Is Content or Interest and Enthusiasm of Mathematics Teachers more important?

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Abstract. Due to the different type of student being taught today both in the classrooms of secondary schools and at tertiary institutions, it has been proposed that teaching pedagogies for the teaching of mathematics and statistics should also be adjusted to more effectively teach the new age student. Students of today, compared to students from two decades ago, for example, are much more technology savvy, are more likely to own mobile phones and more likely to engage with social media. It seems reasonable then that teaching strategies adapt to the changing student. Secondary data of secondary students are presented to assess the performance of students in mathematics for different aspects of teaching; in particular, to compare whether the interest of teachers appears more important when compared to aspects of teaching that focus only on the delivery of relevant content.

1. Introduction

It has been proposed that to improve student outcomes in mathematics, there needs to be a focus on teacher training and professional development. The purpose of this study is to present some insight into teaching practices that may contribute to improved student outcomes. This, however, does require an understanding of the students of today and the use of teaching strategies to maximise learning outcomes of these students.

It has also been recognised that students of today think and learn differently than those from previous generations [1], suggesting the need to revise and potentially update traditional teaching practices. For example, when many learning theories were developed, few people owned mobile phones [2]. There is abundant access to technology today, implying a greater number of people who are technologically advanced [3]. Students of today, compared to students from two decades ago, for example, are much more technology savvy and more likely to engage with social media [4]. Given today’s more digitised world whereby communication is often in terms of words, images, videos and multi-media, these forms of communication are also becoming drivers in learning [5]. It has been claimed that technology has changed learners’ brains [2]. There are also more students entering tertiary study at different life stages, who may hence be in need of more diverse types of instruction and learning [7].

Due to the different types of students being taught today, both in the classrooms of secondary schools and tertiary institutions, it has been proposed that teaching pedagogies that form the basis of teaching practices used for mathematics and statistics subjects should also be adjusted to more effectively teach
the new age student [4]. It seems reasonable then that teaching strategies also adapt to the changing type of student.

The present study aims to compare student outcomes when exposed to teachers who focus on the delivery of content using traditional approaches to teaching to outcomes when students are exposed to teachers who show more enthusiasm and interest when delivering mathematics content. In the field of educational psychology, teacher enthusiasm can be measured in two different ways [8]: in the behavioural sense which refers to stimulating and energetic instruction practices including gestures, vocal delivery, or facial expressions [9] as well as in terms of internal and subjective experiences of teachers who are enthusiastic for teaching, thus dealing with the behaviour of teachers that results from this internal state [8].

The PISA study is an educational large-scale assessment study whereby student perceptions of the quality of teacher instruction are measured. Student perceptions of teacher quality will hence serve in this study as proxies for instructional quality as more objective techniques for assessment of teaching strategies including the use of direct observer ratings were not utilised in the PISA study for practical reasons [10,11]. Despite these proxy measures of teacher traits not being perfectly reliable measures [12], it has been found that ratings by students are substantially related to ratings by teachers of their instruction [8]. Furthermore, perceptions by students of instructional quality are considered among the most reflective criteria for assessment of the effectiveness of teaching [8]. Given that quality of instruction is considered a critical predictor of learning outcomes [13], student perceptions of instructional ability measures have formed a significant focus in national and international assessments [14,15], whereby students have given their perceptions of various teacher traits including how teachers support and manage their classrooms [15].

The present study evaluates student perceptions of instructional quality as proxy measures of instructional quality and assesses the association of student perceptions of instructional quality with educational outcomes in mathematics to ascertain teaching strategies that are more strongly associated with positive student learning outcomes. The main teaching strategies assessed are in terms of delivery of content, which tends to be associated with more traditional approaches to teaching; and interest and enthusiasm of instructors, which is more closely related with personal attributes of the teacher.

2. Methods

2.1. Sample

Secondary data of secondary school students were analysed to assess the performance of students in mathematics with regard to different aspects of teaching. More specifically, the interest and enthusiasm of teachers was compared to aspects of teaching that focus on the delivery of relevant content to ascertain the relative importance of these two aspects on performance in mathematics.

