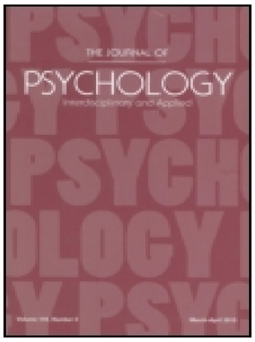

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Enhancing Academic Performance by Strengthening Class-Inclusion Reasoning

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ABSTRACT. Class inclusion is an early form of abstract thought that requires logical rather than perceptually based inferences plus an appreciation of part–whole relationships (B. Inhelder & J. Piaget, 1959/1964). The authors randomly assigned 2 groups of first graders who were having academic difficulties to be instructed on either class inclusion or phonics. Results showed a significant linear relation between individual children's mastery of class inclusion and their scores on the Cognitive Abilities Test Form 6 (D. F. Lohman & E. P. Hagen, 2001) verbal and quantitative measures of reasoning. The authors also found a significant linear relation between mastery of class inclusion and improvement in report card marks issued by teachers who were blind to the children's group assignment.

Key words: abstraction, achievement, class inclusion, reasoning

INHELDER AND PIAGET (1959/1964) REPORTED that young children playing with a few white beads and many brown beads thought that they had more brown beads than they had beads altogether, and persistently clung to this conclusion until reaching a certain level of maturity. Inhelder and Piaget asserted that class inclusion, the understanding that no subclass is more numerous than the superordinate class, coupled with a reliance on abstract thought rather than on perceptual cues, usually emerges at about age 7 and is a significant indicator of readiness for schooling.

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Researchers have debated at what age children develop the reasoning necessary to understand class inclusion. Some researchers suggested that toddlers and preschoolers can show some understanding of class inclusion (Markman, 1983; Siegel, McCabe, Brand, & Matthews, 1978), depending on how the problems are presented. McCabe and Siegel (1987) reported that kindergartners understood class inclusion. However, Agnoli (1991) suggested 8–10 years of age as a more realistic time frame, and Winer (1980) reported that a full understanding did not emerge until 12–14 years of age. Sample differences aside, the way in which problems are presented and the criteria for what is considered to be class inclusion are critical.

Researchers have investigated whether class inclusion must develop through maturation or if it can be taught to children before it has developed. Many researchers have shown that class inclusion can be taught, although how it can be best taught and exactly what is learned are uncertain (Carpendale, McBride, & Chapman, 1996; McCabe & Siegal, 1987; McCabe, Siegal, Spence, & Wilkinson, 1982; Thomas, 1995; Willson-Quayle & Pasnak, 1997). Another question is whether it should be taught even though it develops naturally without the investment of time and resources by teachers, parents, or other adults.

Freyberg (1966), Kaufman and Kaufman (1972), Kingma and Koops (1983), and Kingma (1983) found a relation between children's understanding of class inclusion and their early (especially first grade) academic success. This could be a reflection of general cognitive ability, which presumably underlies both the development of class inclusion reasoning and success in school. However, it is also possible that reasoning about parts and wholes and freedom from perceptual biases involved in class inclusion are important in understanding some aspects of academic instruction, particularly in early grades. If this is true, teaching class inclusion may be more than a theory-testing exercise.

We studied practical aspects of instruction in class inclusion by asking whether or not class inclusion is an important aspect of children's thinking and how the mastering of class inclusion affects readiness for schooling and early achievement. We also investigated the relationship between understanding class inclusion and school aptitude or achievement and studied whether teaching children class inclusion has an impact on their success in school. If class-inclusion reasoning is a basis for the development of early abstract thought, as Inhelder and Piaget (1959/1964) theorized, children who are taught class inclusion might score more highly on measures of aptitude and achievement. If the benefits of class-inclusion reasoning help them understand their classroom teachers' lessons better, they might also exceed other children's scores on what is taught in class.

