Journal of Mathematics Education
2022, Vol. 15, No. 2, 8-20

https://doi.org/10.26711/007577152790091

Data Use to Inform Mathematics Instruction: An Exploratory Study

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This study investigates the state of data use to inform instruction among primary school mathematics teachers in Malaysia. It looks at the type of data these teachers used to inform their mathematics instruction, their predominant level of data literacy, their training needs and support in data use, and their confidence in using data. 88 teachers responded to a questionnaire and five of them were subsequently interviewed. Results of the questionnaire and interviews indicate that the data which was most frequently used was classroom-based assessment data. For those respondents who used data on a weekly basis, the highest percentage of them were involved at data literacy Level 4 which involved the process of collecting, analysing, interpreting, acting and communicating data. The teachers were generally of the perception that the training needs and support for data use were adequate and they were confident in using data to inform mathematics instruction. However, they were also of the opinion that more professional development courses should be conducted for them so that they can use data effectively and systematically to inform their practice. Interview data provided some qualitative descriptions of how the mathematics teachers use data to inform instruction.

Keywords: data use, inform instruction, mathematics teachers, data literacy

In Malaysia, teachers in general collect data frequently and through various means. Classroom-based data such as examination results, quizzes, and homework performance are collected and kept by the subject and class teachers. School-based data such as the Primary School Assessment Report, Take-off Value based on pupils' current academic performance, Pupil Performance Report, Classroom-based Assessment Report, Psychometric Test and Pupil Database Analysis are some examples of data collected and kept at the school, district and/or national levels. On the other hand, teachers are not required to collect international data related to Mathematics, such as Trends in International Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA) data. These data are available to the teachers through the Internet or Ministry of Education.

There is no specific policy nor is it mandatory for the teachers to use the data they have collected or accessible to them while planning instruction. Most teachers would probably refer to the standard-based curriculum and

assessment documents, semester plans, textbooks and reference books as the main resources in the planning process. Adding on to that, not all data are directly relevant to classroom instruction. Hence, with an immense amount of data collected or accessible to the primary school mathematics teachers, do they actually make use of the data to inform their classroom practices?

This study aims to gain an overview of how primary school Mathematics teachers currently use data collected or available to them to inform instruction in their classroom. More specifically, the study attempts to: (a) investigate the state of international, school-based and classroom-based data use by the teachers to inform their mathematics instruction; (b) identify the level of data literacy among the teachers; (c) investigate their perception towards training needs and support in data use; and (d) investigate their confidence in using data.

Data Use and Data Literacy

Data use in education is increasingly important in making many types of decisions from school improvement to classroom and instructional decision-making in what is termed as data-driven decision-making. To improve teaching and learning, it is not the quantity of information that counts, but the quality and how it is used. Effective data use is one of the essential elements of quality teaching for improving student outcomes (Hamilton et al., 2009). Nonetheless up till now, policies have not gone far enough to endorse the skills teachers need to be data literate. Subsequently, many teachers regard data as overwhelming and daunting, rather than as a tool for enhancing instruction and ultimately outcomes for students.

Teachers are being asked to use more and more diverse data to support their practice (Hamilton et al., 2009). Teachers use data to modify classroom instruction to fit the students' needs better (The National Council of Teachers of Mathematics [NCTM], 2010). School and teachers use data to make inquiry into trends in students' achievement, to investigate why such trends occur and how to improve the uncovered weaknesses. Research finds that effective data use requires the use of multiple sources of quantitative and qualitative data, and not solely achievement data (Mandinach & Gummer, 2016a).

