Enhancing Interactions During Dyadic Learning in Mathematics

Pamela M. Stecker, Lynn S. Fuchs and Douglas Fuchs

This article reviews a research program conducted to examine variables that enhance student interactions during dyadic learning in mathematics. A rationale for focusing on methods to enhance interactions is provided. Then, five studies are described. In the first, student interactions were enhanced via explicit training and practice in facilitating participation between participants. The second study examined the efficacy of preparing students to construct conceptual mathematical explanations. The third study investigated the effects of students' mathematical ability in promoting learning among very low performing students. In the final two studies, the effects of group compositions were studied within the context of cooperative work on complex mathematical tasks. Implications for research and practice are highlighted.

Although research has documented the efficacy of collaborative learning strategies for improving academic outcomes of children at different ability levels (e.g., D. Fuchs, L. S. Fuchs, Mathes, and Simmons, l997; Greenwood, Delquadri, and Hall, 1989; Palincsar and Brown, 1984), specific techniques and organizational structures of these methods vary considerably. Such variations may produce different interactional styles among students. The nature and quality of those interactional styles are important because research indicates that student learning depends on the nature and quality of interactions during peer-mediated learning (Slavin, 1996; Webb, 1985). For example, giving explanations, rather than just providing answers, is related to improved achievement (Webb, 1989, 1991). In the absence of explicit training, however, children often fail to develop effective interactional styles (Kohler and Greenwood, 1990).

At the same time, teachers' use of cooperative learning strategies is becoming more commonplace in today's classrooms (Antil, Jenkins, Wayne, and Vadasy, 1998), even as the range of academic performance in classrooms grows due, in part, to larger numbers of children of poverty exhibiting learning problems (Hodgkinson, 1995). Moreover, recent curricular reform has led teachers to incorporate activities that are more challenging and complex, with an increased focus on the development of conceptual understanding and problem solving.

Given the demands of increased classroom diversity and a more challenging curriculum, teachers rely heavily on peer-mediated methods of instruction so students can support one another's learning (Antil et al., l998). Questions related to the differential teaching performance of high- and average-achieving students, therefore, are as critical as questions about differential outcomes for students of varying abilities. Consequently, systematic explication of variables associated with enhanced learning for different types of students during peer-mediated activities is warranted.

In this paper, we review one research program designed to investigate variables associated with effective interactional styles between elementary students in mathematics. Independent variables included the role of previous training and experience in tutoring, preparation of students in constructing conceptual explanations, level of tutor's mathematical ability, and features of group size and structure when peer work involves complex performance activities. First, we describe each study. Then, we integrate results to highlight variables that contribute to high-quality interactions and improved student performance. Finally, we discuss implications for instructional practice.

Five studies incorporated similar methods for describing student interactions and performance. Following assignment to and involvement in various peer-mediated treatments, dyads (and larger groupings in the fifth study) were videotaped outside of their classrooms. We looked at (a) specific categories of student behavior, (b) global ratings and classifications of student interactions, (c) the quality of the work produced, and (d) selected transcripts to uncover phenomena undetected during more structured analyses.

Study 1: Nature of Interactions As Function of Prior Training and Experience

Purpose

L. S. Fuchs, D. Fuchs, Bentz, Phillips, and Hamlett (1994) assigned 16 classrooms to one of two treatments: with or without training and experience in peer tutoring (PT). Teachers in the PT condition taught a structured, interactional explanatory verbal rehearsal routine that incorporated step-by-step feedback (see details below). After children in the treatment group had learned and practiced this structured way of interacting, we videotaped one dyad from each classroom (i.e., those with this training and experience with PT and those without) as the students worked on a math skill. We focused our analysis on student interactions, or the exchange of student responses, during their mathematical explanations.

Subjects

Ten third-grade, four fourth-grade, and two fifth-grade teachers participated. Stratifying on grade level, teachers were assigned randomly to PT or no-PT.