In this study, we randomly assigned children to a group that learned about class inclusion or to an active control group (Pasnak & Howe, 1993) that learned about phonics. First, we hypothesized that the group taught class inclusion would perform better on a test of class inclusion than would the group taught phonics. Second, we expected that the group taught class inclusion would perform better on a reasoning test than would the group taught phonics. Our rationale in creating this hypothesis was that understanding class inclusion requires an advance toward more abstract, less perceptually bound thinking (Inhelder & Piaget, 1959/1964). Third, we hypothesized that the group taught class inclusion would get better report card marks than would the group taught phonics. We expected this result on the basis of the improved reasoning of the children who learned about class inclusion. Last, we hypothesized that the group taught class inclusion would perform better on a phonics test than would the group taught phonics. We expected this result because a better understanding of the phonics lessons (i.e., a benefit of learning about class inclusion) taught over the course of a full year would outweigh the benefits of the relatively small number of extra phonics sessions the active control group would receive.

Method

Participants

Over 2 academic years, six teachers nominated 54 students (2 African American, 9 Latino, and 43 Caucasian) who had difficulty understanding first-grade work. We used a random numbers table to assign the children to two groups with two constraints: We divided children who had the same teacher as evenly as possible between the groups, and we made the number of boys and girls in the groups as equal as possible. In the first year, this restricted randomization produced experimental and control groups of 10 boys and 4 girls each. The next year's restricted randomization produced an experimental group of 8 boys and 5 girls and a control group of 7 boys and 5 girls. We excluded one child from the experimental group when we discovered that he understood class inclusion. The average age of the 27 children in the experimental group was 6.39 years (SD = .43). The average age of the 26 control children was 6.44 years (SD = .52). We did not tell teachers about group assignments, and we treated the participants according to the American Psychological Association's (APA, 2001) standards.

Design

We used an active control group in this study. Instead of receiving no special attention from the researchers or being engaged in a trivial task, the control group learned phonics in sessions matched in timing and extent to the lessons of the experimental group, who learned about class inclusion. This design equalized Hawthorne effects, positive expectations, attention, and investment of resources. It also provided a comparison of the payoffs from teaching something already known to be useful (e.g., phonics) versus something that might be more, equally, or less useful to the children (e.g., class inclusion).

Materials

We glued Velcro patches to the back of 36 sets of small toys (e.g., dinosaurs, trucks, dice), household objects (e.g., muffin cups, rubber bands, bows), and craft items (e.g., paint pots, feathers, beads) for display on a Velcro board during class-inclusion instruction. The first 12 problems presented objects from two subclasses of a superordinate class (e.g., Legos: red and blue; vehicles: trucks and motorcycles; hair clips: rectangular and oval). The next 12 problems also presented objects from two subclasses of a superordinate class, but also presented one set of objects from another superordinate class (e.g., 5 large buttons, 3 small buttons, and 7 erasers; 3 cows, 4 horses, and 9 cars). In these problems, the number of objects in either subclass was always fewer than those in either superordinate class, but the composite superordinate class made by combining the subclasses was larger on half the problems. The next 12 problems each presented two sets of objects from each of two superordinate classes (e.g., 4 yellow and 5 pink plastic fish and 2 big and 6 small paper clips). For these problems, the most numerous subclass was always part of the least numerous superordinate class.

A printed class-inclusion test was composed of 10 class inclusion problems, 14 control problems, and 2 practice problems, all represented by pictures. No objects used in the instruction were included in this test. There were nine problems with pictures of objects from two subclasses that belonged to a superordinate class, eight problems with pictures of objects from two subclasses of the same superordinate class and also pictures of objects from another superordinate class, and seven problems with pictures of two subclasses of objects from one superordinate set and two subclasses of objects from another superordinate class. Children read the question, "Are there more _______ or more _______?" and circled all of the objects that constituted the answer. For half of the problems, the answer was a subclass, and for half the answer was a superordinate class.