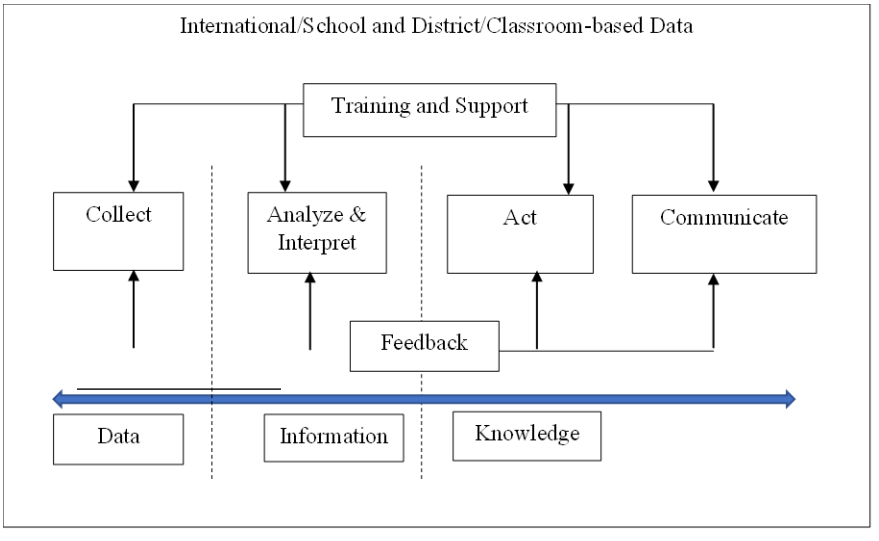
Data exist in raw state and do not carry useful meaning. The raw data need to be transformed into information and subsequently into knowledge in order to be usable (Light et al., 2004). Information is data connected to a context to comprehend and organize our environment. However, it does not convey any implications for future action. Knowledge is the collection of useful information to guide action. Pertaining to assessment information, it is the teacher's ability to see connections between students' scores on different item-skills analysis and classroom instruction, and then act on them, that represents knowledge.

One perspective of investigating data use is by looking at the data literacy of the teachers. Data literacy for teaching is the ability to transform information into actionable instructional knowledge and practices by collecting, analysing, interpreting, acting on, and communicating multiple types of data from state, local, classroom, and other sources to improve outcomes for students (Gummer & Mandinach, 2015; Mandinach & Gummer, 2016b). It combines an understanding of data with learning standards, disciplinary knowledge and practices, curricular knowledge, pedagogical content knowledge, and an understanding of how children learn.

Conceptual Framework

The conceptual framework of data use to inform instruction (Figure 1) is based on ideas developed by Wayman et al. (2016) and Van der Scheer and Visscher (2018). In a broader sense, the use of data to inform instruction is part of data-driven decision making in education. The continuum from raw data to information and subsequently usable knowledge provides the foundation for the theoretical framework of this study. The transformation is grounded within the classroom, the school, and the district, and international context, all of which will use different data in different ways to make decisions. Technology-based tools are used to support and facilitate decision making.

Figure 1
Conceptual Framework of the Study



The set of actions taken by the mathematics teachers with regards to the data include the uses that teachers choose for specific forms of data and the processes involved in using that data. Actions are manifested through how

often teachers use various forms of data from the international, school and district, and classroom-based levels, and the actual actions the teachers do with the data they have access to. For instance, data from pupils' homework reveal how the pupils performed according to the six performance levels specified in Standard-based Curriculum and Assessment Documents for Mathematics, from basic understanding to creative and innovative problem solving (Ministry of Education Malaysia, 2018). This could help inform the teacher on how to assign pupils for group work, seating arrangement, and differentiated instruction, just to mention a few.

Teachers need support from their school, district and/or state education offices and personnel to get the most out of the data (Hamilton et al., 2009). Examples of support include efficient technology to access and examine data, approval and support from the leadership, professional development regarding data use, and school staff or expert who can help teachers use data. It is also essential that teachers are not only able to use data, but at the same time, they perceive themselves as being capable of using data (Gummer & Mandinach, 2015). This information can be gleaned from how confident the teachers believe they are at using data to inform various aspects of their practice.

Against a vast array of data at the international, school/district, and classroom levels, this study attempts to explore from the perspectives of four major components to gain an insight to data use among mathematics teachers. The components are accessibility and frequency of data use, the levels of data use, training and support required, as well as confidence in data use.

