Question
Does an overarching topic help contextualize the math to increase student interest and comprehension? The basic hypothesis was that by giving the context of how math is used, students would understand the purpose. By understanding the purpose, students' interest level would increase, which in turn would improve participation and comprehension. This is viewed as cyclic process, where students who are interested learn more and students who learn are more interested. A positive cycle of learning was created.

As the research progressed, two other questions emerged: “Do hands-on activities help to increase student interest and comprehension?” and “Does peer pressure associated with oral presentations motivate students to learn more in preparing them?”

Study and Implementation
The research project was designed to investigate how an overarching topic could increase student interest and comprehension. The project was conducted over two math chapters (Conic Sections and Polynomial Functions). In the control chapter on Conic Sections, an overarching topic was not used. In the Polynomial Chapter, polynomial functions were introduced by building a 4-ft high roller coaster in the classroom. During the entire chapter, the overarching topic was used extensively to model concepts being taught:

- Students watched a movie on roller coasters.
- Students were able to play with the roller coaster, and observe the shape, velocity, and acceleration.
- Students drew a roller coaster with a specific polynomial shape (example, a negative quartic roller coaster).
- Students answered questions on tests and quizzes about roller coasters.

To answer the secondary question, if hands-on activities would increase student interest and comprehension, several hands-on activities were used:

- Students measured a cardboard semi-circular tunnel and determined an equation to calculate the height at any location
- Students measured a map of the White House grounds to determine the foci of the Ellipse.
In the Polynomial Chapter, hands-on activities included:

- Students playing with the roller coaster, and observing the shape, velocity, and acceleration.
- Students drawing a roller coaster with a specific polynomial shape (example, a negative quartic roller coaster).
- Students creating polynomials that met different criteria during a game using wikki-sticks and white boards.
- Students investigating acceleration and velocity using CBRs.

The third question about how oral presentations can increase student motivation came up after the project started. Oral presentations were used as a method to measure student comprehension. However, once the presentations began, it was impressive to see how motivated the students were to appear knowledgeable in front of their peers.

Student interest and comprehension served as dependent variables. Students’ interest was measured using observation and questionnaire. During both chapters, the researchers kept a log about each day’s activities and how the students reacted. At the end of each chapter, students completed a questionnaire on which activities they enjoyed and which activities helped them learn. Student comprehension was also measured by responses on the questionnaire, test scores, and videotapes of oral presentations. The questionnaire asked students to rate their understanding of each topic in the chapter (Nothing, Some, Most, All). In both video taped chapters, students gave oral presentations in which they were required to complete a problem, describe how they solved it using key words, and respond verbally to higher-level questions.

Some data is difficult to compare because it was collected over two different topics. Both chapters were taught differently than previous chapters:
- More class days were spent
- More hands-on activities were used
- Each student did an oral presentation.

Literature Review

After selecting the research questions, the researchers pursued other articles and papers that would guide the study. The focus of an overarching topic was to contextualize academic concepts (Hamayan, 1990). The roller coaster model was intended to draw on students’ prior experiences and help them categorize the major concepts. For instance, sharing everything they knew about roller coasters with their other classmates. In an attempt to familiarize students with the new concept of polynomial functions by linking the overarching topic (Mohan, 1986).

Many of the hands-on demonstrations used were designed to integrate different learning styles and incorporate other content areas. The introduction to the roller coaster and CBR activity included many aspects of physics (a course many students were enrolled in during the study). The theory of Spatial Intelligence was used when the students were asked to draw the polynomial function (Ormrod, 2000). The wikki-stick game and tunnel activity used the “spiral” fashion of learning. Manipulatives allow
students to develop conceptual understanding of concepts, making better connections between abstract symbols and the concept (Kelly, 2002).

The initial purpose of the oral presentations component of the project was to further document research findings. It was not until after the first set of presentations that the social and peer-relation implications of the presentations was realized. Lev Vygotsky proposes that learning is primarily a social and cultural process (Pransky, 2002). All communities do not think, believe or learn in identical ways and even students in a multicultural classroom can be confused and misunderstood due to language, culture and socioeconomic differences (Delpit, 1996). The usage of keywords during oral presentations create rich language experiences that foster higher-level thinking and make connections between language and the academic concepts (Kelly, 2002). Constructivism is a theory of knowledge and learning where children construct their own understanding of the world. (Brooks & Brooks, 1999). Teachers can create appropriate learning contexts so students can construct or scaffold their own understanding of academic concepts. The clues provided during the tunnel activity and questions asked during the oral presentations were designed to have students construct meaning for themselves.