Teachers implemented PT for 10 weeks prior to the videotaped sessions, which included a representative dyad from each class. Children selected for the videotaped analyses were nominated by teachers as ranking near the bottom (tutees) or near the middle (tutors) of the class in mathematics prior to the onset of PT.

Procedure

During five 30-minute sessions, PT teachers taught students the structured format for conducting PT. For example, for a subtraction with regrouping problem, the tutor would ask this series of questions (tutee responses for the sample problem 42 minus 17 are in parentheses): What kind of problem is this (subtraction)? Where do you start (ones column)? What minus what (2 minus 7)? Do you need to regroup (yes)? Do it (tutee regroups; tutor checks work). Now what minus what (12 minus 7)? Do it (tutee subtracts; tutor checks work). Where do you move next (tens column)? What minus what (3 minus 1)? Do you need to regroup (no)? Do it (tutee subtracts; tutor checks work). During PT sessions, student pairs worked together on 12 instances of the target problem type. The tutor's questions served as a model the tutee could use while working toward answers. During the first three problems, tutors provided feedback for every response. When the tutee was inaccurate or expressed confusion, the tutor provided an explanation to assist the tutee in developing the solution. Within the session, tutors faded this verbal rehearsal routine as the tutee completed problems accurately.

After 10 weeks of using PT twice each week, a representative dyad from each PT and no-PT class participated in a PT videotaped session. In this session, each dyad worked on a near-transfer task (i.e., a skill that neither student had worked on during PT, that the tutor had mastered, that the tutee had not mastered, and that lent itself to classroom PT strategies; e.g., adding fractions) and a far-transfer task (i.e., a math skill that neither student had mastered and that did not readily lend itself to classroom PT strategies; e.g., identifying missing addends).

Observers watched every videotape and collectively developed categories to capture the children's interactions: explanatory prompts or questions, explanatory statements or demonstrations, work on problem, checking or correcting problems, and verbalizations. Then, observers used a 10-sec interval recording system to capture student interactions. PT problem sheets were also analyzed for accuracy. A coder blind to the study's purpose provided a global quality rating of the PT. After being instructed about the nature of the study, this observer rewatched portions of each tape to classify each student as tutor or tutee. Finally, a representative videotape was selected from each condition for transcription.

Results

PT students' videotaped sessions lasted longer, and the accuracy of solutions was higher, especially on far-transfer tasks. PT tutors provided more explanatory prompts or questions, whereas no-PT tutors provided more explanatory statements or demonstrations. PT tutees worked on problems during more intervals than did their tutors; by contrast, no-PT tutors and tutees worked on problems similar amounts of time. Also, PT dyads were rated globally as more effective than no-PT dyads for both types of tasks. According to PT transcripts, the PT tutor displayed a more highly interactional style than did the no-PT tutor. With the far-transfer task, the PT dyad exhibited flexibility in applying classroom PT procedures to novel content. Overall, the PT tutee responded more actively than did his no-PT counterpart, who spent more time watching her no-PT tutor and waiting.

Study 2: Efficacy of Constructing Conceptual Mathematical Explanations

Purpose

L. S. Fuchs et al. (1994) had demonstrated that prior training and experience in PT led to higher quality interactions than did no training and experience. Nevertheless, findings suggested that even with training and experience, explanations tended to focus on procedural rather conceptual content. Therefore, L. S. Fuchs, Fuchs, Hamlett, et al. (1997) examined the effects of explicit instruction in generating conceptual explanations on the quality of student interactions and achievement.

Subjects

Eight second-grade, 24 third-grade, and 8 fourth-grade teachers participated. For assessing peer interactions and performance, each teacher nominated a student with a learning disability (LD), a low-achieving student (LA), an average-achieving student (AA), and high-achieving student (HA) in mathematics.

Procedures

Teachers were assigned to control or PT groups. Then, PT teachers were assigned to one of two treatments: one providing instruction in offering and requesting elaborated help (Elaborated); the other providing the same instruction plus specific strategies for constructing conceptual mathematics explanations (Elaborated + Conceptual).