Methodology

A questionnaire with both Likert scales and yes/no responses adapted from The Teacher Data Use Survey (Wayman et al., 2016) was used to collect information on the availability of data to teachers, frequency of data use, data literacy levels, support and training needs in data use, and confidence with regards to data use. Eighty-eight primary school mathematics teachers from various states in Malaysia responded to the questionnaire which was constructed and distributed via Google Forms.

Semi-structured interviews were also conducted with five of the teachers to gain further understanding on how they actually used data to inform their instruction in the mathematics classroom. Purposeful sampling method was employed to identify these information-rich cases from the survey for more in-depth follow-up. The teachers selected were among those who indicated they used data at least three to four times per month based on the data from the questionnaire (see Table 2). One teacher was chosen as she has indicated she used international data, school-based data and classroom-based data at least three to four times per month. The other four teachers were chosen as they responded that they had used both the school-based and classroom-based data at least three to four times per month. The five teachers

demonstrated their willingness to be interviewed and were able to communicate their experiences and opinions regarding data use to inform mathematics instruction in an articulate, expressive, and reflective manner. The interviews were conducted through video calls as the teachers were distributed across Malaysia.

Results and Discussion

As mentioned earlier, all the teachers involved in this research were primary school mathematics teachers from the various states in Malaysia. The demographic data of these teachers in terms of number of years of service or teaching experience, as well as experience in teaching mathematics are shown in Figure 2 and Figure 3 respectively.

Figure 2
Number of Years of Teaching Experience

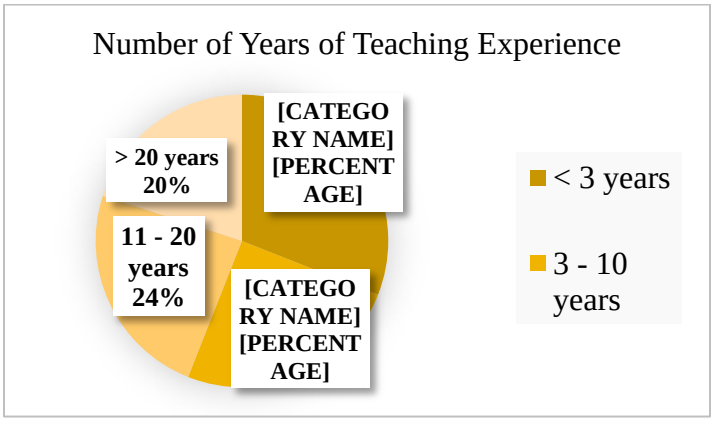
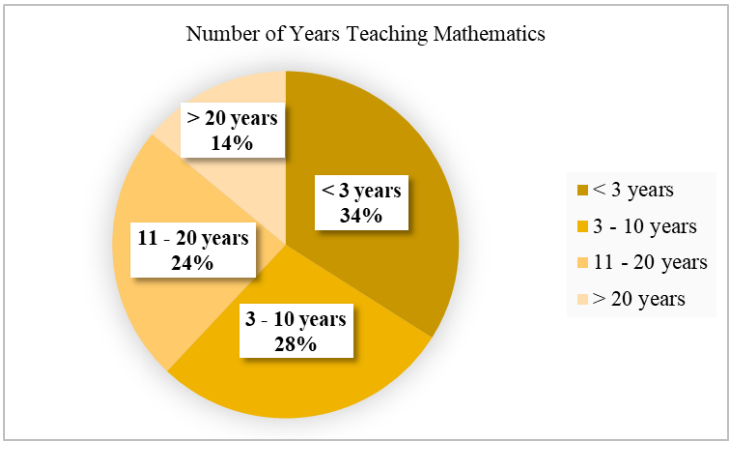


Figure 3
Number of Years Teaching Mathematics



The categories of years chosen were to reflect those of beginning teachers (< 3 years) at the one end, and those of senior teachers (> 20 years) at the other end of the continuum. Nevertheless, no further analysis was conducted in this study on the possibility of relationship between the number of years of service and the pattern of data use.

