COGNITION AND LEARNING IN INCLUSIVE HIGH SCHOOL CHEMISTRY CLASSES

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ABSTRACT

The purpose of this investigation was to compare outcomes associated with peer tutoring vs. teacher-directed instruction for secondary level students with mild disabilities in inclusive chemistry classes. Thirty-nine students of whom 10 were classified with disabilities participated in a 9-week chemistry unit, under either experimental or traditional instruction conditions. The same co-teachers, including one chemistry and one special education teacher during the regularly assigned chemistry classes, taught both classes. The students in the experimental condition participated in classwide peer tutoring of important content required on statewide high stakes testing. Mnemonic and other verbal cues were included to facilitate verbal recall, and peer questioning provided for comprehension and elaboration of the concepts. Post-tests revealed that students in the tutoring condition outperformed students in the traditional condition, and that the gains of the students with learning disabilities descriptively exceeded those of the typically-achieving students. Students without learning disabilities outperformed students with learning disabilities, and students scored
higher on factual items than on comprehension items. Implications for instruction and future research are discussed.

EFFECTS OF CLASSWIDE PEER TUTORING ON LEARNING IN INCLUSIVE HIGH SCHOOL CHEMISTRY CLASSES

Research has documented many effective instructional strategies for content area learning of students with learning disabilities. However, many challenges exist with respect to content area learning on the secondary level (see Mastropieri, Scruggs, & Graetz, 2003, for a discussion). One obvious challenge is the disparity between reading ability of students with learning disabilities, and the reading level of required reading materials in middle and high school. Many secondary students with learning disabilities read on an elementary grade level, but the adopted textbooks are at a much higher level. Frequently, secondary school textbooks have readability levels that are even higher than the assigned grade levels for which they were written. For example, Kinder, Bursuck, and Epstein (1992) reported that the readability level of eighth-grade social studies textbooks ranged from ninth grade to the third year of college, with a mean of a tenth grade level. Many researchers have noted that textbooks are the major instructional resource in classes (Bean, Zigmond, & Hartman, 1994; Okolo & Ferretti, 1996). Such findings highlight the enormous difficulties encountered by secondary students with learning disabilities.

Another challenge for students with learning disabilities is the unfriendly nature of many content area textbooks. Armbruster and Anderson (1988) reported that textbooks frequently lack “considerateness,” in that they are inconsistently organized, lack clear structure, provide insufficient definitions of important vocabulary, and require inappropriate skill demands of learners. Science and social studies textbooks typically emphasize breadth over depth in content coverage; consequently, enormous amounts of content are treated with little depth of coverage or elaboration. Content textbooks typically are at present not reader-friendly, but instead contain densely worded paragraphs that include an overwhelming number of concepts, facts, and details with insufficient explanation (see also Beck, McKeown, & Gromoll, 1989). Further, content area textbooks introduce an extraordinary number of new vocabulary words. Yager (1983) examined vocabulary introduced in science textbooks and concluded that more vocabulary words were intro-
duced in a single year of science than were introduced in the first year of a
foreign language class. For example, the following is from a high school
chemistry text:

In most polymers, like polyethylene and cellulose, the monomers are all identical. In
other cases, such as proteins, different monomers may be combined. Although the amino
acid monomers that make up proteins appear to be very different, each one has an amino
functional group and an organic acid functional group, so the monomers all link in the
same way, forming a “backbone” of carbon, nitrogen, and oxygen atoms. A polymer
with three amino acids is called a tripeptide (Tocci & Viehland, 1996, p. 257).

As dense and complex as this passage appears, it must be considered that
this single paragraph occupies perhaps 15% of the space of one page of an
848-page book, resulting in a text that is also overwhelming in the volume of
content presented.

