Teaching Math as a Language to Second Language Learners

Leonard Bumbaca
Glasgow Middle School
Fairfax County (VA) Public Schools
Submitted June 2000

Introduction

This study was performed as part of the GMU Language Minority Beginning Teacher Induction Project at Ellen Glasgow Middle School in Alexandria, Virginia. It was based on an investigation of how a focus on literacy development among language minority students can impact achievement in content areas.

Glasgow Middle School serves the Bailey's Crossroads, Falls Church, and Annandale communities and is one of three Fairfax County middle schools with grades six, seven, and eight. Fifty-six nations and 32 languages are represented in the student population. Ethnically, 29 percent are Hispanic, 21 percent are Asian, 9 percent are African American, 10 percent are Middle Eastern, and 31 percent are White. Interdisciplinary teams of teachers work with the same students, including special populations, and plan together. Glasgow also houses programs for gifted, ESL, learning disabled, and Spanish partial-immersion students.

Rationale and Question

In order to meet the learning needs of a diverse student population, it is crucial that the material be as accessible as possible. The challenges that second language learners face are compounded by the need to master academic content, language connections, and social skills concurrently. "For students to learn to communicate mathematically, they need opportunities to hear math language and to speak and write mathematically." (Buchanan & Helman, 1993) This study is part of a larger focus on literacy development among language minority students and its impact on achievement in content areas. Specifically: How does an increased focus on content vocabulary development improve achievement in math?

Connections to Existing Literature

Existing research and literature corroborated the methodology and findings of the focus of this paper, with one exception. The material was selected with the assumption that the primary challenges to student achievement would be language based. In fact, socioeconomic status was found to also be a key factor and was not addressed significantly in the literature selected.
Data Collection

Base line data was established from Program of Studies (POS) results from June 1999. Forty-eight students who were still enrolled retook a version of the POS to enable a direct comparison of the results. The tests were assessed for progress and special scrutiny was placed on a desired reduction of the differential between multiple choice and word problem performance. The material in the previous year’s POS directly corresponds to the material for which they are currently responsible because of the “spiraling” between years in Middle School Math. Such standardized tests of students with moderate English language proficiency or better can be considered valid so long as the information is not overly generalized (Llabre & Cuevas, 1983). Another measurement used was the Entry Assessment Mathematics Evaluation (EAME) assessment, administered to students at the beginning and end of the school year 1999 – 2000.

Instruction

It is very difficult to teach “math for math’s sake.” Behind the methodology of this study is a philosophy that is explicitly presented to the students: Math is a language to describe what one observes in nature, or what one needs to change one’s environment. It is a tool, like any other language, and is only as valuable as its product. Math literacy is about using and interpreting numbers to meets one’s goals and function successfully in society. (Smith, 1994) Language and literacy is the key to success in math where a higher level of reading comprehension has been shown to be associated with higher test performance. (Llabre & Cuevas, 1983)

Effective instructional strategies for literacy students include:

- Select mathematical tasks that engage students’ interest and intellect.
- Orchestrate classroom discourse in ways that promote the investigation and growth of mathematical ideas.
- Use and help students use technology and other tools to pursue mathematical investigations.
- Seek, and help students seek, connections to previous and developing knowledge.
- Guide individual, small group, and whole-class work. (Buchanan & Helman, 1993)

An emphasis on a small number of essential terms and symbols has been shown to significantly improve comprehension and achievement (Jackson & Phillips, 1983). The students are regularly exposed to math vocabulary and concepts through the use of glossaries, guided work in problem solving, decoding activities, and direct instruction in word attack skills. Vocabulary-oriented exercises are both easy to integrate into a Math curriculum and enhance rather than detract from the performance of students who perform less computational practice each day (Jackson & Phillips, 1983). Interdisciplinary connections are used at every conceivable opportunity to reinforce math applications and analogies to literary models.
Activities that have been most helpful have been those that are of personal interest to the student, and allow greater access to the larger learning “picture.” A combination of hands-on learning activities and real-life situations aid in conceptual development and problem-solving skills (Collier & Pateracki, 1998).