PT teachers first taught PT to their students. Then, teachers implemented PT twice weekly for 18 weeks, using the same procedures described above (see Fuchs et al., 1994) except that the focus was on concepts/applications as well as operational skills. After 4 weeks of PT, teachers introduced two types of helping and explaining lessons: principles for offering and requesting elaborated help and strategies for providing conceptual explanations. This instruction in elaborated helping was covered in one lesson. In three additional lessons, conceptual strategies were addressed; these lessons explained five methods for helping peers understand problems conceptually: building number sentences; making marks, or symbols to represent numbers in problems; using manipulatives to stand for numbers; discussing what numbers represent or why problems need to be worked a certain way; and asking step-by-step questions beginning with what, where, when, how, and why.

Computation and applications achievement measures (see Stecker et al., 1992) were administered prior to and after treatment. In situ observations of peers' helping behaviors were conducted twice during the study. Videotapes of sessions were conducted 10 weeks following the helping/explaining lessons with LD and AA dyads. Observational data from videotapes were obtained as in L. S. Fuchs et al. (1994).

Results

In terms of achievement, students receiving instruction in conceptual explanations outperformed students receiving only the elaborated instruction, but both PT groups outperformed counterparts who had not been involved in PT. Observations revealed high levels of interactive participation for tutors and tutees in both PT conditions. However, tutors in the Elaborated +Conceptual condition asked more procedural questions and relied on more conceptual explanations than did counterparts who did not receive instruction in conceptual explanations.

Study 3: Tutor Ability Level and Quality of Explanations

Purpose

Research indicates that when students construct explanations that help peers arrive at their own solutions rather than simply providing answers, students who construct those explanations enjoy greater achievement (e.g., Paradis and Peverly, 1994; Webb, 1989, 1991). It remains unclear, however, whether groups with differing student ability levels are necessary for the construction of these explanations. In addition, it is unclear whether, to benefit recipients, some absolute level of competence is needed so that explanations are high quality. Consequently, in this third study, L. S. Fuchs et al. (1996) evaluated the quality and effectiveness of students' mathematical explanations as a function of the tutors' ability.

Subjects

Four second-grade, 10 third-grade, and 6 fourth-grade classrooms, each containing at least one student with LD, participated. Each teacher also nominated two AA students performing near the middle and two HA students performing near the top of the class. Based on pretest scores, one AA student and one HA student were selected for videotaping. Additionally, one student with LD served as the tutee.

Procedures

Teachers taught students the PT-Elaborated + Conceptual procedures in L. S. Fuchs, D. Fuchs, Hamlett, et al. (1997). Dyads covered content in a comprehensive mathematics curriculum, focusing on skills like problem solving, money, and charts/graphs as well as computation. Following 23 weeks of PT, twice weekly, the HA and AA student from each class each were videotaped in the tutor role; each time, the tutor worked with the same student with LD. For these videotaping sessions, two sets of problems were used, which had not been a part of classroom PT. Based on videotaped observations, rating scales were developed to capture the quality of the tutor's explanations. Additionally, observers described one explanation provided by each tutor that best characterized that child's explanations. These descriptions were ranked according to a weighted coding scheme representing nonelaborated help, procedural explanations, aspects of both procedural and conceptual explanations, and conceptual content. Accuracy of tutees' performance during the generalization sessions also was evaluated.

Results

HA tutors' explanations were rated more highly than those of AA tutors. HA tutors also relied more on explanatory strategies with a conceptual focus. Accuracy of LD tutees' performance was greater with HA tutors. Thus, HA tutors who had been instructed in the same PT procedures as AA tutors provided more conceptual explanations and effected better performance among the same LD tutees.