Another challenge for inclusive secondary instruction is the pace at which
teachers proceed through the content. Commonly, a chapter is covered in a
single class session; recently, many teachers have felt compelled to increase
the pace of instruction because of pressures of end-of-school-year high-
stakes testing (Frase-Blunt, 2000). Some students find a new set of concepts
being introduced before they have had time to understand the previously
introduced content. Since the curriculum in many classes builds from unit to
unit, these students may fall farther behind peers and become more frus-
trated as the school year progresses. For example, in chemistry classes, if
students do not learn the initial concepts relevant to the periodic table of
elements, they will experience problems throughout the year as more com-
plex problems involving applications of the periodic table are required.

Peer tutoring has been recommended for improving content area learning
of students with learning disabilities. Differentiated from cross-age tutoring,
in which an older student tutors a younger student in academic skills, peer
tutoring serves to increase academic engagement and ownership of learning
among students of the same age. Within different tutoring configurations,
classwide peer tutoring has often been employed to enhance academic skills
of inclusive classroom settings, particularly for low achieving students.

However, much previous peer-tutoring research has targeted specifically
basic skills such as phonics and word reading (e.g., Scruggs & Osguthorpe,
1986). Peer tutoring has addressed reading comprehension strategies in in-
cclusive classes of diverse academic abilities in elementary grade reading
classes (e.g., Mathes, Howard, Allen, & Fuchs, 1998). Some previous peer
tutoring has also addressed factual learning in secondary content classes
recently, Fuchs, Fuchs, and Kazdan (1999) applied reading fluency and
comprehension strategies with peer tutoring with secondary students with
disabilities and obtained equivocal findings. Results of research to date ap-
pear promising with respect to increased academic time on task, academic
growth, and positive reports about tutoring from students and teachers.
However, little is known with respect to the use of peer-mediation strat-
egies to teach higher level content using elaborative strategies in chemistry at
the secondary level. The present investigation addressed a peer-tutoring
program in chemistry classes conducted within high school inclusive classes.
In this investigation, we attempted to integrate elaborative strategy instruc-
tion within chemistry classes using a peer-tutoring model for practice, given
the successful record of mnemonic and other verbal elaborations (Scruggs &
Mastropieri, 2000). For example, Scruggs and Mastropieri (1992) taught
students with learning disabilities and mild mental handicaps, information
about vertebrate and invertebrate animals using the keyword method. For
example, to teach that *tricina* is a parasitic roundworm that causes disease
and comes from undercooked pork, students were shown a picture of a
roundworm coming out of an undercooked pig and saying, “I have a *trick,*
I’ll make you sick!” In this case, *trick* was the keyword to help students
remember *tricina,* and the other information. Students taught by this meth-
od greatly outperformed students taught by traditional methods. However,
in that investigation, students received instruction from special education
teachers in self-contained special education classes, and classwide peer tu-
toring was not employed.

The present investigation was intended to employ quantitative and qual-
itative methods to determine the success of classwide peer tutoring in in-
clusive high school chemistry classes. Also of interest were teacher and
student perceptions of the experimental methods and materials.

METHOD

Participants

Thirty-nine high school students with and without disabilities participated
in the investigation. Ten of the students enrolled in the inclusive classes met
federal and state criteria for learning disability classification. Forty-eight
percent of the participants were males, and represented a range of racial and
ethnic backgrounds. Students spent a 90-min block period in chemistry
classes on a rotating day schedule, such that in 1 week chemistry class was
on Mondays, Wednesdays, and Fridays and the following week on Tues-
days and Thursdays. Students with disabilities spent their school day in inclusive classes. The IQs of the special education sample ranged from 84 to 122 with a mean of 104.6 (SD = 10.1). On the Woodcock-Johnson, reading achievement standard scores ranged from 65 to 121 with a mean of 94.9 (SD = 14.3); math achievement standard scores ranged from 85 to 122 with a mean of 101.9 (SD = 11.2); and written language standard scores ranged from 74 to 106 with a mean of 88.1 (SD = 11.0). Stanford 9 percentile scores for the entire group in reading ranged from 5 to 98 with a mean of 60.9 (SD = 24.4) (LD = 44.4, non-LD = 68.9); math scores ranged from 6 to 99 with a mean of 58.3 (SD = 27.6) (LD = 43.6, non-LD = 64.9); and science scores ranged from 1 to 99 with a mean of 65.7 (SD = 26.4) (LD = 52.1, non-LD = 72.2). The two classes did not differ significantly on any measure.