Examples by strand include:

- **Statistics**: Using school and district data to “read” statistics for growth, suspensions, mobility, ethnic composition etc., and make predictions and comparisons about their schools, and those of their friends.
- **Statistics**: Using census data to learn about their community.
- **Statistics**: Reading “USA Today” graphs presented as a *Power Point* presentation.
- **Geometry**: Developing vocabulary as it is used in constructions, modeling, and problem solving, and maintaining definitions in words that they understand.
- **Pre-Algebra**: Finding patterns and sequences, and describing the rules that each has to follow in their own words.
- **Problem Solving**: Applying logic, substitution, and group work to decode unrecognizable text with a minimum of contextual clues.

It is important to assume nothing about the foundation on which the student’s language is based. The math teacher must anticipate and explicitly address problems with idioms, acronyms, synonyms, and homographs (Tevebaugh, 1998). The use of rephrasing and oral emphasis in conjunction with various forms of visual display (such as overhead projectors) serves to reinforce concepts through as many media as possible, and reinforces the connection between the audible and the visible (Buchanan & Helman, 1993).

“Teachers must create a supportive and trusting environment in which students are not afraid of speaking out or risking failure” (Tevebaugh, 1998). This will encourage students to demonstrate what they do know, and build on those skills by identifying connections. These connections are essential, for where there is no connection between mathematics and other disciplines, students begin to see math in isolation, and become quick to “write it off” as irrelevant to anything they will ever need (Hackett & Wilson, 1995). I have often found in middle school that this process has already begun, and even students become complicit in this process. Hackett and Wilson go on to write: “Students feel that “writing does not belong in the classroom, and should only be taught during English class. This close-minded attitude may be a hindrance towards writing and communicating to understand mathematics” (Rothman & Cohen, 1989). One example of an effective and popular connection is the computer. This technology allows students to apply their hands-on knowledge through the use of *Geometer’s Sketchpad*, and allows them to reinforce their knowledge of constructions in a dynamic, and ultimately creative medium (Little, 1999).

The “core” of mathematical comprehension, however, remains in the use of language, as students interpret and decode symbols and relationships
expressed in the language of math to bring meaning from abstraction (Rothman & Cohen, 1989). For example, an algebraic expression can be shown to be nothing more than a number sentence (Rothman & Cohen, 1989). Word lists and extensive use of synonyms helps students recognize similar operations through various descriptions (Rothman & Cohen, 1989). Even quotations can be used to “alleviate narrow, educationally detrimental misconceptions of the nature of mathematics by illustrating its rich historical, aesthetic, humanistic, intellectual, artistic, philosophical, and epistemological aspects” (Fleron, 1998).

Instruction must also be aligned to the assessment tools used to measure progress. A wide variety of assessment tools is necessary to demonstrate what the students know, rather than relying on multiple choice style questions that serve to confine the students to a discrete set of terms that they may or may not understand (Buchanan & Helman, 1993). In other words, multiple-choice tests assess what knowledge the students have failed to entirely master, rather than what they actually know.

Findings

Students are using word attack skills with progressive frequency and success in classroom discussions. They are increasingly willing to take risks with the vocabulary and look for links. In tests, they spend extra time on problems, to check their work and make educated guesses. In the EAME and POS assessments, very few questions are left unanswered. Students struggling with a concept often try incorporating other math concepts and reasoning to get “partial credit.”

Table 1.

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>EAME 9/99</th>
<th>EAME 6/00</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
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<td>7</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>

Average Progress

Math Progress (years)

<table>
<thead>
<tr>
<th>Language Proficiency</th>
<th>B1</th>
<th>B2</th>
<th>C</th>
<th>Non LEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>5.2</td>
<td>6.2</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>5.0</td>
<td>6.5</td>
<td>1.5</td>
<td></td>
</tr>
</tbody>
</table>

The EAME results indicate that Math Eight students progressed between 1 and 1.5 years over the course of the school year, but the rates of progress seemed to differ significantly between students of various language proficiencies (See Table 2).
The data was further analyzed by the degree of school lunch subsidy as an indicator of the income level of the student’s home (See Table 4). The following graph clearly shows a major correlation between income and EAME progress (See Table 4 and Table 3, respectively). Other analyses that grouped students by income within language proficiency groups confirmed this pattern in every stratum.

