COMPOUND EFFECTS OF MATHEMATICS DISCUSSION ON FIFTH GRADE MATH ACHIEVEMENT

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Mathematics discussion has been suggested to improve mathematics achievement. The current study investigated the compound effects of students discussing mathematics with one another in both the third and fifth grades using hierarchical linear modeling. Results indicated that having discussion in fifth grade but not in third grade had a positive impact on mathematics achievement. The impact of discussion in both third and fifth grade was not found to be statistically significant from the impact of having no discussion in either grade. However, significant variability found in one variable may explain why a compound effect of discussion was not found.

Background and Objectives

According to Silver, Kilpatrick, and Schlesinger (1990), “mathematics deepens and develops through communication” (p. 15). Students gain a deeper understanding of the meaning of mathematics when they communicate with others about it (Goos, 1995; Lee, 2006; Pimm, 1987). Additionally, discussion has been shown to have a positive impact on mathematical achievement (D’Ambrosio, Johnson, & Hobbs, 1995; Grouws, 2004; Hiebert & Wearne, 1993; Koichu, Berman, and Moore, 2007; Mercer & Sams, 2006). Yet, there is evidence that discussion does not always have a positive impact on mathematics achievement (Kosko & Miyazaki, 2009; Shouse, 2001), which may imply that either discussion is not consistently effective in deepening mathematical understanding or that it is not consistently implemented to maximize its effectiveness.

A previous study conducted by the authors (Kosko & Miyazaki, 2009) investigated the impact of discussion on mathematics achievement using data from the Early Childhood Longitudinal Study (ECLS). Results showed that when accounting for prior achievement the difference between the two discussion groups in the study (weekly and less than weekly) was found not to be statistically significant. However, there was a statistically significant amount of variability in the impact of weekly discussion across schools. This variability was unable to be explained by the authors, even after the addition of covariates.

The previous study conducted by the authors was done with reference only to the impact of discussion in the fifth grade (Kosko & Miyazaki, 2009). The current study seeks to investigate the accumulated impact of discussion on fifth grade mathematics achievement. The large amount of unexplained variability in the previous study led the authors to question if mathematics discussion may take longer than one school year to positively impact math achievement. Yet to determine if this is actually the case, a new study had to be conducted. To date, the authors have yet to find a longitudinal study to investigate the compound effects of discussion on mathematics achievement. Therefore, the purpose and research question for the current study is as follows: Does the frequency of peer mathematics discussion in third and fifth grade have a compound impact on the mathematics achievement scores of fifth grade students.
Theoretical Perspectives

Student discussion of mathematics has been stated as a means to deepen understandings of the mathematics discussed (Goos, 1995; Lee, 2006; Pimm, 1987; Silver et al., 1990). Students who understand mathematics more deeply should predictably perform better on mathematics achievement tests. According to several studies (i.e. Hiebert & Wearne 1993; Mercer & Sams, 2006; Stigler & Hiebert, 1997) students who were asked to explain and justify their mathematics in discussion had higher gains in mathematics achievement than students who were not asked to do so. Yet in some cases, student discussion of mathematics has been found to have a negative impact on achievement (cf. Shouse, 2001). As mentioned above, a previous study by the authors (Kosko & Miyazaki, 2009) found that the impact of student discussion on mathematics achievement varies significantly between schools. This means that in some schools the impact of achievement can be largely positive while in other schools it is largely negative. While some qualitative research (i.e. McGraw, 2002; Nelson 1997) suggests that it takes time for effective mathematics discussion to be successfully implemented, there is little to no quantitative data to support the impact of time or exposure on the effectiveness of discussion.

Research Question

Does the frequency of peer mathematics discussion in third and fifth grade have a compound impact on the mathematics achievement scores of fifth grade students?

Methodology

The current study analyzed data from the Early Childhood Longitudinal Study (ECLS) using a two-level hierarchical linear model (HLM). Hierarchical linear models are typically used when evaluating data nested in many groups (Raudenbush & Bryk, 2002). Since much of what is studied in education exists in hierarchical structures (i.e. students within classes, teachers within schools), HLM is particularly useful in studying differences within and between nested units. A two level hierarchical linear model looks at both the micro units at level-1 and the macro units at level-2. The micro units at level-1 (i.e. students) are nested within the macro units at level-2 (i.e. classrooms or schools). HLM-2 allows factors examined at the first level to be compared at the second level unit of analysis which they are nested in (see Raudenbush & Bryk, 2002 for further information). The purpose of using an HLM-2 model in the current analysis was to take into account the nested nature of the data (students nested within schools).