Study 4: High-Achieving Students' Performance on Complex Tasks within Homogeneous and Heterogeneous Dyads

Purpose

In the previous study (L. S. Fuchs et al., 1996), HA tutors provided more conceptually-oriented explanations than AA tutors, which in turn effected better performance among LD tutees. However, no performance outcome was available for the tutors. Consequently, L. S. Fuchs, D. Fuchs, Hamlett, and Karns (1998) explored HA students' interactions and work quality on complex mathematics tasks as a function of homogeneous versus heterogeneous dyad compositions. Previous work (e.g., Webb, 1991) highlights the importance of constructing explanations for learning, and pairing HA students with LA students may provide maximal opportunities for HA students to construct explanations. Nevertheless, studies provide mixed evidence regarding the learning of HA students in homogeneous versus heterogeneous groupings (e.g., Carter and Jones, 1993; L. S. Fuchs, D. Fuchs, Hamlett, et al., 1997; Webb, 1980). Performance assessments were used to determine whether HA students benefited more from interacting with other HA or with LA classmates on complex mathematics tasks.

Subjects

Four third-grade and six fourth-grade teachers taught PT that focused on offering and requesting help from partners and providing conceptual explanations. Following administration of a mathematics pretest in each classroom, the student with the highest score was labeled as the HA target student. The next highest scoring student became the HA partner. The lowest-scoring student was labeled the LA partner. Analyses indicated that both the HA targets and HA partners performed comparably to each other but higher than LA partners.

Procedures

In addition to implementing PT twice weekly, teachers also administered six performance assessments (PAs). Each PA provided a multi-paragraph narrative describing a problem situation with accompanying tabular and graphic information. Students responded to four questions that required application of mathematical skills, discrimination between relevant and irrelevant information, generation of data not contained within the narrative, and production of written communication related to mathematics. Teachers scored the PAs and provided feedback to students. Following 21 weeks of PT, two alternate form PAs were used during videotaped sessions, which focused on interactions between the HA target and HA partner and between the HA target and LA partner. Rating scales captured student interactions: collaboration, cognitive conflict, student goals, talk, and affect. After ratings were completed, written characterizations of the partners' participation were coded to describe the level of partner participation, from equal contributor to nonfunctional participant. Work produced by each dyad also was scored.

Results

Homogeneous dyads were rated higher on most dimensions of interaction. HA partners working together participated more substantially, and the work generated by these homogeneous dyads was judged better than work generated when HA students worked with LA peers.

Study 5: Effects of Workgroup Structure and Size on Complex Tasks

Purpose

Although L. S. Fuchs et al. (1998) demonstrated that HA students produced better quality work and interactions with other HA students than with LA partners, the nature of the mathematical problems (i.e., PAs) utilized during the generalization sessions was more complex than the discrete mathematical skills students had practiced during PT. Similarly, students had practiced interacting in constructive and helpful ways during classroom PT, but the PAs used in generalization sessions required more peer collaboration than PT. Consequently, in this final study, L. S. Fuchs et al. (2000) examined the effects of several types of classroom PT structures on the productivity of workgroups engaged in complex mathematical tasks. This fifth study also evaluated the effects of two workgroup sizes (i.e., dyads vs. small groups) on student productivity, especially the participation of LA students, who tend to interact less frequently and have less influence in cooperative groups than do HA students (McAuliffe and Dembo, 1994; O'Connor and Jenkins, 1996; Rosenholtz, 1985).

Subjects

Eighteen third-grade and 18 fourth-grade teachers ranked all students in class in terms of mathematical competence. For purposes of videotaped sessions, one workgroup (either pair or small group) was selected from each class. In classes assigned to a dyadic structure, the highest-achieving student was paired with the lowest-achieving student for videotape analyses. In classrooms assigned to a small-group structure, the highest-achieving student, the lowest-achieving student, and the two middle-achieving students were selected for videotape analyses.

Procedures

In addition to classroom assignment to dyads or small groups, classes were assigned randomly to three background experiences: individual (i.e., no PT), collaborative, or collaborative with structure. Immediately following each PA session, students in all three conditions also completed a quiz that contained one PA item and then received answers to all four PA questions. In the individual condition, students completed four weekly PAs individually. In both collaborative conditions, following a training session on workgroup cooperation, students completed weekly PAs in pairs or small groups. For the collaborative with structure condition, an additional training session provided students with specific roles (reader, monitor, checker, writer; when assigned to pairs, students assumed two roles instead of one). The collaborative with structure arrangement also awarded points to workgroups for cooperating, following the rules of participation, and for members' performance on weekly quizzes.