On the availability or accessibility of international, school-based, or classroom-based data, 41%, 75% and 91% of the mathematics teachers respectively responded in the affirmative (see Table 1). A total of 93% of the teachers reported that they either do not use at all or use the international data less than once a month when making mathematics instructional decision (see Table 2). On the other hand, an overall of 32% and 60% of the teachers respectively used the school-based data and the classroom-based data from at least once a month to a few times per week to inform mathematics instruction.

Table 1
Availability or Accessibility of Types of Data to Teachers

	Yes (%)	No (%)
International Data	41	59
School-based Data	75	15
Classroom-based Data	91	9

Table 2
Frequency of Data Use

	Do not use (%)	< once a month (%)	1 – 2 times a month (%)	3 – 4 times a month (%)	A few times a week (%)
International Data	66	27	6	1	0
School-based Data	24	44	20	9	3
Classroom-based Data	6	34	34	12	14

Table 3
Perception of Usefulness of Data to Practice

	Not useful (%)	Somewhat useful (%)	Useful (%)	Very useful (%)
International Data	42	38	17	3
School-based Data	15	34	43	8
Classroom-based Data	4	23	53	20

In tandem to the frequency of use, the perception of usefulness of data to the practice of mathematics teachers also saw the classroom-based data to be the most useful and the international data being the least useful (see Table

3). 96% of the teachers perceived the classroom-based data such as data from classroom-based assessment, homework performance quizzes or examination results to be at least somewhat useful to their practice as a teacher; 85% for the school-based data and only 58% for international data.

Difficulty or lack of knowledge in accessing the international data may have contributed to its low frequency of use to inform mathematics instruction and hence the perception of it being the least useful among the three types of data. From the interviews, four out of five of the teachers interviewed responded that since TIMSS and PISA did not involve primary school pupils (Grade 4/Year 4) in Malaysia, they did not think that it was necessary to refer to these sources of data to inform their instruction although they were aware that Malaysian secondary school students (Grade 8/Form 2) did not fare well in both international surveys. They were unaware that they could source for TIMSS and PISA results reports and sample released items online.

Conversely, the lone teacher who did use the TIMSS and PISA data do so because she believed that primary mathematics is the building block of secondary mathematics. She was aware that TIMSS and PISA data are available online as she had searched for the data while doing research for her postgraduate studies. She used more non-routine problem-solving questions in her mathematics classrooms in order to enhance mathematical thinking and higher order thinking skills among the pupils. "I keep reminding myself that I should give more higher order thinking skills questions. I want to make the pupils think. I try to set questions based on the TIMSS style of mathematics questions, that require the pupils to think, that connect a few skills from different topics, for example, time, money, fractions, ..." (F1, interview: 19/7/2019).

The classroom assessment has been implemented in Malaysian schools since 2016. Beginning 2019, there are no more examinations for Year 1 (Grade 1) to Year 3 (Grade 3) in the primary schools. Assessment is based solely on classroom performance such as homework performance, quizzes, presentations and through the teachers' observations. This may be one of the contributing reasons why the classroom-based data is the most frequently assessed and used.

For classroom assessment, each mathematics topic has a list of performance levels (PL) as contained in Standard-Based Curriculum and Assessment Documents. These documents are official curriculum and assessment documents issued by the Ministry of Education Malaysia for different year levels and are used by all the schools in Malaysia. The teachers will assess the pupils by using their own respective assessment tools constructed based on the performance levels prescribed. The performance levels are hierarchically arranged with level one (PL1) as the lowest performance level and level six (PL6) as the highest.

All the five teachers interviewed responded that classroom-based data were important for them to make instructional decisions. The teachers

interviewed responded that their pupils typically scored at levels three (PL3) and four (PL4) with some at level two (PL2) or level five (PL5) based on the standard-based performance levels. Not many pupils could perform at the highest performance level at PL6. The teachers typically planned their instruction with the average-performing pupils in mind. "I normally look at the performance level (PL) of majority of the pupils in the class to decide what type of activities I would use in my classroom, or how many learning standards I should include in the next lesson, or how I should divide the pupils into groups." (M2, interview: 23/8/2019).