The chemistry classes were taught by the same two co-teachers: a chemistry teacher and a special education teacher. The co-teachers had previously worked together in inclusive chemistry classrooms.

Materials

Both conditions used the same textbooks and accompanying materials. The books by Tocci and Viehland (1998) (Holt Chemistry: Visualizing Matter) and by Smoot, Smith, and Price (1995) (Merrill Chemistry) were adopted by the school district for students enrolled in 10th grade chemistry. Teachers also used the standards of learning adopted by the state for guidance in selecting most important content to emphasize.

Traditional Condition Materials

Materials in the traditional instruction condition consisted of teacher lecture, class notes, class lab activities, and accompanying textbook materials. These materials consisted of worksheets that accompanied each chapter with fill-in-the-blank items, matching items, vocabulary, and short answer items. Teacher materials also included using a general model of teacher effectiveness, in that each day contained daily review, statement of purpose, and teacher presentation of information, guided, and independent practice. Teacher questioning, completion of the notes with assistance using the overhead projector was used, use of supplemental videos, and lab activities.

Experimental Condition Materials

Tutoring materials were developed based on previous research-based strategy instruction with special populations. Materials previously employed by
Greenwood and colleagues and Fuchs and Fuchs and their colleagues, and Mastropieri, Scruggs, Mohler, Beranek, Spencer, et al. (2001) were modified and adapted to meet the needs of secondary students in inclusive chemistry. Materials included lesson plans for introducing the rules and procedures, for identifying and correcting errors, for using elaborative strategies, and for recording daily progress with the information contained in the tutoring materials. All the participants received folders containing check-off sheets on which they recorded their progress with the information covered during tutoring. The specific content of the materials is described next.

Information identified by the teachers as critical for the school year was developed into tutoring materials. For the target unit, this content included, but was not limited to, thermic reactions, including exothermic and endothermic reactions, enthalpy, products, reactants, Mendeleev’s periodic table of elements, groups, periods, alkali metals, alkaline metals, metalloids, halogens, noble gases, transitional elements, mole, molarity, Avogadro’s number, and colligative properties.

Cards containing important concepts and related information were developed, including relevant elaborative strategies to enhance learning and recall of the information. Since comprehension of relevant content was considered to be very important, materials were designed so that they provided not simply question and answer on unit content, but also provided for elaboration and expansion on the answer, and provision of examples by the tutee. In this way, it was hoped that the materials would facilitate factual recall, but also a more thorough understanding of unit content.

Materials were designed so that strategies were included and would be used only if students required assistance learning the new materials. Otherwise, the tutor would simply proceed to the next question. For example, one card contained the question, “What is a mole?” the answer being, “Atomic weight in grams of an element or compound.” If the student did not answer correctly, the student was shown a relevant strategy, in this case a picture of a mole (the animal, a keyword for mole) sitting on a scale, next to a sign that read, “Your weight in grams is...” The tutor then read from the card to tell the tutee, “Think of the word ‘mole.’ Then, think of this picture of a mole on a scale looking at his weight in grams, to help you remember that a mole is the atomic weight in grams of an element.” The student was then asked to repeat the relevant information about moles.

Elaborative strategies were skipped if students knew the information when the tutor first asked the question, and the elaboration and comprehension questions displayed on the card were then asked. After the tutee answered the mole question correctly, for example, additional questions had
been printed on the card to promote comprehension of the target content. In this case, the question read, “What else is important about moles?” A possible answer was: “The mole serves as a bridge between the invisible world of atoms and the macroscopic world of materials and objects.” The next question read, “What is an example of a mole?” A possible answer included, for example, “O (oxygen) is atomic weight 16, so 1 mole O = 16 grams O.”

