaching is more transmissionist in higher year levels and by girls, some of the association between perceived transmissionism and dispositions is indeed attributable to the way teaching is perceived as more transmissionist in higher year groups and by girls. Another interesting observation regards the comparison of Models 2, 3 and 5: the disappearance and then re-establishment of a significant effect for teacher's perceptions on the presence of gender seems to suggest an interaction (or moderating effect) which needs to be further explored in the future.

A summative comparative observation from these models is the consistent negative association of students' perception of transmissionist teaching and their dispositions, which is slightly attenuated as other variables are introduced, but the message is the same: when students perceive their maths lessons as more transmissionist, their maths disposition drops significantly (a unit/logit increase on their perception of transmissionist is associated with an average of at least half a logit drop in dispositions, when all other variables are considered).

7. Conclusion and discussion

The article presented findings from two interconnected analytical approaches: measurement and modelling of the associations between constructed measures of transmissionism and mathematics dispositions. It was first shown with one example how measurement principles have been employed to construct measures of what we called students' and teachers' perceptions of transmissionism in secondary mathematics. They are considered robust measures for the purposes of this analysis, and while we argue that they both reference much the same transmissionist classroom practices, the perceptions they measure are rather different and not highly correlated, with students' measures being highly variable even in the same classrooms, partly because they are gender differentiated. No doubt there are many other factors that might account for such variations that we did not record or have not yet modelled. Furthermore, relative to the practices we wrote into the scales of course, the distribution of both teachers' and students' perceptions of transmissionism seem to be skewed towards the higher ends of the scales, i.e. teaching is currently perceived to be 'highly' transmissionist by both students and teachers, relative to this set of itemized practices.

The regression models presented here provide further evidence in support of our previous results with older students and illuminate declining mathematics dispositions of students and their potential sources. Teachers' self-reported transmissionism is still negatively associated with learners' maths dispositions (as in Pampaka *et al.*, 2012b) though perhaps not quite as strongly. However, once we take into consideration students' perceptions, the effect of teachers' views is attenuated: one can argue that the 'effect' of teachers' self-reported transmissionist practice is partially mediated by, and explained by the students' perception of their pedagogy as transmissionist, even though the students' and teachers' measures are only weakly correlated.

The substantial explorations from further analysis of these measures are also telling: the teaching of mathematics seems to be increasingly perceived as transmissionist as students move from Year 7 to 11, by both girls and boys (girls perceptions always being higher than boys). Others also found that perceptions of learning classroom environment (from a goal theory perspective) change over the year and in general develop over time (Turner *et al.*, 2013). The negative association with gender is also strikingly significant, suggesting that girls perceive maths in different ways that are associated with their lower maths dispositions.

Students' perceptions of more transmissionist teaching are consistently associated with lower maths disposition even after accounting for other factors. The focus here was not on explaining dispositions as much as possible, but rather to test the effect of students' perceptions of teaching, while 'controlling' for some important factors (such as year group, gender) in order to shed more light on the relationships of the two perspectives on learning outcomes. In this sense the models are informative and the combined results indicate the importance of students' perceptions. In fact others have also suggested that it is not the learning environment that influences students' learning approaches, but the way students perceive the learning environment (e.g. Nijhuis *et al.*, 2005).

Given our own previous work also, one could conclude here that there is a strong (causal) effect of perceptions of transmissionism on negative dispositions underlying this measurement model. The result that year group and gender mediate some of this 'effect' of students' perceptions is arguably powerful: it suggests that the negative dispositions of girls and older year groups in particular are partly attributable to their perceptions of teaching as more transmissionist, although the evidence of association might be equally explained as the other way round. All this adds new dimensions to previous findings that suggest new research directions.

Now the caution: our interpretation of 'associations' in previous work as the 'effects' might seem to assume an input-output model where teaching mechanistically causes learner perceptions of teaching and outcomes: this is the dominant paradigm in 'effectiveness' research that policy-oriented research tends to adopt. In Transmaths projects we have been working on alternative theoretical and methodological foundations, including the whole tradition of Activity theory founded by Vygotsky, while still finding it necessary to address the policy debates. In fact we think the causative model is more complex and less mechanistic than the effectiveness paradigm admits: complex models might be considered in which learners' perceptions and dispositions ALSO have backwash effects on teaching and teacher perceptions of their teaching: a dialectical, and dynamic model. Although Vygotsky would not have been aware of formal mathematical dynamics, his concept of 'perezhivanie' (usually translated as 'emotional experience') captures this complexity in dialectics: the 'perezhivanie' that he thought crucial to understanding development is a unit of analysis (a dialectical unity) of the 'objective' environment and its 'subjective' perception/apprehension (Vygotsky, 1994). The dialectic concept of causation is one in which the contradictions between objective and subjective are invoked: thus we suggest that the dispositions of students affect the perceptions of the classroom as much as the other way round, implying a dynamic system.

In such models we have found bifurcation lines, for instance, which divide parameter spaces of dispositions and attainment, with ‘positive’ and ‘negative’ spirals of improving and declining student outcomes occurring on either side of a bifurcation line whose position depends on the classroom transmissionism. We think this is much more likely to provide for the complexity of real classroom life, and anecdotally seems to fit with what teachers have told us (i.e. they tend to become more transmissionist with both high-attaining and highly disengaged classes).

There are many other important limitations in the current exploratory analysis, in that it considered cross sectional data and has not accounted for the multilevel and longitudinal nature of the data; some caution will thus be placed on the interpretation of these results and more complicated analysis should take into account the interaction of different factors that are not presented here to avoid technical burdens.

While concluding that there is an association of transmissionism on declining maths disposition, we should note this effect is also complicated (drawing on analysis not reported here) by other interactions as stated earlier as well as other variables such as students’ perception of lesson difficulty and students’ self-concept (i.e. estimates of their own maths ability). There are, thus various interrelationships with these variables which support our view of teaching–learning practice as a complex, dynamic system. Perhaps more relevant here are the implications of that conclusion for related practice: to keep students positively disposed and interested in mathematics, with potential implications for their future engagement with mathematically demanding courses at higher education, teaching should be less transmissionist throughout secondary mathematics, but perhaps more importantly we believe that it is crucial to monitor and respond to students’ perceptions of the classroom practice, and engage teaching with students views.

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