

Instructional Clarity, Classroom Disorder, and Student Achievement in Mathematics: An Exploratory Analysis of TIMSS 2019

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It is generally understood that both clear teacher instruction and orderly classroom climates support student achievement in mathematics. However, to what extent does instructional clarity “compensate” for classroom disorder? In this exploratory study, we analyse data from 8,864 Year 8 students sampled by TIMSS 2019 to investigate the relationship between instructional clarity, classroom disorder, and mathematics achievement. The findings demonstrate the deleterious effects of classroom disorder for mathematics achievement, even in the presence of high instructional clarity. The findings contribute to an emerging international body of work and reinforce the importance of teachers having an optimal combination of classroom skills to support student learning.

A key competency for any teacher is to be able to clearly communicate with students to facilitate learning in the classroom. Instructional clarity can be defined as a teachers’ capacity to deliver classroom instruction clearly and concisely (Maulana et al., 2016). In mathematics, instructional clarity is of key importance, as many students develop negative attitudes to the subject as they progress through school (Brown et al., 2008) and attitudes of this type are associated with lower mathematics achievement (Namkung et al., 2019). Instructional clarity has been found to enhance student self-efficacy and interest (Maulana et al., 2016) and is associated with higher achievement in mathematics (Thomson et al., 2021)

Disorder in secondary classrooms is a significant concern for teachers and students (Duesund & Ødegård, 2018), with significant negative impacts on student achievement, school belonging, and motivation (Hurd et al., 2018), as well as teacher stress and job satisfaction (Nash et al., 2016). Disorderly behaviour detracts from student learning and contributes to poor classroom climates in which social and emotional needs are unmet (Duesund & Ødegård, 2018). There are significant gender differences in teachers’ perceptions of student misbehaviour, with male students viewed as being more likely to be disruptive and more difficult to control in the classroom (Glock & Keen, 2017).

Previous research has demonstrated that one precursor to disorderly classroom behaviour is poor instructional clarity. That is, if students do not understand the content and skills being taught, they may disengage and misbehave (Cothran et al., 2009). On the other hand, there are many other causes for student misbehaviour (Nash et al., 2016), and if this misbehaviour escalates to distract other students in the classroom, it is likely to detract from the impact of instructional clarity. Previous studies using Trends in International Mathematics and Science Study (TIMSS) 2019 data have found an association between instructional clarity, classroom management, and positive attitudes to mathematics in the US (Chen, 2022) and in the UK, but not in Hong Kong (Chen & Lu, 2022), revealing important contextual differences between countries.

In reporting Australian results for TIMSS 2019, Thomson and colleagues (2021) found that 40% of Year 8 students reported high clarity of mathematics instruction (compared to the 46% international average) and observed that these students had significantly higher mathematics scores

(2023). In B. Reid-O’Connor, E. Prieto-Rodriguez, K. Holmes, & A. Hughes (Eds.), *Weaving mathematics education research from all perspectives. Proceedings of the 45th annual conference of the Mathematics Education Research Group of Australasia* (pp. 107–114). Newcastle: MERGA.

than those who reported low clarity instruction. For classroom climate, some 65% of Australian Year 8 students reported disorderly behaviour occurred in *some* lessons and 24% in *most* lessons (Thomson et al., 2021). Higher mathematics achievement was found to be strongly associated with lower levels of disorderly behaviour. However, a significant gap in the literature is the extent to which instructional clarity compensates for the impact of classroom disorder on academic achievement in mathematics in Australian classrooms. In this study, we explore the relationship between students' perceptions of instructional clarity, disorderly behaviour in mathematics classes, and mathematics achievement using Australian data from TIMSS 2019.

Method

Dataset and Sample

Data are from TIMSS 2019 administered by the International Association for the Evaluation of Educational Achievement (IEA). In Australia, a representative sample of 9,060 Year 8 students from 284 secondary schools participated in standardised mathematics achievement tests and completed context questionnaires about their mathematics classrooms (Thomson et al., 2020). The sample used in this paper is 8,864 due to missing data on key variables.

