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Constructing An Exemplary Mathematical Justification

Why Is It So Hard for Mathematics Teachers?

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KEY IMPLICATIONS

- Producing an exemplary or competent mathematical justification requires one to recognize the different types of justification tasks and the respective demands of the tasks.
- Mathematics teachers need to attend a relevant workshop or Networked Learning Community (NLC) on mathematical justification, organized by the Academy of Singapore Teachers (AST), to acquaint and equip themselves with appropriate instructional practices to better engage and guide their students to develop competencies in constructing an exemplary justification.

BACKGROUND

Getting learners to reason and justify in the learning of mathematics is an essential component of any mathematical activity that every learner, and not just the more able ones, should be familiar with. Yet many learners, as well as mathematics teachers, struggle to navigate mathematical justification successfully. With the current emphasis on mathematical reasoning and justification in the mathematics curriculum, there is therefore a need to examine the current state of written justifications produced by learners and mathematics teachers to find out why they are still not answering justification tasks well.

FOCUS OF STUDY

The Justification in Mathematics (JiM) project aimed to (i) examine the quality of written justifications produced by Secondary school students and mathematics teachers, and (ii) investigate the participants' views of an acceptable justification through a survey. The findings could then serve to guide teacher educators in developing a professional development programme to support mathematics teachers' efforts in the classrooms to engage and help students to develop competencies in expressing mathematical reasoning and justification.

KEY FINDINGS

1. This study produces compelling evidence of a sizeable number of mathematics teachers in the participating secondary schools who could hardly produce a complete and clear justification.
2. Many mathematics teachers were not acquainted with the different types of justification tasks and their demands. In particular, those justification tasks that required a decision to be made were often missing a conclusion and were thus not answered well.

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3. Many mathematics teachers were not clear how much to write to construct a complete justification, often relying on the mark allocated to the task to gauge the amount to write.
4. Mathematics teachers seldom have to write mathematical solutions in prose form. So many struggled with the justification tasks when they had to express their justification coherently in prose form.

SIGNIFICANCE OF FINDINGS

Implications for practice

1. This JiM project sheds light on the construction of justification by Secondary school students and mathematics teachers for the different types of justification tasks across the three content strands. Through analyzing the numerous justifications produced by the participating students and mathematics teachers, we validated the critical features that must be present in an exemplary or competent response for each type of justification task. Mathematics teachers can use these critical features to guide their students to construct exemplary justifications.
2. Another significant contribution is the development of a 4-point coding scheme to classify the various written justifications that were produced. This coding scheme can offer a quick means to help mathematics teachers sort and group the student justifications for classroom discussion.
3. Both the PI and a Master Teacher in Mathematics from AST hold termly meetings with members of the NLC on mathematical justification in different members' schools. Mathematics teachers should consider joining this NLC to pick up instructional practices on how to foster mathematical justification in the classroom. The meetings cover a wide range of matters such as the critical features expected in an exemplary justification, the various ways to answer the different types of justification tasks, and GCE O Level and N Level examiners' comments on students' performance in justification tasks.

PARTICIPANTS

This project involved Secondary Four students in both the Express and Normal (Academic) courses and mathematics teachers from six secondary schools, each being a convenient sample. The mean PSLE aggregate scores of these schools range between 199 and 225 for Express and between 161 and 185 for Normal (Academic).

RESEARCH DESIGN

This project adopted a survey design to collect data using a written test and a questionnaire. The test items covered all three content strands in the Singapore Mathematics syllabus: Number and Algebra, Geometry and Measurement, and Statistics and Probability. It also involved three types of justification tasks, namely validation, decision-making and inference. The research data set comprised student responses to written test and survey items; teacher responses to written tests and survey items; and interviews of students and teachers. A four-point coding-and-marking scheme was developed to code the written test responses. The data were analyzed using a mixed-methods approach that involved both quantitative (frequencies, percentages and facility index) and qualitative (thematic) techniques.

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