The 10 class-inclusion questions required the children to realize that a superordinate class necessarily has more members than does the subordinate classes of which it is composed. For example, Problem 2 showed four lions and three elephants, and the question asked whether there were more lions or more animals. This is the simplest kind of class inclusion question. The most difficult class inclusion questions showed objects that could be combined into two subordinate classes, each belonging to the same superordinate class. For example, Problem 13 showed two hamburgers, one hot dog, two pears, and two bunches of grapes. The question asked whether there was more food or more fruit.

The test included 14 control questions that we designed to prevent respondents from obtaining perfect scores by thoughtlessly circling all the objects pictured for every question. For example, Problem 1 presented two large stars, three small stars, and four geese. The question was whether there were more birds or stars. This is a control question; a class inclusion question would ask the children whether there were more stars or more small stars. We counterbalanced the order in which objects were pictured on the page and the order of terms in the questions. We used the same order of questions and terms in the questions for each child.

Materials for the phonics group included a flannel board, felt letters and shapes, objects made of felt, plastic, and wood, and pictures of objects. We used the Sounds and Letters Scale from the Stanford Early School Achievement Test (SESAT) Level 2 (Psychological Corporation, 1996) to measure knowledge of phonics. This scale comprises 43 multiple-choice questions presenting pictures and letters that test children's ability to recognize vowel and consonant beginning and end sounds. We also analyzed Cognitive Abilities Test (CogAT) Form 6 (Lohman & Hagen, 2001) scores obtained as part of programmatic school testing at the end of the academic year. The CogAT has three scales: Verbal, Nonverbal, and Quantitative. CogAT composite scores correlate ($r = .69$) with Woodcock Johnson III General Ability Index (McGrew & Woodcock, 2001) scores and also with Wechsler Intelligence Scale for Children III (WISC III; Wechsler, 1991) total scale scores ($r = .79$). The SESAT correlates with the Otis-Lennon School Abilities Test (Otis & Lennon, 1997; $r = .62$), and the median Kuder-Richardson reliabilities are .87 (Psychological Corporation).

Procedure

Two college students instructed the participants each October and switched groups on alternate days. Both groups attended twelve 15-min yoked sessions at the same time in an otherwise unused classroom. The college students taught the experimental group (14 children the first year, 13 the second year) about class inclusion as a group through demonstration, explanation, and questioning, simulating the way a teacher instructs a whole class. They presented objects in two rows (e.g., a row of pink flowers and a row of blue flowers) on the Velcro board, which was placed where all children could see it. They then chose a child to answer the class inclusion question, "Are there more pink flowers or more flowers?" After the child answered, the teacher and the group of children counted the objects out loud and arrived at a consensus on what the correct answer should be.

The college students also taught the children in the control group (14 the first year and 12 the second year) in groups, using the flannel board, flannel letters, felt pieces depicting animals, shapes, and other objects, and pictures of food and objects. This instruction followed methods recommended by the cooperating school system for first-grade teachers. The children each chose a letter, placed it on the flannel board, and said a word that began with that letter. The instructor would then help the children sound out that word and spell it with the flannel letters. The different sounds that letters and pairs of letters make were the focus of these sessions. Children also chose an object and said what it was, what letter its name started with, and another word that started with the same letter. The teacher explained which sounds were appropriate to each letter and encouraged the children to repeat them, a method similar to that of teachers in this school. The teachers also passed out pictures of objects to the children and asked each student to find another student who had a picture that started or ended with the same letter.

In May, all children completed the Sounds and Letters (phonics) scale of the SESAT (Psychological Corporation, 1996) on one day and our class inclusion test on the next day. Both experimental and control groups took the tests at the same time in the same room. They sat individually at tables in the school library to prevent copying. The school provided us with the children's report card marks and with their CogAT (Lohman & Hagen, 2001) scores, which teachers collected in group testing sessions in June.