One week after the last classroom PA, we videotaped one workgroup from each class working on a PA. So, students with individual background experiences participated in dyads or small groups for the videotapings, as did students in the other conditions where experience in collaborative work was greater. Ratings were developed on quality of interactions; rankings were used to characterize LA students' participation; and scores described the quality of PA work. To illustrate the effects of workgroup size, a representative pair and small group was selected for transcription.

Results

Many students trained in the structured interaction style relied on those features during the PA videotaped sessions, and students in the other conditions did not spontaneously engage in the structured interactional features. However, the quality of interactions among students in the structured background condition did not differ from those in the unstructured collaborative condition. Peer interactions were more effective among students in both collaborative conditions compared to those of counterparts who had worked on classroom PAs individually.

Workgroup size, however, did influence interactions and quality of work. Dyads were rated higher than small groups on procedural and conceptual talk, helpfulness, and cooperation. Quality of work was better in dyads for conceptual underpinnings, computational applications, and problem-solving strategies. Moreover, LA students participated more and collaborated more in dyads.

Summary of Results Across Studies

L. S. Fuchs et al. (1994) demonstrated that explicit PT training and experience facilitated peer interactions. PT tutors relied more on explanatory questions and prompts, rather than the explanatory statements and demonstrations no-PT tutors used. Likewise, tutees in the PT condition spent more time working. To build on these findings, L. S. Fuchs et al. (1997) demonstrated the importance of training students explicitly in generating conceptual explanations, strengthened the connection between students' use of conceptual explanations and student achievement, and emphasized the importance of the quality of student interactions. This study, however, also suggested that HA and LA students achieved better with PT than did AA and LD students, even when training in conceptual training was provided. Rules for pairing children may help explain this effect for students of varying ability levels. For example, pairing HA students with LA students may have provided more challenging opportunities for HA tutors to construct rich explanations; pairing AA students with other AA students may have deprived AA students of these opportunities. Moreover, perhaps the LD students required the most capable students to benefit from explanations.

L. S. Fuchs et al. (1996), therefore, examined the effects of tutor ability on LD students' performance. Results showed that HA tutors incorporated greater conceptual focus to their explanations than did the AA peers and that LD students in fact performed better when working with HA tutors. Thus, students with significant learning problems may not achieve without some absolutely high level of explanations.

Then, examining the quality of HA students' interactions, L.S. Fuchs et al. (l998) studied alternative pairing strategies with complex tasks. HA students fared better on PAs when paired with other HA peers than when paired with LA students. In this study, however, students were not taught explicitly how to collaborate on challenging material.

Consequently, in the final study, L. S. Fuchs et al. (2000) examined the effect that explicit instruction in collaboration has on student interaction and performance when working on complex tasks. Additionally, workgroup size was contrasted. Although students in both collaborative conditions interacted more effectively than students with no collaborative experience, explicit structure did not enhance interactions beyond those demonstrated with unstructured collaboration. Differential effects did, however, occur for group size: LA students fared better when working in dyads over small groups.

Study Limitations

As with any research, several caveats must be considered when considering results. We identify three. First, videotaped sessions occurred outside of students' classrooms. Students may behave differently within more natural contexts. Second, in the L. S. Fuchs et al. (1994) study, training and prior experience in PT were not separated; over time, given experience in PT, untrained dyads may have performed differently. Third, except for the L. S. Fuchs, Fuchs, Hamlett, et al. (1997) study, mathematics achievement was not evaluated. Instead, performance on tasks during generalization sessions was used to estimate achievement. However, in absence of achievement data for students in contrasting conditions, conclusions about the efficacy of various PT strategies on student mathematics achievement remain tentative. These limitations suggest avenues for future research.

