ELLs with Disabilities Report 16

Math Strategy Instruction for Students with Disabilities who are Learning English

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Introduction

Implementation of the 2001 reauthorization of the Elementary and Secondary Education Act, the No Child Left Behind Act (NCLB), has lent urgency to redressing the historic under-achievement of students with diverse cultural, linguistic, and exceptional needs. In Title I of NCLB, states, districts, and schools are required to give special attention to the instruction and assessment of specific groups of students often shown to exhibit minimal academic achievement. Moreover, to assure that such efforts exemplify the strongest academic rigor, programs designed to provide schools assistance must demonstrate that the teaching methods they use are "grounded in scientifically based research" (U.S. Department of Education, 2002, p.13). Clearly, a new level of expectation has been established to assure that schools are directing educational reform toward students historically underserved in public education.

English language learners (ELLs) and students with disabilities are two groups specifically targeted in NCLB for which schools must demonstrate "adequate yearly progress." However, ELLs with disabilities, a category where these two groups overlap, are not specifically mentioned in NCLB. Students with "high-incidence" learning-related disabilities (e.g., speech and language impairments, learning disabilities, and emotional/behavioral disabilities) in particular exhibit unique educational needs likely to place them at risk as schools strive to improve academic outcomes across the range of students specifically targeted in NCLB. With the rapid growth of the population of ELLs in the U.S., schools have an urgent need for research-based information on how to instruct ELLs with disabilities in grade-level content.

The Need for Research and the Purposes of this Report

To date, limited empirical research has focused on instructional strategies in mathematics specifically directed at improving standards-based academic achievement among ELLs with disabilities at any grade level. Research focusing on instruction in middle schools and junior high schools (grades 6–9) is particularly important given the higher level of academic demands in the secondary curriculum and the compounded difficulties for students with special needs. Today the students with special needs include the many ELLs who arrive in the United States at early adolescence with significant gaps in their prior education (McKeon, 1994).

This report describes a series of single-subject studies conducted to examine the effect of a mathematics instructional strategy, teacher-directed "think-aloud," on the standards-based academic achievement of Latino and Hmong ELLs with disabilities attending middle or junior high school. The study targeted students with disabilities participating in mainstream content classes using standards-based curriculum.

Background

Before discussing the relevant literature on instructional strategies, it is important to describe some aspects of the research process that influenced our choice of mathematics strategy for inclusion in the study. The research described in this report was developed based on the input of multidisciplinary teams of teachers in one Midwestern state who participated in small groups during the 2003–2004 school year (Thurlow, Albus, Shyyan, Liu, & Barrera, 2004). During these small group sessions, teachers were asked the question, "What instructional strategies do you use or do you recommend for teaching grade-level, standards-based content to middle school and junior high ELLs with disabilities?" Teachers used a structured brainstorming procedure, Multi-Attribute Consensus Building (MACB; cf. Vanderwood, Ysseldyke, & Thurlow, 1993), to develop and weight the importance of a list of recommended reading, mathematics, and science instructional strategies (Thurlow et al., 2004). Definitions of the strategies were created by the participants (see Thurlow et al., 2004 for a comprehensive list). These identified strategies served as a starting point for single subject intervention studies described here as well as other related research reported previously (cf. Shyyan, Thurlow, & Liu, 2005).

Procedures for the intervention studies were developed using established single-subject research methods (cf. Tawney & Gast, 1984) and were based on the mathematics strategies most highly supported through the MACB focus groups. Teacher-identified strategies were chosen both for their relatively strong support and the degree to which they could be "operationalized" into a specific procedure.

Strategy Definition: Mathematics Think-Aloud

The mathematics instructional strategy examined in this study was mathematics "think-aloud." During the Multi-Attribute Consensus Building process, teachers described this strategy as thinking through the steps of a problem and helping ELLs with disabilities to remember to follow each step. This strategy was considered relevant because students with learning disabilities, emotional behavioral disabilities, speech-language disabilities, and mild to moderate mental retardation who participate in grade-level mathematics instruction may experience difficulty performing basic mathematical functions, difficulty paying attention, or difficulty giving self-directions.

Through the MACB process, teachers came to the following consensus definition:

> Think-alouds: Using explicit explanations of the steps of problem solving through teacher modeling [of] metacognitive thought. For example: Reading a story aloud and stopping at points to think-aloud about reading strategies/processes or, in mathematics, demonstrating the thought process used in problem solving. (Thurlow et al., 2004, p.8)

Operationalizing Mathematics Think-Aloud For Use in Research

At the writing of this paper, no direct research could be identified on the effectiveness of mathematics think-alouds as an instructional strategy, especially for their use with ELLs with or without disabilities. A few studies were identified where think-aloud procedures were used as a tool to help researchers view the problem solving strategies of students with learning disabilities as they were solving mathematics problems. In one study that included students with disabilities, but not ELLs, Havertape and Kass (1978) recorded students' verbalized directions to themselves while solving problems and compared the procedures that students with learning disabilities used to those used by students without learning disabilities. Results of the study indicated that the responses of students with learning disabilities tended to be more random and unrelated to the problem than those of their non-disabled peers. Students with learning disabilities either did not appear to know of strategies for solving the problems or did not know how to apply the strategies they did know. They often guessed at solutions even when they had the knowledge to solve the problem.

Another study (Naglieri & Gottling, 1997) based on "PASS" information-processing theory (Planning, Attention, Simultaneous, and Successive processing; Das, Naglieri, & Kirby, 1994) examined whether teaching students with disabilities to plan mathematics problem solving would improve their problem solving ability. The researchers asked students to verbalize their problem solving strategies, then assigned scores to students depending on the level of planning apparent in the think-aloud of the solution.

Additional studies of this sort that did not explicitly focus on students with disabilities include Lawson and Chinnappan (1994) and Meijer and Riemersma (1986). Lawson and Chinnappan asked secondary mathematics students to verbalize their thinking as they solved geometry problems. The researchers then used the content of these think-alouds to analyze the effectiveness of students' problem solving behaviors. They found that low-achieving students had a harder time knowing which information in the problem was needed in the solution. Meijer and Riemersma collected student think-aloud data during problem solving and categorized these think-alouds by the type of student response in order to help develop an experimental program for teaching problem solving. The researchers provided descriptions of the processes students used to solve the problems. None of the studies described here taught students a think-aloud as a procedure for improving their mathematics problem solving ability and therefore the articles did not contain explicit procedures that could be used in a single case intervention of Mathematics Think-Aloud (MTA) for use in this study.