Third and fifth grade data from 3583 students in 1006 schools was used in the current analysis. The main variables included in the analysis were achievement scores and a teacher assessed item which asked how often the students involved in the study engaged in discussion about mathematics with other students. Teachers were required to complete this item for each student they taught who was a part of the ECLS study and was therefore used as an individual level variable rather than a classroom level variable. The variable addressing how frequently students discussed math with their peers was assessed in both third and fifth grade. For the purposes of simplifying the model for analysis, the variable was dichotomized at both levels to students who did have weekly discussions about mathematics and students who had discussions about mathematics less than weekly.

To investigate the compound effects of discussion on fifth grade achievement scores, four categories of students were compared in the analysis: students who did not have mathematical discussions with other students on a weekly basis in third grade or in fifth grade (control); students who did not have weekly math discussion in third grade but did in fifth grade; students who did not have weekly math discussion in third grade but did in fifth grade; students who did have weekly math discussion in both third and fifth grade.
(\textit{disc}_{0\_1}); students who had weekly math discussion in third grade but not in fifth grade (\textit{disc}_{1\_0}); and students who had weekly math discussion in both third and fifth grade (\textit{disc}_{1\_1}). These categories were included as dummy-coded variables in addition to other variables which served as covariates. These covariates included third-grade math achievement scores, race/ethnicity, gender, and socio-economic status.

**Results**

Results showed that students in the \textit{disc}_{0\_1} group had statistically significant higher scores than students who did not have discussion in either third or fifth grade. Students in both the \textit{disc}_{1\_0} and \textit{disc}_{1\_1} groups did not score significantly higher than students without discussion (\textit{control}). At first glance this seems to indicate that there is no compound effect of discussion. However, the variable \textit{disc}_{1\_0} was found to have significant variability across schools, more than four times the impact of \textit{disc}_{1\_0}. Such variability indicates that weekly discussion in third grade had a largely positive impact on math achievement in some schools but also had a largely negative impact on math achievement in other schools. In turn, this variability may have affected the impact of \textit{disc}_{1\_1} on math achievement. Since weekly discussion in third grade was shown to have a negative impact on math achievement for many students, such discussion may, in part, counteract the generally positive benefits of having weekly math discussion in fifth grade. This would therefore explain why a compound effect of discussion was not found in the analysis.

**Discussion**

Mathematics discussion has been shown to have a positive impact on math achievement in some instances (D’Ambrosio, Johnson, & Hobbs, 1995; Hiebert & Wearne, 1993; Koichu, Berman, and Moore, 2007; Mercer & Sams, 2006; Stigler & Hiebert, 1997) and a negative impact in others (Shouse, 2001). The previous study conducted by the authors (Kosko & Miyazaki, 2009) showed a large amount of statistical variability in the impact of discussion that could not be explained. The current analysis sought to explain the variability in the previous study (Kosko & Miyazaki, 2009) and conflicting results of other studies (i.e. Shouse, 2001; Stigler & Hiebert, 1997). Although the results of the current study seem, at first glance, not to support a compound impact of discussion, the statistically significant amount of variability found in the impact of discussion in third grade is reminiscent of the results for analysis of the impact of fifth grade discussion (Kosko & Miyazaki, 2009). Therefore, the current study provides evidence that in a given year the general impact of student discussion on mathematics achievement can vary significantly between school setting if prior exposure to discussion is not taken into account.

One interesting result of the current study was that the impact of weekly discussion in the fifth grade without weekly discussion in the third grade (\textit{disc}_{0\_1}). This result could support claims made by Mercer and Sams (2006) who suggested that younger students may not inherently possess the skills necessary to maintain mathematics discussion without specific guidelines from the teacher. However, it is unknown how much guidance or structure these students received from the teacher in discussing mathematics with their peers.
References