Implications for Practice

This program of research has important implications for classroom practice. First, this work demonstrates that peer-mediated techniques can be taught successfully to young, elementary-age students. Second, peer interactions and performance are enhanced when students receive explicit training and practice in peer-mediated strategies (L. S. Fuchs et al., 1994). Third, young students also can be taught to provide effective conceptual explanations that facilitate interactions and performance beyond mere algorithmic routines (L. S. Fuchs, D. Fuchs, Hamlett, et al., 1997).

Fourth, the ability level of students appears to mediate the effectiveness peer-assisted instruction; so, teacher need to consider the competence of their students as they formulate methods for pairing or grouping students. Perhaps most important, teachers need to alter grouping arrangements to optimize learning for different types of students and across different types of instructional tasks. L. S.

Fuchs et al. (1996), for example, found that HA tutors provided better conceptual explanations and facilitated better interactions among students with LD than did AA peers. Thus, high-quality conceptual explanations may be necessary for students with serious learning problems to benefit from peer assistance. Conversely, L. S. Fuchs et al. (1998) found that, with complex mathematical tasks, superior interactions and performance for HA students were facilitated when paired with other HA students.

In light of current evidence, teachers need to consider the nature of the task and the ability of the student when implementing peer-assisted learning strategies. Varying grouping arrangements and instructional practices may facilitate the accomplishment of different types of goals for different types of students. Teachers must be careful to evaluate the purposes for which peer-assisted activities are being implemented.

Results of this research program have been operationalized within a mathematics PT program (Fuchs, Fuchs, Karns, and Phillips, l999). This program relies on dyads rather than groups. The program varies pairing strategies so that HA students have opportunities to work with LA classmates as well as HA peers and to insure a discrepancy in competence levels when AAs are grouped together; dyads change every 2 weeks. The program incorporates the structured, interactional tutoring system described by Fuchs et al. (l994), but it also incorporates routine opportunities for tutors to construct their own explanations. And importantly, the program provides children with explicit instruction in how to offer and seek explanations from peers and how to construct conceptual mathematical explanations.

References

Antil, L. R., Jenkins, J. R., Wayne, S. K., & Vadasy, P. F. (1998). Cooperative learning: Prevalence, conceptualizations, and the relation between research and practice. *American Educational Research Journal, 35,* 419-454.

Bell, N., Grossen, M., & Perret-Clermont, A. (1985). Sociocognitive conflict and intellectual growth. In M. W. Berkowitz (Ed.), *Peer conflict and psychological growth* (New Directions for Child Development, No. 29) (pp. 41-54). San Francisco: Jossey-Bass.

Carter, G., & Jones, G. M. (1993). *The relationship between ability-paired interactions and the development of fifth graders' concepts of balance.* Paper presented at the Conference of the National Association of Research in Science Teaching: Atlanta. (ERIC Document Reproduction Service No. ED 361 175)

Fuchs, L. S., Fuchs, D., Hamlett, C. L., & Stecker, P. M. (1991). Effects of curriculum-based measurement and consultation on teacher planning and student achievement in mathematics operations. American *Educational Research Journal, 23,* 617-641.

Fuchs, L. S., Fuchs, D., Bentz, J., Phillips, N. B., & Hamlett, C. L. (1994). The nature of student interactions during peer tutoring with and without prior training and experience. *American Educational Research Journal, 31,* 75-103.

Fuchs, L. S., Fuchs, D., Karns, K., Hamlett, C. L., Dutka, S., & Katzaroff, M. (1996). The relation between student ability and the quality and effectiveness of explanations. *American Educational Research Journal, 33,* 631-664.

Fuchs, D., Fuchs, L. S., Mathes, P. G., & Simmons, D. (1997). Peer-Assisted Learning Strategies: Making classrooms more responsive to diversity. *American Educational Research Journal, 34,* 174-206.