To design an appropriate procedure that teachers involved in this research could follow and implement, we reviewed research known as "self-instructional strategy development" (SI) or "self-regulated learning" (SRL). Different descriptions of self-instructional strategy development or self-regulated learning abound within the research literature and each description seems to contain slightly different elements. However, training students with disabilities to become aware of their own thinking about mathematics, otherwise known as "metacognition," appears to be an essential aspect of SI and SRL (Moore, Reith, & Ebeling, 1993). Students whose mild disabilities affect the learning of mathematics typically need individualized learning supports that focus on explicit steps in problem solving (Jarrett, 1999). According to Leon and Pepe (1983), self-regulated or self-instructional strategies may involve learning a list of solution steps; perhaps with a set of corresponding prompts that take the form of questions such as "What does the problem say?" Students are taught to ask themselves the questions aloud and continue thinking aloud while answering them. In the beginning, teachers model the use of the steps and apply the steps to a problem. Gradually, the teacher transfers responsibility for using the strategy to the student. Over time, the student internalizes the prompts and self-instructions so that he or she no longer verbalizes them aloud and the student independently uses the steps to solve problems.

The general think aloud procedures are applied specifically to mathematics instruction for students with disabilities in the work of Leon and Pepe (1983); Davis and Hajicek (1985); Case, Harris, and Graham (1992); and Braten and Throndsen (1998). All of these studies involved single-subject research, although Leon and Pepe (1983) aggregated findings from 37 students in single-subject studies. The students who participated in the studies had learning disabilities, emotional-behavioral disabilities, or mild-moderate mental impairment in most cases.

Three studies examined the use of this instructional strategy to increase student skills in mathematics (Braten & Throndsen, 1998; Case, Harris, & Graham, 1992; Leon & Pepe, 1983), while one (Davis & Hajicek, 1985) taught a behavioral self-instructional strategy to increase time on task when solving mathematics problems. A larger body of research on instruction and metacognition describes the importance of teaching students to focus on more "ill-formed" or abstract mathematics problems that do not prescribe a unique solution (cf. Moore et al., 1993). These research studies primarily examined the application of self-instruction or self-regulation procedures to mathematics computation problems in the basic operations of addition, subtraction, division, or multiplication. These studies indicated that students who used self-instructional strategies were more successful at solving mathematics problems than they were prior to learning the strategy.

Case et al. (1992) conducted a study that bears the most resemblance to the procedures we used in our research and is described in more detail here. This study involved a multiple baseline intervention across four students for two different behaviors. The study focused on correcting the incorrect choices of 5th and 6th grade students when solving addition and subtraction word problems. Students were taught a mathematics problem solving strategy that followed self-regulated strategy development procedures: (1) read the problem aloud, (2) circle the important words, (3) draw a picture to explain what is happening, (4) write down the mathematics problem, and (5) write the answer. Questions such as "What is it I have to do?" helped prompt the students to remember the steps. Overt teacher modeling of these steps took place first. Students then practiced the steps until they memorized them and together with the teacher they applied the strategy to addition word problems first and subtraction word problems later on in a separate phase of the intervention. Over time, the teacher support was phased out so that the student was using the strategy independently.

Students were next encouraged to transfer the use of the strategy to other class materials and report back about times when they had done so. Individual strategy instruction sessions took place two to three times a week for about 35 minutes each and continued for as long as it took each student to learn to apply the strategy to the addition or subtraction problems (approximately 2–3 hours per type of mathematics problem). A follow up probe was administered 2–3 months after students completed the strategy instruction.

The results of Case et al. (1992) indicated that students with learning disabilities in the study made gains in their abilities to solve both addition and subtraction word problems. In general, the students maintained a high rate of correct addition problem solving as they subsequently worked with subtraction problems during the intervention. Gains were also registered in transfer of learning to other settings but only for half of the students at a 2 to 3 month follow-up. The researchers concluded that the sequenced set of steps for word problem solving that was used in this investigation was beneficial in increasing student performance. Separating into two phases the types of problems to which the strategy was applied (addition, then subtraction) was beneficial as well. The researchers recommended booster sessions for students to maintain their skills after the instructional intervention.

Single-Case Studies Involving ELLs with Disabilities

This study was undertaken to answer the following research question: What are the effects of teacher-initiated instruction in, and student use of, a mathematics think-aloud strategy on the performance of ELLs with disabilities in grade-level, standards-based education? A secondary question was "How do teachers adjust the use of an instructional strategy to meet the individualized needs of a student?"

Based on our review of research, we developed a Math Think Aloud (MTA) strategy that could be used by several teachers for a range of standards-based mathematics objectives. We recruited one special education teacher and one English as a Second Language teacher to examine the efficacy of the MTA as a strategy to support the mathematics progress of students under their tutelage. For our study these teachers worked individually or in small groups with four ELLs identified with learning disabilities (the ESL teacher worked one to one, and the special education teacher worked with three students, but provided individualized instruction and progress monitoring). This type of learning setting, where teachers could adapt the lesson to meet a student's specific learning needs and could provide careful monitoring of student progress and intensive feedback about student performance (Hocutt, 1996), was considered an ideal condition for studying the effects of the MTA strategy.

Method

Single subject research (also known as single case research) was the core methodology of this study. This method is considered experimental rather than correlational or descriptive, and its purpose is to document causal or functional relationships between independent and dependent variables as applied to research with individual subjects (Campbell & Stanley, 1963; Tawney & Gast, 1984). Single case research employs within- and between-subjects comparisons to control for major threats to internal validity, and requires systematic replication to enhance external validity (Martella, Nelson, & Marchand-Martella, 1999). An additional feature of this research was to simulate the instructional assessment and planning process by conducting our training of teachers so that they could (a) identify a student's academic needs from the student's IEP and observed needs in meeting state academic standards, and (b) choose the appropriate strategy for a student based on these identified student needs.

Choosing a Strategy

The research team selected three mathematics instructional strategies derived from among the highest supported strategies identified through the prior study using Multi-Attribute Consensus Building with classroom teachers (Thurlow et al., 2004). Factors used in choosing strategies consisted of attributed levels of importance, feasibility, and use from the previous study; research support within the research literature; specific treatment needs of students identified by teachers; prerequisite skill requirements; and roles of teachers and students in employing each strategy. Table 1 describes the three mathematics teaching strategies initially chosen for the study.