Variables

Instructional clarity during mathematics lessons. Students' perceptions of instructional clarity in their mathematics lessons were measured using a seven-item scale. The question was *how much do you agree with these statements about your mathematics lessons* and sample items included *my teacher is easy to understand* and *my teacher does a variety of things to help us learn*. Students responded to each item using a four-point scale from *disagree a lot* to *agree a lot*. Scale cut scores were calculated by the IEA to indicate Low Clarity (disagree a lot or a little), Medium Clarity (agree a little), and High Clarity (agree a lot). The scale had excellent reliability for the Australian sample ($\alpha = .92$).

Disorderly behaviour during mathematics lessons. Students' perceptions of classroom disorder in their mathematics lessons were measured using a six-item scale. Sample items included: *My teacher has to wait a long time for students to quiet down* and *it is too disorderly for students to work well*. Students responded to each item using a four-point scale from *never* to *every or almost every lesson*. Scale cut scores were calculated by the IEA to indicate Low Disorder (disruption during few or no lessons), Medium Disorder (disruption in some lessons), and High Disorder (disruption in most lessons). This scale was highly reliable for the Australian sample ($\alpha = .92$).

Classroom climate. To explore the relationship between instructional clarity and disorderly behaviour, the two TIMSS variables described above were combined to create the following nine groups characterising the classroom climate from the students' perspective: 1) Low Clarity/Low Disorder (LC/LD), 2) Low Clarity/Medium Disorder (LC/MD), 3) Low Clarity/High Disorder (LC/HD), 4) Medium Clarity/Low Disorder (MC/LD), 5) Medium Clarity/Medium Disorder (MC/MD), 6) Medium Clarity/High Disorder (MC/HD), 7) High Clarity/Low Disorder (HC/LD), 8) High Clarity/Medium Disorder (HC/MD), and 9) High Clarity/High Disorder (HC/DC).

Mathematics achievement. TIMSS assessed student achievement across content and cognitive domains and item response theory was used to generate a single achievement score where higher scores indicated better achievement in the subject (Fishbein et al., 2021). Due to TIMSS's complex sampling method, each participant's mathematics achievement score was recorded as a series of five plausible values. These require special handling during analyses to prevent biased estimates of mathematics achievement (Berger et al., 2020).

Analysis

Analyses were conducted using IBM SPSS Statistics 27. Syntax for analyses involving plausible values were created using the IEA IDB Analyser software, allowing accurate estimates of achievement scores and standard errors and statistical weighting so the sampled students represent the total population of Australian Year 8 students (Berger et al., 2020). The association between mathematics achievement, classroom climate, and gender was primarily investigated using linear regression (Fishbein et al., 2021). Dummy coding was used to enter categorical variables into linear regressions as independent variables.

Results

Table 1 shows descriptive statistics for the classroom climate groups. The largest groups were Medium Clarity/Medium Disorder (28%) and High Clarity/Medium Disorder (28%) while the smallest group was Low Clarity/Low Disorder (1%). Mathematics achievement was highest in the High Clarity/Low Disorder group (581.33) and lowest in the Low Clarity/Medium Disorder group (485.87). While overall there were equal numbers of girls and boys in the sample, the proportions differed in each of the classroom climate groups. To highlight the highest deviations from the sample split, there were more girls than boys in the Low Clarity/Medium Disorder group, while there were more boys than girls in the High Clarity/Medium Disorder and High Clarity/High Disorder groups.