For another example, another card, to be shown after the mole questions, asked, “What is molarity?” the answer being, “the concentration of a solute in a solution; moles per liter.” If the tutee answered correctly, a picture was displayed (in this case, of a number of animal moles in a large beaker of solution), and an elaboration question was printed for the tutor to ask. If the tutee did not know the answer, the strategy was printed on the card for the tutor to review: “Think of the word ‘moles’ for mole, and remember the picture of a number of moles in solution, to remember molarity is the concentration of a solute in a solution, in moles per liter.” After further strategy questioning, the elaboration question was printed for the tutor to ask next. In this case, the question next read, “What else is important about molarity?” Possible acceptable answers included: “Molarity is a ratio,” or “Moles of solute divided by liters of solution.”

Approximately five cards were included in separately sequenced folders, such that when students finished with one folder they proceeded at their own pace to the next folder and so forth until they had completed learning the content for the respective unit of instruction.

Procedure

Once district, student, and parent permission were obtained, classes were assigned a treatment order to the two instructional conditions. Since one class was considered lower functioning than the other class, this lower-functioning class was assigned to the treatment condition to provide a more rigorous contrast. The intervention was conducted over a period of 9 weeks and included pre-testing, training, post-testing, and final exams. Since the high school used block scheduling, classes met for approximately 90 min on a rotating block schedule. Students in both classes were informed they were participating in a project designed to provide information on how teachers could be better trained to teach students in chemistry. Sessions were observed by project staff who recorded notes and videotaped classes.
**Traditional Condition Procedure**

During this condition, the teachers directed all aspects of instruction. Lessons began with a daily review, teacher presentation of new information, guided and independent practice, and lab activities. Students participated in answering teacher questioning of content, taking notes independently, and in completing relevant lab work. Relevant worksheet activities and student labs on the chapters were also completed.

**Tutoring Condition**

During this condition, all teacher presentations were the same as the traditional condition; however, time usually spent completing worksheets was devoted to the tutoring activity. Tutoring roles, rules, materials were covered, and students tutored one another using the tutoring materials. Teachers selected dyads such that only one student with disabilities was in a particular dyad. During tutoring the stronger students began by asking partners the chemistry content. Immediately following this, roles were reversed and the other partner asked the questions. Dyads proceeded through the materials independently, and recorded their performance on their recording sheets. When a set of approximately five pieces of information was mastered, students selected the next folder of materials.

**Data Sources**

Quantitative data sources included pre- and post-tests of chemistry content. The post-tests consisted of factual items and comprehension items, which were analyzed separately in this investigation. Qualitative data sources included videotapes, observations, field notes, surveys, and interviews.

**RESULTS**

Since pre-test scores were very similar across classrooms, and in fact favored the control condition, analysis of covariance was not conducted. Post-test data were entered into a two condition (experimental vs. traditional) by two group (non-LD vs. LD) by two item type (facts vs. comprehension) analysis of variance (ANOVA), with repeated measures on the test variable, which yielded significant main effects for condition, $F(1, 34) = 6.97, p = 0.012$, group $F(1, 34) = 6.89, p = 0.013$, and test $F(1, 34) = 11.36, p = 0.002$. Descriptively, experimental condition students outperformed traditional condition students, with mean scores of 22.4 (SD = 5.2) and 19.1 (SD = 5.4), respectively. Students without learning disabilities outperformed students
with learning disabilities, with mean scores of 21.9 (SD = 4.6) and 17.1 (SD = 6.6), respectively. Finally, students overall scored higher on factual items than on items reflecting comprehension of the content, with mean scores of 11.6 (SD = 2.6) and 9.1 (SD = 3.6), respectively (Table 1). No two-way or three-way interactions were found to be statistically significant. However, it was observed that the advantage of the experimental condition over the control condition for students with learning disabilities was 42.5%, while the advantage of the experimental condition over the control condition for students without learning disabilities was 16.1%. These means are presented graphically in Fig. 1 and reported descriptively in Table 2.