Table 1: Selected Instructional Strategies

Mathematics Strategy	Definition
Problem solving instruction and task analysis strategies	Explicit instruction in the steps to solving a mathematical or science problem including understanding the question, identifying relevant and irrelevant information, choosing a plan to solve the problem, solving it, and checking answers
Teacher "think-alouds"	Using explicit explanations of the steps of problem solving through teacher modeling metacognitive thought; that is, demonstrating the thought process used in problem solving
Student-developed glossary	Students keep track of key content and concept words and define them in a log or series of worksheets that they keep with their text and to which they refer

After selecting the instructional strategies, the research team designed training sessions for teachers who were potential study participants at three middle schools; one in Minnesota and two in southern Texas. These sessions included the description of the theoretical basis of the study, study procedures, strategy definitions, checklists, and demonstration videos of each instructional intervention. Teachers had an opportunity to complete the preparation sessions and select one instructional strategy that they considered most effective and feasible for their students (whom teachers had identified as ELLs with disabilities). Two teachers participated in this study with four students using mathematics think-aloud strategies.

The training sessions resulted in teachers agreeing to use the mathematics think-aloud strategy. The teacher in Minnesota chose to work with one student of Hmong (Southeast Asian) background and the teacher in Texas conducted single case studies with three students of Mexican-American background. The four students who participated in the single subject research all were learning English. Some were currently designated as ELLs and were receiving specific services to address their language learning needs. Others were not currently designated as ELL but their teachers believed that they still had difficulties with academic work that were related to a lack of proficiency in academic English. Because processes for determining whether students are ELLs can vary across districts and states we accepted teachers' decisions about students to include in the study. However, we also collected available test data on each student.

To investigate the effects of the interventions, the research team used a baseline and intervention model for the strategy tested. Post intervention data were collected to examine maintenance of strategy effects. Students' standards-based test scores, pre- and post-curriculum-based measurement in basic skills for reading and mathematics, and ongoing performance outcomes were collected for the study.

Study Participants

This study involved six research participants: two teachers and four students identified with learning disabilities and limited literacy proficiency in English. The teacher working with the Hmong student in Minnesota (Student M) was a Chinese-American immigrant with roots in mainland China serving as the English as a Second Language resource teacher. Her area of secondary education expertise was mathematics and she had been teaching in secondary education for more than five years. The teacher conducted all mathematics pre-assessments and standards-based instruction for this study.

The teacher working with the Mexican-American students in Texas (Students T1, T2, and T3) was Mexican-American from southern Texas. This teacher served as a resource teacher for students with learning disabilities across a range of subjects including reading and mathematics.

Both teachers were fluently bilingual in their respective languages and English, but instruction was conducted primarily in English. The teacher and student in Minnesota were part of a community-initiated charter school sponsored by the local urban school district to serve a surrounding community with a large composition of Hmong families. The teacher and students in southern Texas were from a middle school in an urban school district on the Texas-Mexico border.

Table 2 describes several characteristics of the four students in this study in more detail.

Table 2. Characteristics of Student Participants and Their Most Recent Assessment Data

Student	Grade	Age	Ethnicity/Language	English Proficiency*	Reading Level*	Mathematics Level*
M	8	15	Hmong	Oral=3 *(19 pts, SOLOM)* Reading=3 *(237 TEAE reading)*	2.5 *(GE)*	25/75 *(514; low performance)*
T1	6	13	Mexican-American/ Spanish	Oral=4 *(LAS-O)* Intermediate *(706, RTPE)*	4-II (*Grade 4 Level II, SDAA II)* **	4-II *(Grade 4, level II, SDAA II)***
T2	6	13	Mexican-American/ Spanish	Oral=4 *(LAS-O)* Reading= Intermediate *(711, RTPE)*	3-III *(Grade 3, level III, SDAA II)***	3-III *(Grade 3, level III, SDAA II)***
T3	6	12	Mexican-American/ Spanish	Oral=1 *(LAS-O)* Reading= Beginner *(588, RTPE)*	1716 (*Did Not Meet Standard; TAKS)*	1728 *(Did Not Meet Standard; TAKS)*

*GE = Grade Equivalent, LAS-O = Language Assessment Scales-Oral, SOLOM = Student Oral Language Observation Matrix, TEAE = Test of Emerging Academic English, RTPE = Reading Test of Proficiency in English, SDAA = State Developed Alternative Assessment II, TAKS = Texas Assessment of Knowledge and Skills.

**The Texas Education Agency describes the levels of achievement on the SDAA in the following manner: "There are three achievement levels (I-III) within each instructional level…Level I: Few, if any, of the test questions were answered correctly (beginning knowledge and skills); Level II: Many of the test questions were answered correctly (developing knowledge and skills); Level III: Most or all of the test questions were answered correctly (proficient knowledge and skills)" (TEA, 2006).

Student M was a 15 year old U.S.-born Hmong girl in the 8th grade. She spoke Hmong as her primary language and was identified as an English language learner who also had a learning disability. Her tested English proficiency level based on the state-mandated Student Oral Language Observation Matrix (SOLOM, California Department of Education) was at level 3 in listening comprehension and speaking which the state classifies as intermediate English proficiency. Minnesota gives a state-developed test of proficiency in reading English called the

Test of Emerging Academic English (TEAE). Student M had scored at level 3 of 4 levels on the TEAE Reading Test on her most recent attempt in the previous school year. Teacher records indicated that her independent reading level was tested at 2.5 (equivalent to a student who has been in second grade for five months). Her scores on the statewide content assessment of basic skills at the time of the study were:

- **Reading Year 1:** 205 (state average 244.3), **Year 2:** 237 (state average 247.9)
- **Writing Year 1:** 21 (state average 23.4), **Year 2:** 19 (state average 23.8).
- **Math Year 1:** not available, **Year 2:** 25/75 or scale score of 514 (state average 632)

This student demonstrated low performance on all types of mathematics items except Shape & Space where she had correct answers for 6 of 7 possible items. The student was deemed by her teacher as a "quiet and cooperative personality" willing to work on improving her mathematics skills in this study.