Fuchs, L. S., Fuchs, D., Hamlett, C. L., Phillips, N. B., Karns, K., & Dutka, S. (1997). Enhancing students' helping behavior during peer-mediated instruction with conceptual mathematical explanations. *Elementary School Journal, 97,* 223-249.

Fuchs, L. S., Fuchs, D., Hamlett, C. L, & Karns, K. (1998). High-achieving students' interactions and performance on complex mathematical tasks as a function of homogeneous and heterogeneous pairings. *American Educational Research Journal, 35*, 227-267.

Fuchs, L. S., Fuchs, D., Karns, K., & Phillips, N. B. (1999). *Peer-assisted learning strategies (PALS) for mathematics: A manual.* (Available from Box 328, Peabody College, Vanderbilt University, Nashville, TN 37203).

Fuchs, L. S., Fuchs, D., Kazden, S., Karns, K., Calhoon, M. B., Hamlett, C. L., & Hewlett, S. (in press). The effects of workgroup structure and size on student productivity during collaborative work on complex tasks. *Elementary School Journal.*

Graham, S., & Harris, K. R. (1989). Components analysis of cognitive strategy instruction: Effects on learning disabled students' composition and self-efficacy. *Journal of Educational Psychology, 81,* 353-361.

Greenwood, C. R., Delquadri, J., & Hall, R. V. (1989). Longitudinal effects of classwide peer tutoring. *Journal of Educational Psychology, 81,* 371-383.

Hodgkinson, H. L. (1995). What should we call people?: Race, class, and the census for 2000. *Phi Delta Kappan, 77,* 173-179.

Johnson, J. A. (1979). *Learning in peer tutoring interactions: The influence of status, role change, time-on-task, and verbalization.* Unpublished doctoral dissertation, Los Angeles: University of California.

Kohler, F. W., & Greenwood, C. R. (1990). Effects of collateral peer supportive behaviors with in the classwide peer-tutoring program. *Journal of Applied Behavioral Analysis, 23,* 307-322.

McAuliffe, T. J., & Dembo, M. H. (1994). Status roles of behavior in scenarios of peer learning. J*ournal of Educational Psychology, 86,* 163-172.

O'Connor, R. E., & Jenkins, J. R. (1996). Cooperative learning as an inclusion strategy: A close look. *Exceptionality, 6,* 29-52.

Palincsar, A. S., & Brown, A. L. (1984). The reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. *Cognition and Instruction, 1*(2), 117-175.

Palincsar, A. S., & Brown, A. L. (1989). Classroom dialogues to promote self-regulated comprehension. In J. Brophy (Eds.), *Advances in research on teaching: Vol. 1* (pp. 35-71). New York: JAI Press.

Paradis, L. M., & Peverly, S. (1994). *The effects of knowledge and task on students' peer-directed questions in modified cooperative learning groups.* Paper presented at the Annual Meeting of the American Educational Research Association: New Orleans. (ERIC Document Reproduction Service No. ED 371 027).

Rosenholtz, S. J. (1985). Treating problems of academic status. In J. Berger & M. Zelditch, Jr. (Eds.), *Status, rewards, and influence* (pp. 445-470). San Francisco: Jossey-Bass.

Slavin, R. E. (1977). *Student learning teams and scores for past achievement: A summary of field experiments* (Rep. No. 227). Johns Hopkins University Baltimore: Center for Social Organization of Schools.

Slavin, R. E. (1978). Student teams and achievement division. *Journal of Research and Development in Education, 12,* 39-49.

Slavin, R. E. (1996). Research on cooperative learning and achievement: What we know, what we need to know. *Contemporary Educational Psychology, 21,* 43-69.

Stecker, P. M., Fuchs, L. S., & Hamlett, C. L. (1992). *Technical features of mathematics operations and applications progress monitoring measures.* Unpublished manuscript, Nashville: Vanderbilt University.

Walberg, H. J. (1984). Improving the productivity of America's schools. *Educational Leadership, 41*(8), 19-27.

Webb, N. M. (1980). Peer interaction and learning in small groups. *International Journal of Educational Research, 13,* 21-40.