Table 3. Pre and Post EAME Results

![Graph showing Pre and Post EAME Results](image)

Table 4. Average EAME Progress by Income

![Bar chart showing Average EAME Progress by Income](image)

This was a clear indication that the challenges students face learning in school go beyond those presented by language. EAME data has a limited range and, while it is quick to assess, does not lend itself to more detailed analysis.

The seventh grade POS test results further supported the interpretation that language was not the key determinant in the success of students on tests. In multiple choice questions, student scores improved from their results the previous year by a median rate of 9.6%, but disparities in these results were again accounted for by income levels. This was confirmed again within each language level.

Table 5. Average Multiple Choice Test Progress by Income

![Bar chart showing Average Multiple Choice Test Progress by Income](image)

Table 6. Median Multiple Choice Test Progress by Language Proficiency

![Bar chart showing Median Multiple Choice Test Progress by Language Proficiency](image)
At first this was very discouraging, because the progress of students who needed the most help was the least. On the other hand, it would seem that an absence of a language “barrier” is, in itself, an important observation. It seems that a more explicit and language based approach serves to “level” the playing field for second language learners.

The greatest surprise, however, came with an analysis of the word problem portion of the POS (part III). Word problem performance jumped tremendously because students are attempting more problems, taking more risks, making more connections.

One of the major reasons for the dramatic progress was the higher number of attempts and completion of answers. By refusing to accept blank work, students were pressed to write what they did know, and to think and work harder. It is essential that teachers model and expect effective problem solving skills, and provide activities in which persistence is reinforced (Buchanan & Helman, 1993).

Table 7.

<table>
<thead>
<tr>
<th>Language Proficiency</th>
<th>Word Problem Test Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>100.9%</td>
</tr>
<tr>
<td>B2</td>
<td>179.6%</td>
</tr>
<tr>
<td>C</td>
<td>52.5%</td>
</tr>
<tr>
<td>Non LEP</td>
<td>48.7%</td>
</tr>
</tbody>
</table>

Even more unexpected, was the area of exceptional growth. Students with the most limited language proficiency achieved the most progress in answering word problems, more than doubling their point scores in this portion of the assessment.

Considerations

There are areas of this research that could affect the significance of the findings. The cognitive development of students is a major factor in any learning. With an extra year, students could have developed a more mature sense of reasoning and a greater capacity for abstract thought.

While all the students seemed to work hard on the POS assessment, it was not as great a concern or point of focus as the SOL assessment taken only a few days before. With less pressure on the students, some may have performed better because they were more relaxed, while others may have had a difficult time focusing.

All the materials from the school year 1999 – 2000 were assessed by myself. While I have had a lot of experience grading these assessments, I did not
have a practical way of maintaining inter-rater reliability. The sample size is only forty-eight, and a larger study would be called for to further assess the benefits of language-based math instruction.

Implications for Further Study

Of immediate concern is how this data can be related to Standards of Learning Assessment (SOL) performance. Language minority students seem to be at a disadvantage in a multiple-choice assessment such as the SOL that does not allow for the expression or the choices of word and performance problems. These skills were the slowest in developing among students seeking to overcome social and linguistic challenges. It has been shown that an over-reliance on paper and pencil tests is not valid for second language learners, (Buchanan & Helman, 1993) and yet that will be the most important measure of their progress in their work towards a high school diploma.

The study also lends itself to a greater focus by strand, to analyze specific categories of content and modify the curriculum to meet those needs. Finally, I will work to ensure greater alignment of the curriculum to assessment tools in use to improve reliability and validity.

References