Results

In a pilot study during the previous year in this school, researchers found that only first graders in roughly the upper half of their class would understand class inclusion. Nevertheless, early in the experimental instruction, the first author noticed that one boy in the experimental group had a good understanding of class inclusion, so we dismissed him from the experiment. No other children in the group answered class inclusion questions correctly at the beginning of instruction. The highest score any child in the control group made on the year-end class inclusion test was 7 out of 10, so their knowledge of class inclusion, if any, must have been poor at the beginning of the year. On the year-end test, children taught class inclusion scored more highly on the class inclusion test than did children taught phonics, $t(51) = 3.93$, $p < .001$. They averaged two errors on the 10-problem test, whereas the control children averaged six errors. The effect size coefficient ($d = 1.11$) indicates that this result is a large effect. Children in the experimental group also scored more highly on other measures not about class inclusion, but the differences were not statistically significant for this sample size (See Table 1).

Within-group correlations offer better evidence for the importance of class inclusion in first graders' reasoning and achievement. The groups differed significantly in the strength of correlations between mastery of class inclusion and report card scores (sees Tables 2 and 3). For children's report card scores, we calculated the difference in their scores on 10 academic areas from fall to spring, where the score in any one area ranged from 1 (*unsatisfactory*) to 4 (*outstanding*). For children in the experimental group, class-inclusion scores predicted improvement in report card marks with moderate accuracy. For children in the control group, the correlation was near zero.

Class-inclusion scores also correlated significantly with verbal and quantitative CogAT scores for the group taught class inclusion, but not for the control group. These CogAT verbal and quantitative scores, in turn, correlated significantly with improvement in report card marks for children in the experimental group, but not for children in the control group. Correlation coefficients of .50 or higher denote large effect sizes (Cohen, 1992).

TABLE 1. Descriptive and Inferential Statistics for Class Inclusion, SESAT, CogAT, and Report Card Grades

	Class inclusion group		Phonics group			
Measure	*M*	*SD*	*M*	*SD*	*t*	*df*
Class inclusion	7.85	3.04	4.07	3.81	3.93*	51
SESAT	66.27	22.82	60.22	23.95	.92	51
CogAT						
Nonverbal	53.77	22.33	48.81	27.53	.70	50
Verbal	41.58	25.19	40.81	22.93	.11	50
Quantitative	44.88	25.17	37.88	23.57	1.01	50
Report card	16.09	3.82	14.74	3.37	1.18	44

Note. SESAT = Stanford Early School Achievement Test Level 2 (Psychological Corporation, 1996); CogAT = Cognitive Abilities Test Form 6 (D. F. Lohman & E. P. Hagen, 2001).
*$p < .001$.

TABLE 2. Correlations Between Measures for the Class Inclusion (Experimental) Group

Measure	SESAT	CogAT-N	CogAT-V	CogAT-Q	RC
Class inclusion	.38	.25	.53**	.64***	.48*
SESAT	—	.36	.46*	.50*	.55**
CogAT-N		—	.19	.48*	.43*
CogAT-V			—	.64***	.37
CogAT-Q				—	.46*

Note. SESAT = Stanford Early School Achievement Test Level 2 (Psychological Corporation, 1996); CogAT-N = Cognitive Abilities Test Form 6 (D. F. Lohman & E. P. Hagen, 2001) Nonverbal; CogAT-V = CogAT Verbal; CogAT-Q = CogAT Quantitative; RC = report card.
*$p < .05$. **$p < .01$. ***$p < .001$.

This pattern of significant within-group correlations for the experimental group suggests that being taught about class inclusion early in the year was positively related to June CogAT scores and report card marks for children who seemed to have learned the most about class inclusion, as indicated by their higher scores on the May class-inclusion test. Participants who received high scores on the class-inclusion test as a consequence of the October intervention also recevied high scores on the CogAT and on their report cards in June. Participants who learned

TABLE 3. Correlations Between Measures for the Phonics (Active Control) Group

Measure	SESAT	CogAT-N	CogAT-V	CogAT-Q	RC
Class inclusion	–.31	.06	.16	–.03	–.14
SESAT	—	.47*	.11	.34	.63***
CogAT-N		—	.50**	.54**	.50**
CogAT-V			—	.68***	.37
CogAT-Q				—	.22

Note. SESAT = Stanford Early School Achievement Test Level 2 (Psychological Corporation, 1996); CogAT-N = Cognitive Abilities Test Form 6 (D. F. Lohman & E. P. Hagen, 2001) Nonverbal; CogAT-V = CogAT Verbal; CogAT-Q = CogAT Quantitative; RC = report card.
*$p < .05$. **$p < .01$. ***$p < .001$.

class inclusion less well performed less well on the CogAT and their report cards, and participants who did not understand class inclusion at all received the lowest marks on the CogAT and their report cards. The significant linear correlations (r) describe this pattern (see Table 2).