Student T1 was a 13 year old Mexican-American girl in the 6th grade. Her oral English proficiency using the Language Assessment Scales-Oral (LAS-O, Duncan & DeAvila, 1990) was measured as fluent in Spanish (LAS 5) and proficient in English (LAS 4). She demonstrated intermediate reading skills on the state-developed English Reading Proficiency Test (RPTE). As a sixth grader, her English reading scores on the State Developed Alternattive Assessment II (SDAA II) were measured at the 4th grade level. Her mathematics scores (SDAA II) also placed her at the 4th grade level; fully 2 years below expected grade level at the time of testing.

Student T2 was a 13 year old Mexican-American girl in the 6th grade. Her oral proficiency using the LAS-O was measured as fluent in Spanish (LAS 5) and proficient in English (LAS 4). Her English reading proficiency test scores (RTPE) were at the intermediate range of proficiency for her grade level. As a sixth grader, her reading scores on the State Developed Alternative Assessment (SDAA II) were assessed at the third grade level. Student T2's mathematics scores (SDAA II) were also assessed at the third grade level; fully 3 years below expected grade level at the time of testing.

Student T3 was a 12 year old Mexican-American girl in the 6th grade. Her oral proficiency using the LAS-O was measured as proficient in Spanish (LAS 4). She was found to have "beginning" proficiency in both spoken English (LAS 1) and reading English (Beginning level, RPTE). This student took the regular state content assessment (TAKS) in reading and her score "did not meet the standard," according to Texas Education Agency specifications. Student T3's mathematics score (TAKS) also received a designation of "did not meet the standard."

Procedures

Pre-assessment baseline data were collected at the beginning of each study and post-assessment baseline data were collected at the end of each intervention. Pre-assessment data included the students' state test results, IEP records, and content area test results. In addition to frequent teacher observations and reports, three observations of each student were conducted by researchers using multiple checklists and assessment protocols. Appendix A includes assessment protocols for the two strategies.

Procedure for Student M

The think-aloud strategy with Student M was investigated using a modified baseline criteria design, A_1-B-A_2 (A_1 – introductory baseline, B – study intervention, and A_2 – modified concluding baseline; Tawney & Gast, 1984). The student did not possess some of the skills required by the mathematics content and the teacher was unable to collect some of the data during the pre-assessment stage. Gradually, Student M developed essential mathematics skills and the teacher was able to collect post-assessment data using modified criteria.

The study with Student M was conducted between the middle of January 2005 and the end of March 2005 encompassing 2.5 months. The content used in this study consisted of the Minnesota middle school academic standard relating to knowledge of fractions (i.e., "The student will…represent rational numbers as fractions, mixed numbers, decimals, or percents, and convert among various forms as appropriate," Minnesota Department of Education, 2005). Specifically, the focus of instruction was the ability to identify and convert proper and improper fractions (e.g., 95/10 = improper and 9 and 5/10 = proper). The teacher identified the following instructional objective for Student M: Given instruction in using a think aloud strategy, the student will first learn to identify, then learn to convert, proper and improper fractions using standard 20 to 25 problem sets. The criterion for performance was set at 90% accuracy.

At the beginning of the study, Teacher M collected pre-assessment baseline data. The teacher verified through this process that the student had no basic knowledge or skill for converting proper and improper fractions. Baseline, therefore, was set at 0. After collecting the introductory data, the teacher initiated the intervention by teaching the student the MTA strategy as she helped her learn to identify proper and improper fractions. The procedure was a two-step process. First, she taught the student to apply the MTA strategy toward differentiating between proper and improper fractions and then she had the student use the strategy to convert improper fractions to proper fractions.

The teacher started by defining the MTA strategy and helping Student M use it to identify different fraction types. At the beginning of the process, the teacher used direct instruction to explain and model the strategy, encouraging the student to follow along and demonstrate understanding of the strategy through teacher prompts. Gradually, the teacher emphasized collaborative work with the student as she became increasingly familiar and comfortable with the strategy. Finally, the student was asked to present the strategy and demonstrate her skills completely by herself. In the introductory stages, the teacher used a poster describing the strategy steps that had been prepared by the researchers. The poster was used as a graphic organizer to help the student remember to complete all the steps of the strategy. As the student developed the necessary skills, the poster was removed from the classroom.

The teacher determined the curriculum for this study based on collaboration with the student's mathematics teacher. At the time of the study, the student's mathematics class had just finished work on converting improper fractions to proper fractions after roughly two weeks of instruction. The student's mathematics teacher reported that the concept was first introduced in sixth grade and reinforced in seventh grade. However, at the start of eighth grade, half of the students (including Student M) still demonstrated difficulties in comprehending how to complete this particular calculation. The topic was considered particularly ideal because of the minimal English demands necessary for conducting a course of instruction. Finally, the student had demonstrated particular difficulties in retention of information. Hence, the teacher was eager to determine how a think-aloud strategy might help the student internalize her skill in identifying, and subsequently converting, proper and improper fractions. Materials used in this study primarily consisted of teacher-developed worksheets on proper and improper fractions and the poster illustrating the steps of the think-aloud strategy.

Procedure for Students T1, T2, & T3

The procedure used for students in Texas was a changing criterion design ($A_1B_1A_2B_{1-2}A_3$...) with the difficulty level as the changing criterion. The changing criteria were a function of the primary objective, which was set as "solving for an 'unknown' variable over the four basic operations of addition, subtraction, multiplication, and division." Competence at each set of operations was the basis for moving to the next set of operations. For example, students were provided instruction and strategy development to solve for an unknown "n" using addition (5+n = 25), then subtraction (25-n = 5), multiplication (5n = 25), and division (25/n = 5). In the case of the Texas students, the teacher believed it important to build competency in learning the strategy using content that was initially familiar to students so as not to compromise the students' self-confidence with baseline "failure" while developing new ways to learn. We note that this approach may in some ways confound initial results on monitoring progress of student improvement in the content area, but it seemed insightful of the teacher to implement this study in the context of her real concerns and knowledge about the students she was teaching.

The content objective was selected from the Texas Essential Knowledge and Skills (TEKS) (7th grade—111.23b2), which states, "The student adds, subtracts, multiplies, or divides to solve problems and justify solutions." In addition to the content objective, the teacher focused on teaching the students to use the strategy independently. Hence, she collected two sets of data, students' ability to solve problems and students' ability to use the strategy independently.

Students were asked to solve problems using the following strategy. An example of a multiplication problem is provided: 5n=50.