Webb, N. M. (1985). Student interaction and learning in small groups: A research summary. In R. E. Slavin, S. Sharon, S. Kagan, R. Hertz-Lazarowitz, N. Webb, & R. Schmuck (Eds.), *Learning to cooperate, cooperating to learn* (pp. 147-172). New York: Plenum.

Webb, N. M. (1989). Peer interaction and learning in small groups. *International Journal of Educational Research, 13,* 21-40.

Webb, N. M. (1991). Task-related verbal interaction and mathematics learning in small groups. *Journal for Research in Mathematics Education, 22,* 366-389.

Webb, N. M. (1992). Testing a theoretical model of student interaction and learning in small groups. In R. Hertz-Lazarowitz & N. Miller (Eds.), *Interactions in cooperative groups: The theoretical anatomy of group learning* (pp. 102-119). New York: Cambridge University Press.

Verbesserung der Interaktionen während des Mathematiklernens in Dyaden

Zusammenfassung

In diesem Beitrag wird ein Forschungsprogramm vorgestellt, das Bedingungen untersucht, die die Interaktionen zwischen Schülern während des Mathematiklernens in Dyaden fördern sollen. Zuerst behandelt der Artikel Grundüberlegungen zu Methoden der Verbesserung von Interaktionen. Dann werden fünf Studien dargestellt. In der ersten Studie wurden Interaktionen durch explizites Trainieren und Üben von einfachen Formen der Zusammenarbeit gefördert. Die zweite Studie untersuchte, wie wirksam die Schüler darauf vorbereitet werden können, Konzepte für mathematische Erläuterungen zu bilden. Die dritte Studie ermittelte die Wirkung der mathematischen Fähigkeiten der Schüler auf die Leistungsförderung von Schülern mit Lernschwierigkeiten. Die letzten zwei Studien behandeln die Wirkung von Gruppenzusammensetzungen im Kontext kooperativer Arbeit an komplexen Mathematikaufgaben. Folgerungen für Forschung und Praxis werden hervorgehoben.

Renforcement des interactions lors d'apprentissage en dyade en mathématiques

Résumé

Cet article rend compte d’un programme de recherches visant à examiner les variables susceptibles de favoriser les interactions pendant l’apprentissage en dyade en mathématiques. Il débute en apportant des arguments soutenant l'importance du renforcement des interactions. Cinq études sont ensuite décrites. Dans la première, les interactions entre élèves sont stimulées par l'intermédiaire d'un entraînement explicite et une pratique de facilitation de la participation des individus dans un groupe. La deuxième étude examine l’efficacité de la préparation des élèves à construire des explications portant sur des concepts mathématiques. La troisième étude investigue les effets des capacités des élèves en mathématiques sur la promotion des apprentissages chez des élèves présentant des difficultés d'apprentissage. Les deux dernières études portent sur l'effet de la composition des groupes dans un contexte de travail coopératif portant sur des tâches mathématiques complexes. L'article se termine par une mise en évidence des implications pour la recherche et la pratique.

Intensificazione delle interazioni durante l’apprendimento a coppie della matematica

Riassunto

In questo articolo si presenta un programma di ricerca che analizza variabili in predicato di favorire le interazioni di allievi durante l’apprendimento a gruppi di due. Dapprima si toccano problemi di fondo relativi all’impiego di tali metodi. In seguito vengono presentati 5 studi. Il primo spiega come le interazioni vengano favorite da un training e un’esercitazione espliciti, miranti al coinvolgimento. Il secondo analizza l’efficacia di una preparazione degli allievi tesa allo sviluppo di concetti appropriati per spiegazioni matematiche. Nel terzo si individua l’influsso delle capacità matematiche degli allievi sul miglioramento delle prestazioni di allievi con difficoltà di apprendimento. Gli ultimi due studi analizzano l’impatto della configurazione dei gruppi sull’attività cooperativa svolta su compiti matematici complessi. Si conclude discutendo le conseguenze per la ricerca e la pratica educativa.