Unlike the verbal and quantitative scales, the nonverbal CogAT scale scores correlated with report card marks for both experimental and control groups and hence do not reflect relationships that are a consequence of learning about class inclusion. Scores on all CogAT scores were intercorrelated (nonorthogonal), as might be expected. This result presumably represents a *g* (general intelligence) factor and other sources of common variance, such as attentiveness and comfort with the test-taking situation, and is consistent with the CogAT manual (Lohman & Hagen, 2001). This overlap was not large enough to mask the difference in correlations of verbal and quantitative scores with report card marks between the experimental and control groups.

Discussion

In this study, differences in the way measures correlated for the experimental and control groups for class-inclusion knowledge reflect differences in how that knowledge was acquired and the extent to which it had been acquired. The significant correlations between class inclusion, CogAT scores, and report card marks for the experimental group, but not for the control group, suggest a direct relationship between understanding class inclusion, the types of reasoning measured objectively by the CogAT verbal and quantitative scales, and the teachers' assessment of classroom performance. Lower class-inclusion scores earned by children in the control group did not correlate as highly with scores on these measures, possibly because of a truncated range coupled with a low average. Understanding of class inclusion developed naturally but slowly for the children in the control group. The relatively small differences between these children's scores in class-inclusion reasoning combined with the low level of such reasoning they had developed did not correlate with differences in academic grades or CogAT scores. When we accelerated the development of class-inclusion reasoning by teaching it to the children in the experimental group, we found larger differences than we found for children in the control group in how much they learned about class inclusion. Both the range of class-inclusion ability and the average amount of such ability were high for children in the experimental group. These factors led to the linear relation between the class-inclusion reasoning of the children in the experimental group and their year-end scores on the academic reasoning and achievement measures. To explain these findings, we hypothesize that children who gained more understanding of class inclusion from the instructional intervention were able to learn more in the classroom during the second semester, score more highly on year-end standardized tests, and receive higher marks on the teacher-issued report card. The significant correlations between class inclusion, CogAT scores, and report card marks for children in the experimental group support this hypothesis, but the lack of significant absolute differences between the experimental and control groups on the latter two variables do not. The small sample size ($N = 53$) may have prevented us from finding significant differences.

It seems likely that instruction about class inclusion helped the participants understand part–whole or set–subset relationships, which could help them think more abstractly in general. Children who answer class-inclusion problems incorrectly fail because their reasoning is tied to perceptual properties of objects (Inhelder & Piaget, 1959/1964). Logical inferences are difficult when perceptual intrusions interfere with response to abstract relations, but children overcome this interference when they master class inclusion.

The children to whom we taught class inclusion improved in multiple academic areas. They scored as well on the test of phonics as did the children to whom we taught phonics. The reasoning skills that accompany an understanding of class inclusion may have helped the children in the experimental group to profit from their teacher's classroom instruction, which was their main vehicle for learning numeracy and verbal skills, including phonics, during the 7.5-hr school day. Their ability to comprehend the teacher's lessons could have offset the 15-min control instruction in phonics.

Although it is limited, our preliminary evidence suggests that instruction in class inclusion has a measurable effect on children's reasoning abilities and on their school performance. The correlational evidence for this instruction effect applied only to first graders who did not already understand class inclusion. In this study, their gains in class inclusion varied. The children whose reasoning advanced the most tended to receive the best scores on standardized and teacher-reported measures of academic achievement. The limited class-inclusion reasoning of children in the control group did not develop enough during the schoolyear to be correlated with these measures.

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