Step 1: Identify the variable and the kind of problem. (Answer: n, multiplication)

Step 2: What operation do you use to solve the problem? (Answer: the opposite of multiplication, division)

Step 3: What number is used to solve the problem and why? (Answer: 5, because it is next to the variable)

Step 4: Perform the operation on both sides of the equation.

The teacher modified the strategy when students experienced initial difficulty. For example, she simplified the language of the strategy for all three students. In addition, she translated the strategy into Spanish for student T3, because of her limited proficiency in English.

The teacher modeled the strategy (i.e., thinking aloud as she followed the steps), used guided practice as she checked for comprehension and utility of the strategy, provided opportunities for independent practice (i.e., homework), assessed students on mastery of the strategy and content, and provided feedback throughout. The teacher often prompted students to go to the next step after completing the previous one. Positive reinforcement (e.g., praise, gift certificate upon completion) was used throughout to motivate students. Instruction of the strategy took place over a four week period in the spring 2005 semester, with an interruption of one week for statewide testing after the first week of instruction (instruction lasted a total of 22 days).

Results

Results of each student are reported here in terms of performance during baseline and when instruction was delivered. Results that could be combined are aggregated for additional interpretation.

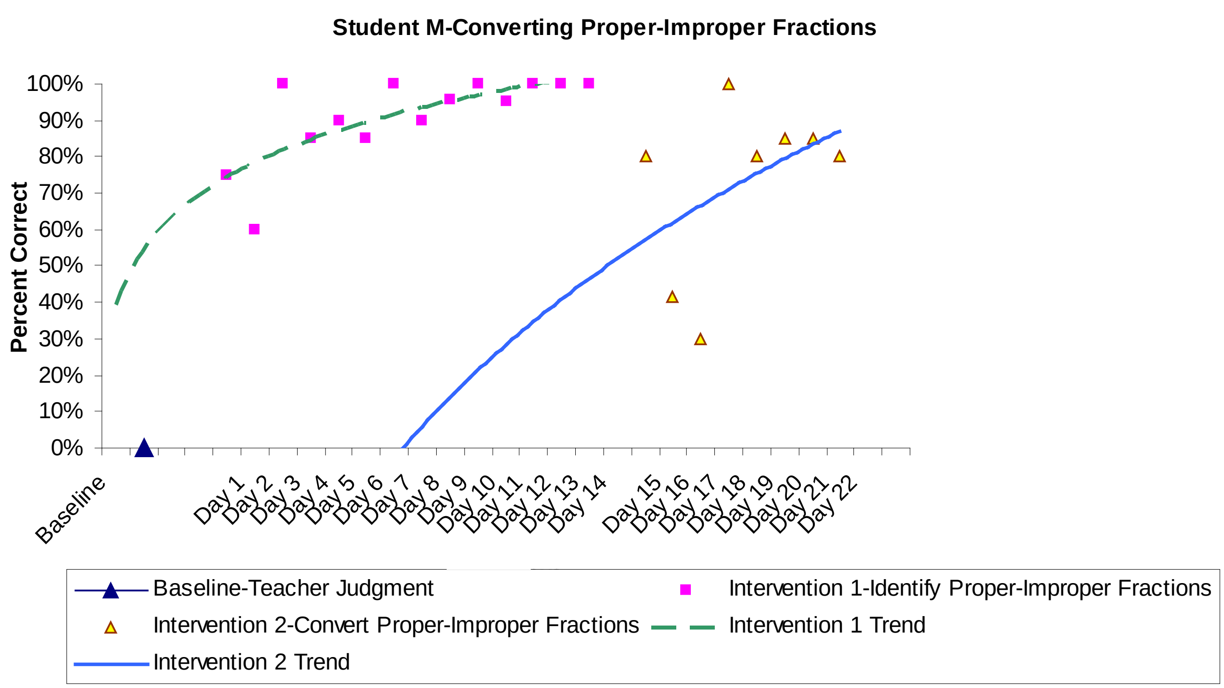
The four students in this study were all identified with learning disabilities and came from language minority backgrounds. At the time of the study the three Mexican-American students were not designated as ELLs. One of these students (T3) was tested as "beginning proficient" in English despite not having a designation of ELL. The Hmong student in this study tested at the initial level of English fluency as measured by the SOLOM and was designated as an ELL.

Each of the 6th and 7th grade students demonstrated significantly below grade proficiency in literacy and mathematics skills. Table 2 described student mathematics proficiency for all four students before the study. Student M (7th grade) was tested with the Minnesota Comprehensive Assessment (MCA) at Grade 7. Her proficiency in Mathematics was measured as low on most measures including solving of problems involving fractions where she scored 4 of a possible 10 points (8–9 = Medium, and 10 = High). Two of the Texas students tested with the Texas State Developed Alternative Assessment-II (SDAA II) in mathematics were found to be two to three years below grade level in mathematics. The third student in Texas had a score on the general state assessment which simply indicated she did not meet the grade level standard in mathematics.

Student M Results

Figure 1 illustrates the progress of Student M from pre-intervention through a two-tiered intervention; first, identifying proper and improper fractions and then converting improper fractions to proper fractions. Student M's baseline of 0 was determined by the teacher's initial review with the student on the conversion of improper and proper fractions. During this initial review, it was clear that the student was unable to convert even initial levels of proper and improper fractions; the teacher worked backward with the student and determined that she would first need to learn to identify the differences between these fraction types. The second set of data points beyond the first phase change line indicates the student's progress through instruction in

Figure 1. Student M—Converting Proper-Improper Fractions



identifying proper/improper fractions as measured by curriculum-based probes. Once Student M demonstrated consistent mastery in identification, the teacher initiated instruction on the conversion of improper to proper fractions. Those data are represented in the third set of data points beyond the second phase change line. As noted, the student underwent an initial drop in performance and then improved to maintain a level of 80% correct (range from 80 to 100) on improper to proper fraction conversions.

Students T1, T2, and T3 Results

The progress of students T1, T2, and T3 was tracked on two measures, strategy mastery and content mastery. The Texas students were assessed on content by having them complete 10 basic algebra problems using one of the four basic operations. Strategy mastery was assessed by teacher judgment using a rubric as a scale. A score of 1 was the lowest, where the student was judged to need the most teacher help. A score of 4 was the highest, where students were judged able to use the strategy independently. A maintenance check was conducted two weeks after the three week instructional period was completed. At the beginning of the study, the teacher determined that students had no facility in solving basic algebraic equations or in using the think aloud strategy before the beginning of instruction. Thus, baseline was set at 0 for content mastery and 1 (the lowest level) for strategy mastery. For each of the students, instruction and data collection were interrupted for one week while students took the statewide assessment.