Data from 14 481 secondary school students participating in the large-scale Programme for International Student Assessment (PISA) 2012 study in Australia were analysed. The PISA study assesses performance of 15-year-old school students in mathematics, reading and science [11]. An aim of the PISA study was to compare countries with respect to how teacher instruction is perceived by students [16]. Some measures collected as part of the study include math achievement scores as well as measures that assess the ability of students to learn in the form of the frequency with which different teaching strategies were used in the classroom [11].
2.2. Measures
Mathematics was the main domain assessed in the PISA 2012 study and is the key student outcome of interest for the present study. The present research paper measures the frequency with which mathematics teachers adopt each of the studied instructional teaching strategies, based on student perceptions. The teaching strategies assessed for the present study are those which focus on aspects of standard delivery of content (content) and aspects that focus on enthusiasm and interest. The relationship between each selected teaching strategy and student outcomes in mathematics is assessed.

The PISA 2012 study measured students’ mathematical literacy in terms of several mathematical techniques (including the mathematical formulation of scenarios; the use of mathematical concepts and methods in mathematics; and the interpretation and application of mathematical solutions) and topics (including relationships; aspects of space and shape; quantification; data and uncertainty) [15]. Mathematics exam performance was measured using a total score representing the proportion of administered questions, covering all of these mathematical techniques and topics, which were answered correctly. The proportion scores were used as the main outcome variable for the present study.

The teaching strategies selected as most reflective of content delivery are listed in table 1 and relate to items pertaining to teacher directed instructions and measures of clarity and understanding of learning goals. These measures comprise the following: explains content well, sets clear goals, summarises previous lessons and teacher helps. The teaching strategies selected as most reflective of the Enthusiasm and Interest trait include teacher shows interest and teacher expresses opinions.

Questions on the utilisation of each of these teaching strategies in the classroom were administered to students as part of a student questionnaire. In the questionnaire, students rated how often their teacher incorporated each teaching technique in the classroom with possible answers given on a four-point Likert scale, with answers ranging from 1 = (every lesson), 2 = (most lessons), 3 = (some lessons) to 4 = (never or hardly ever). For the proposed analyses, items were reverse recoded so that a higher score reflected a higher uptake of the teaching strategy.

2.3. Statistical Analysis
Variables were used on two different levels in the proposed analyses, with student mathematics achievement scores and the student’s perception of the rate of utilisation of each teaching strategy used on the individual student level, while school was used as the class level. This clustered sampling method violates the assumption of independent observations which is associated with conventional statistical tests. Students from different schools can be expected to vary in terms of their achievement levels, and possibly in terms of other variables, including socio-demographics, for example [17]. The effects of the considered teaching strategies on mathematics achievement scores were assessed using multilevel regressions [18], which take into account the hierarchical structure of data with students nested within schools, and simultaneously models data from the different levels.

3. Results
Bivariate analyses of each of the studied teaching strategies by Mathematics performance score are displayed in Table 1. Each of the studied teaching strategies was positively and significantly related with math achievement score, whereby the greater utilisation of each teaching technique was associated with a higher mathematics performance score. The only exception to this trend was ‘teacher summarises previous lessons’, which although was significantly related with math achievement score, was negatively associated with it, indicating that students who rated their teacher as displaying this trait more frequently scored more poorly, on average, in terms of mathematics performance. This could potentially be due to students perceiving teachers to spend more time on revising content than on teaching new content, hence resulting in poorer opportunity to learn relevant content.
All teaching strategies were consequently entered into a multilevel regression simultaneously to enable adjustment for the uptake of other teaching strategies as in practice, some of these techniques can be used simultaneously (Table 2). Interestingly, the item ‘teacher sets clear goals’ became non statistically significant \( p=0.13 \) after adjusting for the other teaching strategies, suggesting that this item setting of goals was not a significant predictor of mathematics performance after adjusting for the other teaching strategies in the model. Removing this item resulted in the model presented in Table 3, in which all teaching strategies remained positively and statistically significant predictors of math performance except for ‘teacher summarises previous lessons’ which remained statistically significant but negatively related with mathematics performance score suggesting that after adjustment for the other variables, all of the considered teacher attributes remained important predictors of mathematics performance.