Table 1

Descriptive Statistics for Classroom Climate Groups

Group	Entire sample		Girls		Boys	
	n (%) [*]	M (SD)	n (%) [†]	M (SD)	n (%) [†]	M (SD)
LC/LD	98 (1%)	490.03 (100.45)	52 (53%)	488.08 (92.15)	46 (47%)	491.69 (106.96)
LC/MD	852 (9%)	485.87 (79.36)	463 (54%)	491.27 (80.20)	389 (46%)	479.73 (77.91)
LC/HD	488 (5%)	489.67 (77.69)	258 (53%)	494.09 (67.59)	230 (47%)	484.61 (87.45)
MC/LD	314 (4%)	555.05 (88.37)	165 (53%)	548.30 (81.46)	149 (47%)	561.95 (94.31)
MC/MD	2508 (28%)	514.88 (86.71)	1278 (51%)	517.05 (82.97)	1230 (49%)	512.67 (90.30)
MC/HD	807 (9%)	488.67 (86.42)	418 (52%)	484.77 (81.70)	389 (48%)	492.79 (90.39)
HC/LD	726 (8%)	581.33 (85.83)	368 (51%)	574.69 (80.33)	358 (49%)	587.64 (90.26)
HC/MD	2529 (28%)	538.53 (86.85)	1195 (43%)	529.65 (80.29)	1334 (57%)	546.61 (91.66)
HC/HD	542 (6%)	504.14 (80.43)	231 (43%)	502.63 (71.55)	311 (57%)	505.32 (86.74)
	8864 (100%)	518.40 (89.19)	4428 (50%)	515.83 (83.40)	4436 (50%)	520.94 (94.50)

^{*}Percentages as proportion of entire sample.

[†]Percentages as proportion within group. Percentages may not add to 100% due to rounding.

Classroom Climate and Mathematics Achievement

The first analysis explored whether there was an association between mathematics achievement and classroom climate. Figure 1 shows mathematics achievement in each of the classroom climate groups.

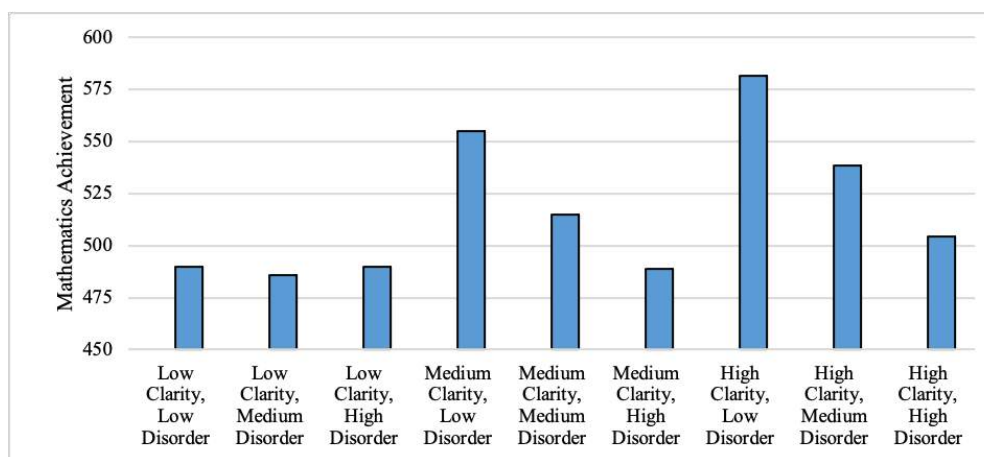


Figure 1. Mathematics achievement in classroom climate groups.

Table 2 shows the results of the linear regression analysis with mathematics achievement as the dependent variable and classroom climate group as the dummy-coded categorical independent variable. Low Clarity/Low Disorder was the reference category and was held constant in the regression. Mathematics achievement in the Medium Clarity/Low Disorder, High Clarity/Low Disorder, and High Clarity/Medium Disorder groups was statistically significantly higher than in the reference category. As such, mathematics achievement in medium clarity instructional environments was no different to low clarity instructional environments when classroom disorder also was medium or high. Furthermore, while high clarity instructional environments appeared to compensate for low and medium levels of classroom disorder, high levels of classroom disorder nullified the effect of high clarity. The mathematics achievement of students in High Clarity/High Disorder classrooms was not statistically different to that of their peers in Low Clarity/Low Disorder classrooms.