Student T1 Results

Strategy mastery for Student T1 fluctuated between the lowest level (needing the most teacher prompting) and the next two higher levels (needing less prompting but still unable to use the strategy independently), until the last week of intervention, when Student T1 was able to use the strategy independently (score = 4) on the last two days of data collection (see Figure 2). Student T1 was also able to use the strategy independently two weeks later when maintenance of the strategy was assessed. Content scores for Student T1 fluctuated between 100% on the initial assessment after intervention and 75% on the second assessment. All subsequent assessments yielded 80% or higher, including 100% on the final two days of assessment (the final content score for each student was the maintenance check).

Student T2 Results

Figure 3 indicates that Student T2 experienced initial difficulty in using the strategy. She scored at the lowest level on six of the first seven days of assessment (achieving the 2nd lowest level on the 6th day of assessment), before using the strategy independently on consecutive days on the last week of intervention, in addition to the maintenance assessment. Content scores indicate a perfect score on the first day of content assessment, with a low score of 70% on the third day, and 95% correct on the other three days of assessment.

Figure 2. Student T1

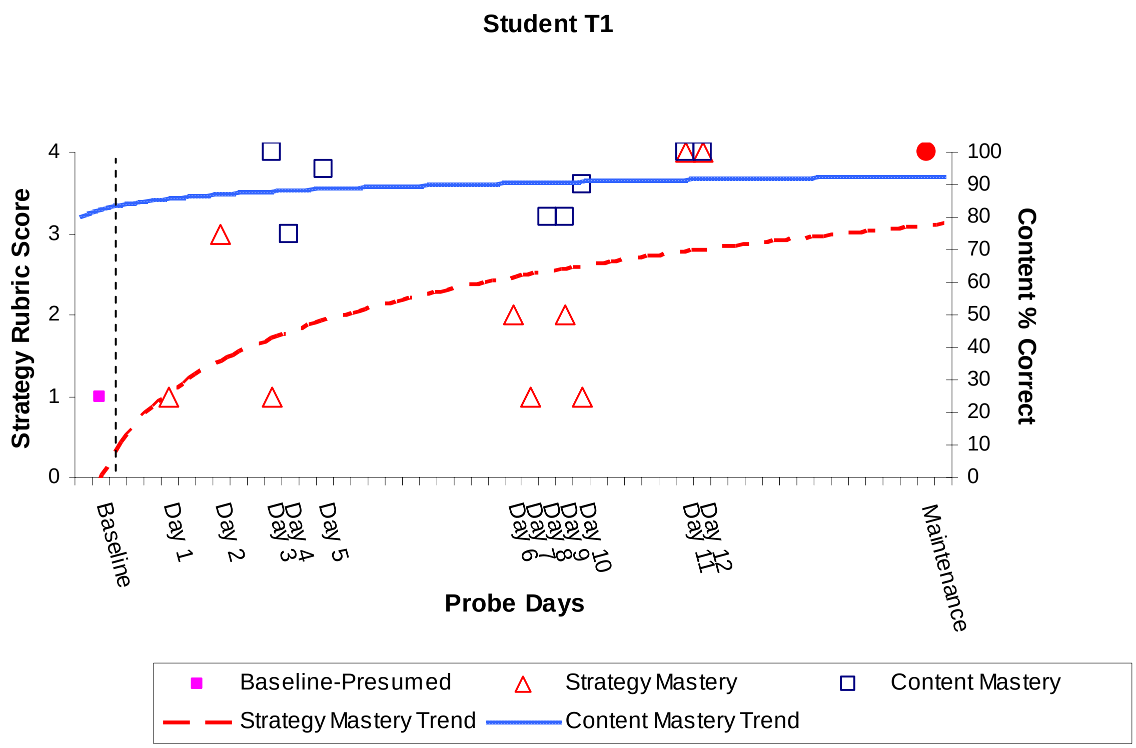
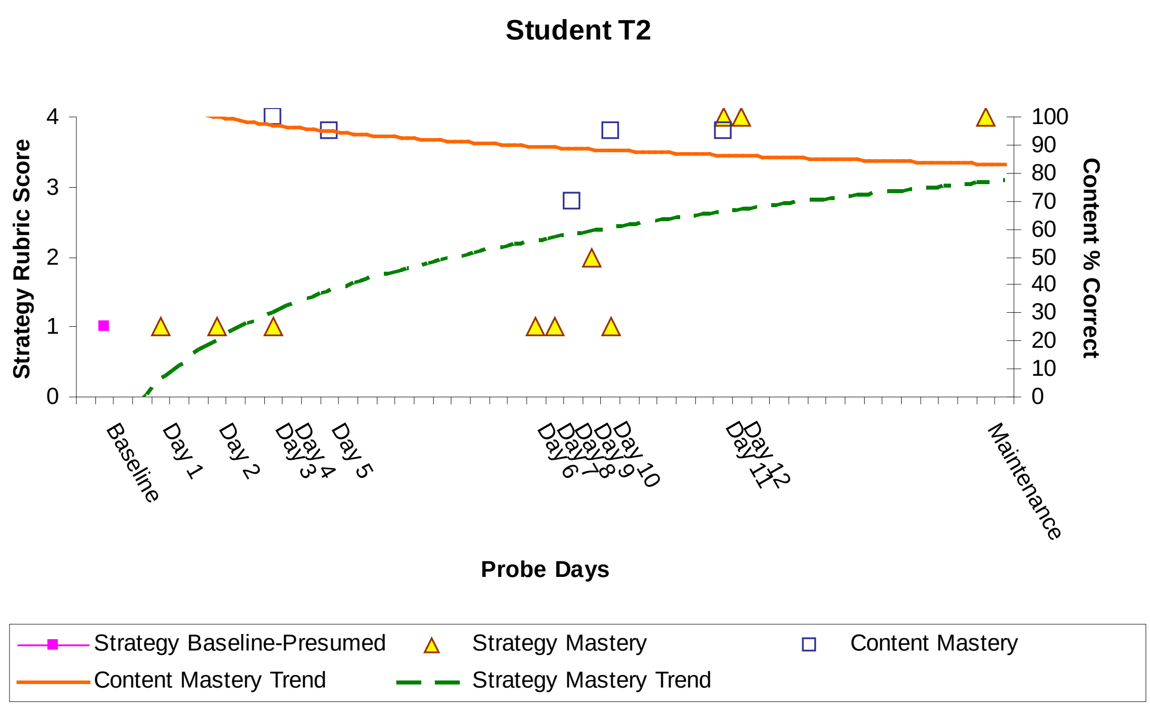