By studying the data, the teachers dedicated more attention to those pupils who fared poorly. Actions taken included differentiated instruction. As one of the teachers put it, "I usually divide the pupils into two groups based on the classroom assessment data. One group which can perform normally, the other group which needs more attention from me. I normally give easier exercises to the weaker group to begin with. If they are able to catch up, I will then give them more challenging exercises." (F2, interview: 2/8/2019)

Based on Mandinach and Gummer's (2016b) definition of data literacy, the data literacy levels in this study are broadly classified as:

Level 1: collect and identify data;
Level 2: collect, analyze and interpret data;
Level 3: collect, analyze, interpret, and act based on data;
Level 4: collect, analyze, interpret, act and communicate based on data.

The items for this part of the questionnaire did not categorize the data into international, school-based or classroom-based data. Instead, the word 'data' was used in the general sense. Table 4 shows the items used for the different levels. The results in Table 5 indicate that at each of the data literacy level, the highest percentage falls into the two lower frequency of use categories. A mean of 36% of the respondents used the data to inform instruction once or twice a year at various data literacy levels; and a mean of 37% used the data a few times a year at the various levels.

Table 4
Items for Data Literacy Levels

In a typical school year, how often do you do the following?	Level
Collect and identify data useful to instruction	1
Analyze and interpret data useful to instruction	2
Use data to identify instructional content to use in class	3
Use data to tailor instruction to individual pupils' needs	3
Use data to form small groups of pupils for targeted instruction	3
Discuss data with a parent or guardian	4
Discuss data with a pupil	4
Meet with another teacher about the data	4

Table 5
Data Literacy Levels and Frequencies of Use
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	1 to 2 times a year (%)	A few times a year (%)	Monthly (%)	Weekly (%)
Level 1	35	41	20	4
Level 2	35	41	17	7
Level 3	37	32	21	10
Level 4	38	35	9	18

Nevertheless, at the other end of the frequency scale, that is, for those teachers who use the data weekly, the highest percentage (18%) occurred at Level 4 (versus 4% for those at Level 1). This shows that for these respondents who made use of data on a weekly basis, they collected, analyzed, interpreted, acted and subsequently communicated the results based on the data. Another indication of this result is that if a teacher used data to inform instruction on a weekly basis, he would less likely stop at just collecting and identifying the data alone (Level 1).

The teachers interviewed explained that they planned their instruction in their mathematics classroom based on the assessment data collected or through observations of pupil performance in the class. In Malaysia, teachers communicate the assessment data to the parents once a year during a face-to-face meeting and at other times through the assessment reports. The use of data to inform instruction is normally done by the individual teachers and occasionally through the mathematics panel of a particular school. The panel of mathematics may organize enhancement or remedial classes based on the assessment data, particularly for those classes involved in national assessment such as the Year 6 pupils. However, the national assessment has since been abolished beginning year 2021. The teachers have since put more emphasis on classroom-based data.

On training needs and support in data use (see Table 6), 70% of the mathematics teachers reported that they were adequately supported in data use and were prepared to use data; 75% acknowledged that there was someone in the school who could answer their questions about using data; 64% revealed that there was someone who helped them change their practice, for example their teaching, based on data; 66% felt that the state/district/school provided enough professional development about data use; and 67% were of the opinion that the state's/district's/school's professional development was useful for learning about data use. Despite the positive views, a mean of 31% of the mathematics teachers felt that they needed more support and training for data use to improve classroom instruction.

Table 6

Perception on Training Needs and Support for Data Use

	Yes (%)	No (%)
I am adequately supported in data use.	70	19
I am adequately prepared to use data.	70	19
There is someone who answers my questions about using data.	75	25
There is someone who helps me change my practice (e.g. my teaching) based on data.	64	36
My state/district/school provides enough professional development about data use.	66	34
My state's/district's/school's professional development is useful for learning about data use.	67	33
The school's data teacher provides support and guidance with regards to data use.	70	30

With regards to confidence in data use (see Table 7), 86% of the mathematics teachers reported that they were good at collecting data to diagnose student learning needs; 84% were good at analyzing and interpreting data to diagnose student learning needs; 83% were good at adjusting instruction based on data; 78% were good at using data to plan lessons; 81% were good at using data to set student learning goals; and 78% were good at using appropriate technology to access, transform and interpret data for instructional purpose. To summarize, a mean of 82% of them indicated confidence in using data.