Table 2

Regression Coefficients for Mathematics Achievement in Clarity/Disorder Groups

Group	B	SE	t
(Constant)	490.03	16.81	29.15
LC/MD	-4.15	16.77	-0.25
LC/HD	-0.36	18.7	-0.02
MC/LD	65.03*	15.82	4.11
MC/MD	24.86	16.02	1.55
MC/HD	-1.35	17.11	-0.08
HC/LD	91.31*	16.12	5.66
HC/MD	48.50*	16.30	2.98
HC/HD	14.11	16.90	0.83

Note. Reference group (constant) is LC/LD.

*Statistically significant difference from the reference group at $p < 0.05$.

Gender Differences

The second analysis explored whether there were gender differences in the association between classroom climate and mathematics achievement. Figure 2 shows mathematics achievement in each of the classroom climate groups split by gender.

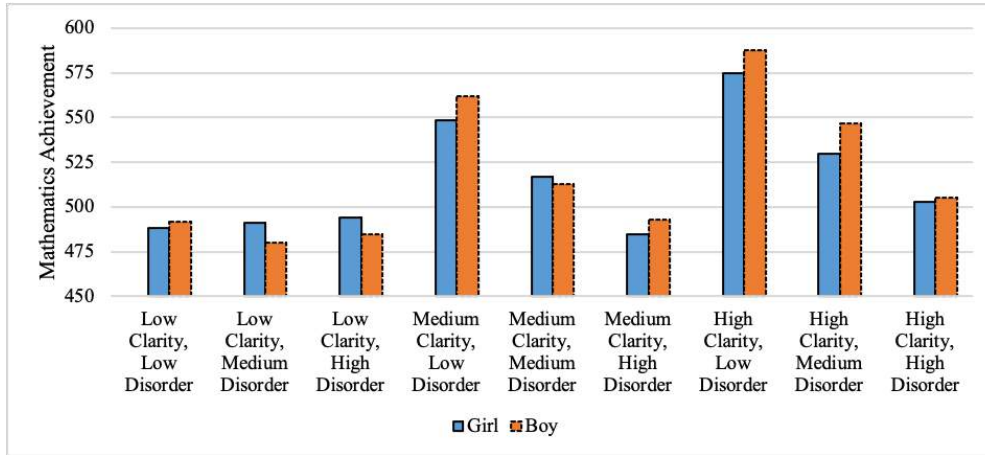


Figure 2. Mathematics achievement by gender in classroom climate groups.

Table 3 shows the results of linear regression analyses with mathematics achievement as the dependent variable and gender as the dummy-coded categorical independent variable, with separate regressions for each classroom climate group. Girls were the reference category which was held constant in each regression. The only statistically significant difference between genders was in High Clarity/Medium Disorder classrooms where boys scored higher on mathematics achievement than girls. As such, the observed association between classroom climate and mathematics achievement largely does not differ between boys and girls.

Table 3

Regression Coefficients for Maths Achievement by Gender in Classroom Climate Groups

Group	Gender	B	SE	t
LC/LD	(Constant)	488.08	18.92	25.80
	Boys	3.61	31.42	0.11
LC/MD	(Constant)	491.27	6.55	75.01
	Boys	-11.54	7.63	-1.51
LC/HD	(Constant)	494.09	7.17	68.96
	Boys	-9.48	11.83	-0.80
MC/LD	(Constant)	548.30	12.62	43.45
	Boys	13.65	18.76	0.73
MC/MD	(Constant)	517.05	4.15	124.55
	Boys	-4.39	5.68	-0.77
MC/HD	(Constant)	484.77	6.31	76.87
	Boys	8.03	9.07	0.89
HC/LD	(Constant)	574.69	6.95	82.71
	Boys	12.95	13.43	0.96

Group	Gender	B	SE	t
HC/MD	(Constant)	529.65	4.84	109.54
	Boys	16.96*	7.50	2.26
HC/HD	(Constant)	502.63	6.26	80.24
	Boys	2.69	9.55	0.28

Note. Reference category (constant) is Girls.

*Statistically significant difference from the reference group at $p < 0.05$.