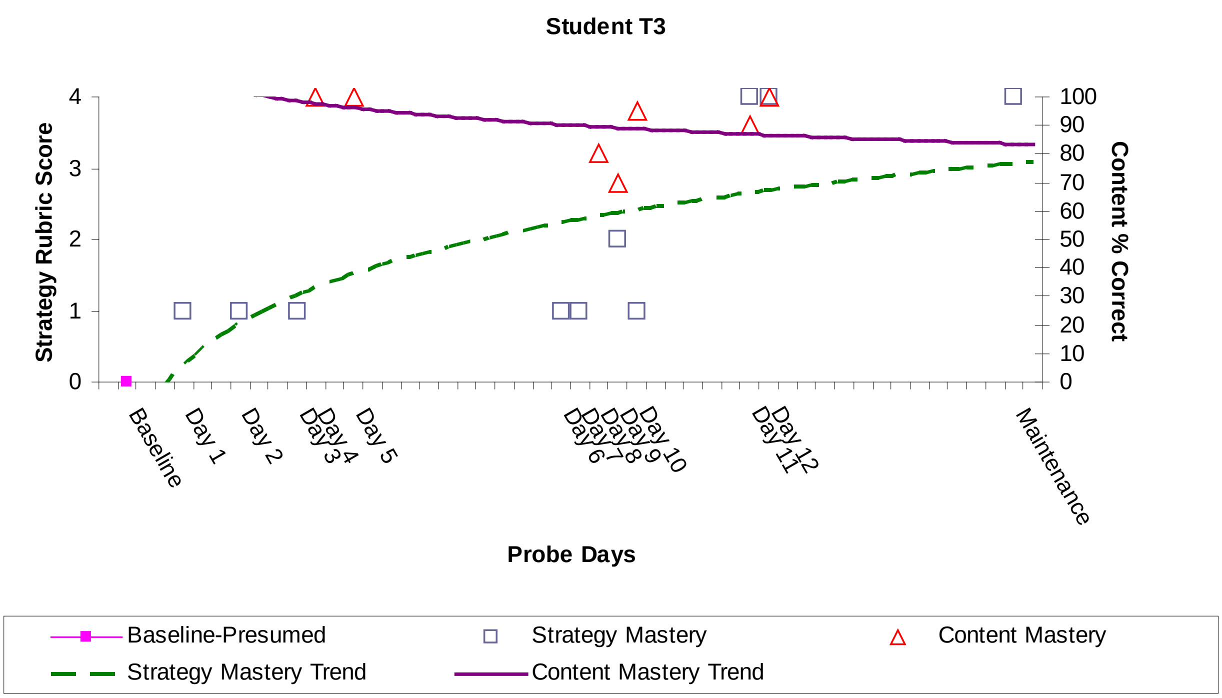
Figure 3. Student T2



Student T3 Results

Student T3 scored similarly to Student T2 on strategy mastery. She scored at the lowest level on 6 of the first 7 days of strategy assessment, before demonstrating the ability to use the strategy independently on consecutive days during the last week of intervention and at the time of the maintenance assessment (see Figure 4). On content mastery assessments, Student T3's scores ranged from 100% to 70%. His score on the maintenance assessment was 100%.

Figure 4. Student T3



Discussion

The first research question in this study was whether an MTA strategy initiated through teacher instruction and subsequent use by ELLs with learning disabilities would improve academic performance in meeting standards-based mathematics objectives. The process used by both teachers, despite some differences in approach, yielded positive results for the students in this study. Our results also yielded important information on the second research question—to examine how teachers adjusted their instruction to match the specific needs of a student.

In working with the Hmong student (Student M), Teacher M found it necessary to "work backwards" first when she identified the student's minimal prerequisite skill and knowledge in converting improper fractions to proper fractions. Teacher M decided to begin by using the MTA strategy to help the student gain the necessary pre-skill of recognizing the difference between a proper and improper fraction. Only after the student achieved at least an instructional level of mastery in this pre-skill did the teacher begin the use of MTA to master the primary objective—to convert the fractions. The results indicate that the student still required additional time to master the primary objective at the end of data recording. However, Teacher M believed that this substantial progress would bode well for future work as the student progressed through the individualized curriculum.

The teacher in Texas employed a different approach in accounting for her students' minimal skill in the primary objective (to solve for the unknown variable). Teacher T began instruction on the MTA strategy by gradually increasing the difficulty level of the content as students attempted to learn and master the strategy. This teacher believed it best for her students to develop strategy mastery by building in success for mastering new content. She began with less difficult operations such as solving an unknown in addition problems before moving on to more difficult levels of operations. As a result, the data show that content mastery was initially higher than the students' mastery of the MTA strategy and that content mastery would "dip" at later points even as strategy mastery began to increase. An interesting result in our data is that strategy mastery of the Texas students was not a "gradual" process where they showed initial low levels of competence to successively higher ones. In fact, in most cases the students' demonstration of strategy mastery came at the later stages of the intervention and was verified to remain high at a subsequent maintenance check. One explanation for this result may lie in the scoring rubric used to evaluate student mastery of the MTA strategy. It could be that the teacher was unable to discern truly different levels of pre-independent skill. It could also be that the teacher was lenient in her scoring of independent mastery at the end of intervention. This latter possibility was dispelled through independent verification of student mastery by a member of the research team who conducted observations of students' use of the strategy at the end of instruction and at subsequent maintenance checks. In any case, it was clear from our results that both mastery in using the MTA strategy and continuous skill improvement in solving for algebraic unknowns were accomplished during the course of this study.