Some qualitative information was also collected from videotapes, observations, field notes, surveys, and interviews with teachers. On the surveys, the majority of the students agreed they enjoyed working together with

**Table 1.** Means and Standard Deviations by Condition, Group, and Item Type.

<table>
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<th>Variable</th>
<th>Mean (SD)</th>
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<tr>
<td>Condition</td>
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<tr>
<td>Tutoring</td>
<td>22.4 (5.2)</td>
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<tr>
<td>Traditional</td>
<td>19.1 (5.4)</td>
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<tr>
<td>Group</td>
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<tr>
<td>Normally achieving</td>
<td>21.9 (4.6)</td>
</tr>
<tr>
<td>Students with LD</td>
<td>17.1 (6.6)</td>
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<tr>
<td>Item type</td>
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<tr>
<td>Factual</td>
<td>11.6 (2.6)</td>
</tr>
<tr>
<td>Comprehension</td>
<td>9.1 (3.6)</td>
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**Table 2.** Means and Standard Deviations of Pre-test and Total Post-test Scores by Condition and Group.

<table>
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<th>Variable</th>
<th>Pre-test (SD)</th>
<th>Post-test</th>
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<td>Control condition</td>
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<tr>
<td>Special Ed.</td>
<td>3.92 (2.01)</td>
<td>13.63 (6.21)</td>
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<tr>
<td>General Ed.</td>
<td>5.06 (2.16)</td>
<td>20.44 (4.35)</td>
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<tr>
<td>Experimental condition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Special Ed.</td>
<td>3.88 (2.67)</td>
<td>19.42 (6.20)</td>
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<tr>
<td>General Ed.</td>
<td>4.41 (1.89)</td>
<td>23.73 (4.3)</td>
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partners, and felt that the extra practice with materials was beneficial. Some students felt they already knew the materials and wanted to proceed at a more rapid rate. Analysis of teacher reports revealed positive support for tutoring, citing for benefits teacher collaboration, student interactions, student enthusiasm, student learning, and use of elaborative strategies. The concern most frequently noted was some of the brighter students in the experimental condition might not have needed the tutoring practice (although analyses of the data indicated that students performed better with tutoring). Analysis of field notes and videotape records triangulated and confirmed information taken from student and teacher responses and journal entries.

**DISCUSSION**

The present investigation confirmed the effectiveness of a peer tutoring in chemistry conducted within a secondary inclusive class. When using tutoring materials that included elaborative strategies, students outperformed peers taught more traditionally on a post-test of content knowledge. In addition, teacher and student attitudes were overall very positive about tutoring. Al-
though the total number of participants was limited, results of the present investigation suggest that appropriately employed peer-tutoring programs can be used to increase comprehension and content area learning in high school inclusive chemistry classes. In sum, the results of this investigation suggest that students with learning disabilities can participate in classwide peer tutoring in inclusive chemistry classes, and that the performance of all students is improved under these circumstances.

Descriptive analysis of the data suggested that, while all students apparently benefited from the experimental condition, students with learning disabilities appeared to gain more from the intervention. This interaction was not statistically significant; however, this may have been due to the relatively small number of students with learning disabilities. Further research could address this issue. Students in both conditions scored higher on factual recall than on comprehension of chemistry content; no condition by test item-type interaction was observed; tutoring effects were apparently similar for both item types.

As students with mild disabilities progress through the grade levels to secondary school, they find less and less regular classroom time allocated to strategic instruction for learning the content area information. The results of the present investigation suggest that students in inclusive chemistry classes can tutor each other in critical content area materials, and that when they do so, their content area learning improves at a rate greater than that attained through more traditional instruction. Co-teachers of high school students should consider classwide peer tutoring as one important method for delivering high-quality instruction to all students.

AUTHOR NOTE

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REFERENCES


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