Table 7
Confidence in Data Use

	Yes (%)	No (%)
I am good at collecting data to diagnose student learning needs.	86	14
I am good at analyzing and interpreting data to diagnose student learning needs.	84	16
I am good at adjusting instruction based on data.	83	17
I am good at using data to plan lessons.	78	22
I am good at using data to set student learning goals.	81	19
I am good at using appropriate technology to access, transform and interpret data for instructional purpose.	78	22

Despite showing rather high confidence in using data, the mathematics teachers interviewed felt that they still require support and training for data use. One example given was the use of appropriate software to help in data analyses. As for data interpretations, they were confident with statistics such

as central tendency and dispersion but typically considered only the mean when making interpretations.

The mathematics teachers interviewed were also of the opinion that there should be professional development courses on how to transform data based on the classroom context and about the pupils to make meaningful and informed decisions on instructional steps and instructional adjustments in their classroom. The professional development courses could cover content, among others, on ways to evaluate and analyze the data obtained from international, school/district and classroom-based levels; to determine the instructional needs of individual pupils and groups of pupils; to define specific, measurable, and challenging learning and performance goals; and to decide which instructional approach is most promising for accomplishing the goals, all within the realms of the available data.

Educational Implications

Instead of sporadic and individual data use, the mathematics teachers need to, in my point of view, enculture themselves to the use of data and employ more concerted effort such as collaborative inquiry based on an appropriate data driven decision making model to improve instruction and learning. Effective and consistent data use requires professional development and teamwork. Ongoing capacity building should focus on design, administration, and interpretation of qualitative and quantitative data assessments to impact instruction. The teachers should share practice with colleagues, rely on data to test hypotheses, generate and test out solutions to student-learning problems, and use data as a catalyst to reflect their own practice.

Training on computer data system related to data use needs to be timed appropriately and in context (Jimerson & Wayman, 2015). Some trainings are not effective as they are ill-timed, occurring a few months before the skills are to be used or when the teachers are overwhelmed by other responsibilities. Training also needs to be contextual or coherent, such that the teachers are able to use the computer data system in ways related to their practice and not merely learning computer data functions.

In order to use data to inform instruction, the teachers need to understand what data meant in relation to their day-to-day practice so that they can make practical changes or modifications. In fact, the teachers interviewed voiced their concern about decisions they made based on data as they might not have understood the data well enough. Hence, training and support need to prepare the teachers to be able to identify data useful for instruction and to have a deep pedagogical data literacy, so as to enable them to transform raw data into actionable and usable knowledge.

Data use has gained increasing importance in education. As such, it only seems fit to prepare the mathematics teachers from as early in their

career as possible on data-driven decision making so that they have a strong awareness on how to use data to inform their classroom practice. In other words, data literacy should be integrated into the mathematics teacher preparation programs to give the pre-service teachers knowledge and skills on how to use data to improve instruction.

Conclusion

This study shows that more information needs to be gathered to gain a more detailed insight into data use by teachers to inform mathematics instruction. Areas of further research should include the specific types of support and training needs required by the teachers to make informed decisions on mathematics instructional practices. Other areas such as actual teacher data use practices, how teachers' instruction is informed by the use of data, how teachers use data individually or work in groups to analyze and act on data, roles of leadership and leadership strategies for successful implementation of data use in schools could all be potential directions for future research.

This study has provided some results and information with regards to data use by primary school Mathematics teachers to inform instruction in their classroom. To be specific, it identifies the state of international, school-based and classroom-based data use, the teachers' data literacy, and their perception towards training needs and support in data use. The design of future initiatives aimed at improving instructional data use in the mathematics classroom should take these results and information into consideration to ensure more effective data-driven instruction.

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