All parameter estimates were also of similar magnitude making it difficult to differentiate between items in terms of which set of teaching related factors were more important when determining their impact on mathematics performance scores. The parameter estimate for teacher expresses opinions was slightly lower than other estimates. This teaching strategy, upon further reflection, could technically be argued to not be as indicative of teacher interest or enthusiasm as there is an element of ambiguity in terms of how students may have interpreted this item.

### Table 1. Bivariate analyses of each teaching strategy by Math performance score.

| Teaching Strategy                              | Coefficient \((p\text{-value})\) |
|-----------------------------------------------|----------------------------------|
| **Content**                                   |                                  |
| Teacher explains content well                 | 0.010 \(<0.001\)                |
| Teacher sets clear goals                      | 0.019 \(<0.001\)                |
| Teacher helps                                 | 0.034 \(<0.001\)                |
| Teacher summarises previous lessons           | -0.009 \(<0.001\)              |
| **Interest and Enthusiasm**                   |                                  |
| Teacher shows interest                        | 0.024 \(<0.001\)                |
| Teacher expresses opinions                   | 0.021 \(<0.001\)                |

### Table 2. Adjusted multilevel regression by including all teaching strategies by Math performance score.

| Domain            | Teaching Strategy                              | Coefficient \((p\text{-value})\) |
|-------------------|-----------------------------------------------|----------------------------------|
| **Content**       | Teacher explains content well                 | 0.027 \(<0.001\)                |
|                   | Teacher sets clear goals                      | 0.006 \(<0.126\)                |
|                   | Teacher helps                                 | 0.024 \(<0.001\)                |
|                   | Teacher summarises previous lessons           | -0.022 \(<0.001\)              |
| **Interest and Enthusiasm**                  | Teacher shows interest                        | 0.021 \(<0.001\)                |
|                   | Teacher expresses opinions                   | 0.017 \(<0.001\)                |

### Table 3. Final adjusted multilevel regression of strategies by Math performance score.

| Domain            | Teaching Strategy                              | Coefficient \((p\text{-value})\) |
|-------------------|-----------------------------------------------|----------------------------------|
| **Content**       | Teacher explains content well                 | 0.027 \(<0.001\)                |
|                   | Teacher helps                                 | 0.025 \(<0.001\)                |
|                   | Teacher summarises previous lessons           | -0.021 \(<0.001\)              |
| **Interest and Enthusiasm**                  | Teacher shows interest                        | 0.022 \(<0.001\)                |
|                   | Teacher expresses opinions                   | 0.017 \(<0.001\)                |
Hierarchical linear regression models were then used to determine if, collectively, the items relating to content added significantly to the model containing items measuring interest and enthusiasm. The change in the coefficient of determination between models was associated with a statistically significant improvement in model fit (p<0.01). Similarly, the items relating to interest and enthusiasm added significantly to the model already containing the set of items measuring content (p<0.01).

4. Discussion
The results demonstrated that it was difficult to differentiate between items measuring enthusiasm and interest and those items measuring content in terms of their influence on mathematics achievement scores. Each set of items appeared to complement the other set and no set of items appeared superior to the other in terms of their influence on mathematics performance scores. However, both sets of items appeared statistically significant in terms of their effect on mathematics performance score. It should be noted, however, that for future research the relationships between teaching strategies and student outcomes should be assessed in conjunction with other factors including student socioeconomic status and potentially school socioeconomic distribution, as these factors could impact the studied relationships. Similarly, teacher experience and school characteristics such as availability of funding and teacher training could also be investigated as these could serve as potential confounders on the studied relationships. It should also be noted that the magnitudes of the effect sizes seem rather small which can be common for large sample sizes. However, the outcome variable, performance score, was measured as the proportion of items in the test scored correctly in which case a coefficient of 0.02, for example, would equate to a difference of 0.02 or two percent in mathematics performance for a one unit change in the perceived uptake of each teaching strategy. Nonetheless, the directions were mostly as anticipated and are suggestive of higher uptakes being associated with higher mathematics scores, on average, for most of the studied items suggesting that the emphasis of effective teaching strategies and hence teacher training should be broadened to include techniques beyond those associated with the delivery of content alone. The study highlights that an emphasis on engagement and perceived enthusiasm of teachers should also be a focus of teaching mathematics based courses.

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