One additional observation of the Texas students is that all three students appeared to understand the MTA strategy. Their content mastery improvement seemed to trend toward the 80–90% level; an "instructional" as opposed to an independent level of mastery (cf. Salvia & Hughes, 1990). Two factors may be involved in explaining these results. First, it is likely that attaining mastery in the MTA even at maintenance is simply not enough to promote more than initial improvement in content mastery. More and consistent time in using the strategy is necessary to bring students to results so often expected from strategy-based instruction (cf. Deshler, Schumaker, Lenz, Bulgren, Hock, Knight & Ehren, 2001). Additional time spent using the strategy would allow for the development of "automaticity" so that the student could use the strategy to meet academic goals (Kroesbergen, Van Luit, & Maas, 2004). Second, it is likely that ELLs with learning disabilities, in particular, will need more time to register academic improvements considering their levels of academic English proficiency (as registered by state assessments) and other aspects of their academic profile. In mathematics, two students had received alternative assessments (SDAA II) and two had taken their state's general mathematics assessment. All four students demonstrated below-grade level performance in reading, writing and mathematics. It may be that as the content of the mathematics tasks increased in difficulty, their ability to comprehend English-based instruction (the teacher reported providing English instruction primarily) might have had a limiting effect on their ability to improve content mastery.

The demonstrated growth of the Hmong student as she registered improvement in the prerequisite skill and subsequent improvement in the target skill is a further indicator regarding how best to conduct the instruction of strategy development toward improvement of academic outcomes. In that student's case, the teacher believed it important first to teach to the prerequisite skills necessary for meeting the target objective, which appeared to support the student's subsequent improvement in the content. Even so, the Hmong student also registered a trend to limited levels of mastery in the target content.

We think it is best to view the observed results as representing a "snapshot" of improving progress. Continued work would eventually demonstrate desired independent functioning in targeted academic outcomes. The fact that all of the students (Hmong- and Spanish-speaking) registered improvement in the use of the strategy, and that content mastery either improved or was maintained, indicates this process has potential for improved academic outcomes.

Limitations of the Study

As one of the few studies directly examining the use of instructional strategies with ELLs who also are identified with learning disabilities, the work described here should be viewed cautiously as an initial attempt to build a knowledge base regarding the successful instruction and learning of these students. Many more such studies should be conducted to develop such a base. In particular, this study incorporated features of earlier research on self-regulated learning with features of teacher-directed instruction as specified by the individualized needs of the students in the study. What is "generalizable" about this work may not lie in the specific manner in which the applications of instruction and strategy use were employed, but the more general approach to individualizing instruction and adapting instructional or individual learning strategies to the specific needs of the learner. For example, although the MTA strategy was the same in procedure across all four students, the way that the teacher in Minnesota conducted the process of instruction (one to one) was different from the process of instruction (small group to one teacher) employed by the teacher in Texas. A second difference was in the way that the two teachers approached the lack of prerequisite skills of the students. While Teacher M reverse-engineered her instruction to teach the prerequisite skills necessary to achieve the primary objective, Teacher T chose to provide initial instruction using content at a lower difficulty level. Both of these approaches were adjustments to the initial intents of this study. Finally, the process of instruction in Texas and Minnesota was often fraught with extraneous interruptions. Students in Texas in particular often registered absences and had at least one whole week in which instruction was interrupted by statewide testing. Hence, it is possible that results in this study were influenced by other unknown variables. At the same time, we are heartened to have observed learner growth through use of these strategies despite the observed difficulties under these all too often "normal" conditions of instruction.

Conclusions

The process and results of this study served the dual purpose of examining the efficacy of an instructional approach to support the mathematics think-aloud process and to examine how teachers might implement such a strategy in specific ways to support the individualized needs of their students. The "think-aloud" is a strategy identified by teachers who have worked with ELLs with disabilities (Thurlow et al., 2004) and suggested as a strategy within published scholarship on this issue (Gersten, Baker, & Marks, 1998). Yet, little empirical evidence has been provided to validate the use of such strategies with this or other similar groups of learners. We believe that our research begins to provide such a base of knowledge. It is hoped that the advent of improved instruction based on empirically-supported research will include further efforts to support the instruction of English language learners with disabilities.

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Observer initials __________ Teacher___________ Student __________

Math--Think Aloud Strategy Teacher Observation	
Explanation of what will be done No Yes	Unclear ... Clear 0 1 2 3 4
Explanation of why it is being done No Yes	Unclear ... Clear 0 1 2 3 4
Description of steps No Yes	Unclear ... Clear 0 1 2 3 4
Has predetermined list of vocabulary No Yes	**If yes: Use of key vocabulary** Frequency Rarely Sometimes Frequently 0 1 2 3 4
	Consistency All key vocabulary (100%)___ Some key vocabulary (99-50%)___ Minimal key vocabulary (under 50%)___
Exemplars No Yes	Has two identical, diverse sets___ Has one diverse set___ Has few that are similar___
Uses visual depictions No Yes	
Use of questions/vocabulary from Math Think Aloud Prompt sheet No Yes	Consistency Most/all phrases and questions (95%-100%)___ Some phrases/questions (50%-94%)___ Minimal use of phrases/questions (under 50%)___
Discussion of process No Yes	Minimal ... Thorough 0 1 2 3 4
Opportunity for students to contribute to prompt sheet No Yes	Minimal ... Thorough 0 1 2 3 4
Teacher directed oral problem solving No Yes	Unclear ... Clear 0 1 2 3 4
Think Aloud role-playing No Yes	
Supervision for role-playing No Yes	Inadequate ... Adequate

	0 1 2 3 4
Additional modeling provided NA No Yes	Inadequate Adequate 0 1 2 3 4
Follow-up discussion on Think Aloud process No Yes	Minimal Thorough 0 1 2 3 4
Self-Assessment rubric provided No Yes	
Comments on Student (Is student on task?)	
Instruction Environment (e.g., interruptions, firedrill, etc.)	

Teacher Lesson

	Explanation of what will be done and why
	Description of steps
	Oral description of steps while working
	Predetermined list of vocabulary
	Exemplars: (two identical diverse sets, has one diverse set, or has few that are similar) Uses visuals:

Student Check-in Sheet

Was explanation clear?	Did you understand what the teacher said about the strategy? Was the teacher easy to understand, hard to understand or in the middle?	Hard to understand — Easy to understand 0 1 2 3 4
Can student explain what the strategy is?	Can you tell me what a think aloud is and why you would do it?	No Yes
Can student explain steps?	If you explained think aloud to a friend, how would you teacher him/her how to do it?	No Yes
Student thoughts about key language:	Did you learn any new words today? Can you tell me words that were important? Etc.	
Other comments (brief)	What do you think about the Think Aloud strategy? Do you think it is helpful or not helpful? Why?....	