Discussion

Australian mathematics classrooms are characterised by sustained disorderly behaviour at levels above international averages (Thomson et al., 2021). Previous research into instructional clarity and classroom disorder has demonstrated the impact of these phenomena on mathematics achievement (Namkung et al., 2019; Thomson et al., 2021). While poor instructional clarity can lead to greater classroom disorder (Cothran et al., 2009), the two concepts are not indivisible. Indeed, our analysis showed the extent to which students separately may perceive the phenomena operating in their mathematics classrooms. Some students perceived high instructional clarity in otherwise highly disordered classrooms. In this context, relatively little is known about the extent to which instructional clarity could ‘compensate’ for the sustained levels of disorderly behaviour seen in Australian mathematics classrooms. Recent international research has found associations between instructional clarity, classroom disorder, and achievement differ by country (Chen, 2022; Chen & Lu, 2022). So how might these factors play out in Australian classrooms?

The findings from our exploratory analysis of a representative sample of Australian adolescents reveal important links between instructional clarity, classroom disorder, and student achievement in mathematics. These findings reinforce concerns about the impact of classroom disorder on achievement (Duesund & Ødegård, 2018; Hurd et al., 2018). Specifically, we found that while higher student perceptions of instructional clarity were generally associated with higher achievement, that achievement was significantly lower in the presence of medium or high levels of disorder. If instructional clarity was low, however, the level of classroom disorder did not appear to be related to mathematics achievement levels. Orderly classrooms, therefore, appeared to be an enabling condition for teacher instruction to have the desired effect on student achievement in mathematics.

To highlight a particular finding from our analysis, the mathematics achievement of students in high clarity/high disorder classrooms was *not statistically different* to that in low clarity/low disorder classrooms. As such, instructional clarity was not able to compensate for disorderly behaviour. A practical implication is that an effective teacher must be able to manage their classroom *as well as* provide clear mathematical instruction to students. It is important to note that student misbehaviour is a complex issue with many potential antecedents. Teachers are not solely responsible for managing student disorder in classrooms and must be supported through school and system policies to achieve optimal learning environments.

In terms of gender, we found no differences in the achievement levels of Year 8 boys and girls across the nine categories, except in the case of the high instructional clarity/medium disorder category where boys achieved significantly higher than girls. These results largely accord with those of Thomson et al. (2021) who found no gender differences in mathematics achievement between boys and girls in aggregate. However, the finding begs the question of why boys achieved better than girls in conditions of medium disorder? Research suggests that boys are more likely to be disruptive in the classroom (Glock & Keen, 2017), so in such circumstances are boys more likely

than girls to benefit from greater instructional clarity? Further research is required to fully understand this anomalous finding.

Limitations and Future Research

The exploratory analysis presented in this paper used established TIMSS categories (low, medium, and high) to examine the relationships between student perceptions of instructional clarity, classroom disorder, and their mathematics achievement. Future research could draw on person-centred analyses to develop student profiles based on statistical modelling of students with similar characteristics. In this way, a more nuanced understanding of how student perceptions of instructional clarity and classroom disorder are clustered may be revealed, allowing for a more sophisticated analysis of how these variables are related to student achievement. It should also be noted that we examined students' perceptions of classroom disorder. Future research is needed to determine whether teachers' perceptions of classroom disorder align with the views of their students and are similarly related to student achievement.

Conclusion

There is substantial evidence that instructional clarity and classroom disorder affect student achievement in a variety of subjects, including mathematics (Maulana et al., 2016; Thomson et al., 2021). However, less is known about the combinatorial effects of clarity and disorder, with extant studies having context-dependent outcomes (Chen, 2022; Chen & Lu, 2022). Our exploratory analysis of Australian TIMSS 2019 data provides further evidence of this. In the Australian context, higher mathematics achievement was associated with high instructional clarity but only when levels of classroom disorder were low. The findings point to the critical importance of Australian mathematics teachers developing clear instructional skills *and* being adequately supported to effectively respond to student misbehaviour.

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