Finally, the use of games, such as the wikki-stick activity, was designed to create a positive learning environment. The game was designed to encourage students to participate in their own learning. Though competitive, the team component of the game created a low stress, safe, fun environment yet still allowed for learning to occur. This type of activity helps students cope with mathematics anxiety. Small amounts of anxiety, facilitating anxiety, often improve performance and comprehension. Students approach their classwork carefully and think about their responses in a thoughtful and reflective fashion when asked to complete tasks with low levels of anxiety (Shipman & Shipman, 1985). Before students were asked to give their oral presentation, the researchers modeled a typical presentation, gave the students sample questions, and reduced the class size observing the presentation all in hopes of keeping the anxiety levels below the debilitating, destructive level.

Results

Student Comprehension

Student comprehension was measured using three methods: student questionnaires, test scores, and qualitative differences in oral presentations. Although the student questionnaires showed no significant difference in student comprehension, both the test scores and the oral presentations showed a significant improvement in our experimental chapter.

The questionnaire gave each student an opportunity to rate their knowledge on different concepts in each chapter. Below is a sample questionnaire used to evaluate Chapter 8:
Nothing | Some | Most | All
---|---|---|---
The shapes of different degree functions | | | |
The effect of a positive or negative leading coefficient on graph | | | |
Different methods to find zeros of a polynomial | | | |
Composite of functions | | | |
Inverse of functions | | | |

Next, test grades were used to measure student comprehension. The experimental chapter had significantly higher test scores than the other chapters:

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Mr. Collins’ Test Grades</th>
<th>Ms. Consoletti Test Grades</th>
<th>Mr. Collins’ Filming Grades</th>
<th>Ms. Consoletti Filming Grades</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter 5</td>
<td>Control</td>
<td>68.77%</td>
<td>70.06%</td>
<td></td>
</tr>
<tr>
<td>Chapter 6</td>
<td>Control</td>
<td>73.00%</td>
<td>70.50%</td>
<td></td>
</tr>
<tr>
<td>Chapter 7</td>
<td>Add Filming</td>
<td>73.00%</td>
<td>71.83%</td>
<td>87.70%</td>
</tr>
<tr>
<td>Chapter 8</td>
<td>Experiment / Filming</td>
<td>82.15%</td>
<td>83.16%</td>
<td>82.28%</td>
</tr>
</tbody>
</table>

The quality of oral presentations also showed improvement. For example, in one LEP student’s presentation on conics, he showed very little understanding about how to graph a circle. He was supposed to graph a circle with the equation \((x + 2)^2 + (y + 2)^2 = 36\). His graph was correct; however, he incorrectly pointed to the \((h, k)\) values. In addition, when asked a higher-order question about whether the center was a solution he answered incorrectly that it was. He did not show an understanding of this topic.

In his oral presentation on polynomial functions, he showed a remarkable improvement in his understanding. While pointing at the graph of his polynomial function, he said, “it was a positive quartic function”, that “it had 2 mins and 1 max”. He pointed out and gave coordinates for the both minimums, the maximum, and the 4 x-intercepts. He said that he had to adjust the window in this calculator because one of the minimums was “really far down there” (it was located at (-8.2, -1686.2)). He showed
an impressive ability to adjust the window, graph, and table. It was an excellent presentation.

**Student Interest**

We measured student comprehension using two methods: student questionnaires and teacher logs. The questionnaire asked students whether they enjoyed certain activities and if they felt they had learned the material presented. Overall, students rated themselves as enjoying and learning during all of the hands-on activities. Students enjoyed watching others and learned during the oral presentations. Even though the students did not all enjoy doing oral presentations, most felt that they learned from preparing their own and from watching others.

In the teacher logs, the researchers wrote daily comments about each activity. The logs recorded the daily agenda, how things went, what went well, possible adjustments for next year, who seemed interested that day, and who did not pay attention. Many students paid attention and did classwork every day. Keeping the log helped researchers see which activities kept more of the “at-risk” students on task. In Chapter 7, the only activities which held everyone’s interest were the group tunnel activity and the oral peer presentations. During the tunnel activity, students began questioning each other with confidence, taking responsibility for their own (and the group’s) learning. In Chapter 8, students were really excited on the first day when they saw the roller coaster. Other activities that held everyone’s interest were the drawing roller coaster activity, the wikki-stick game, CBR activity, and the presentations. In Chapter 8, more students participated throughout the chapter even when a special activity was not planned. Since students had a greater understanding, the researchers conclude that students were more comfortable answering questions and doing classwork.

**Summary**

Oral presentations proved to be the most effective strategy for student comprehension and interest. Peer relations encouraged students to become more informed on key words and concepts. The requirement to use keywords, encouraged students to comprehend deeply, not simply memorize, important vocabulary. The roller coaster drawing project increased student interest and comprehension. Students enjoyed using their artistic abilities. By requiring each drawing to match a specific polynomial function, students gained an understanding of the different shapes of polynomials. The roller coaster tunnel activity demanded student collaboration to solve a challenging problem. Clues were optional, but reduced group grade. Students were encouraged to figure out solutions for themselves. Students enjoyed the Wikki-stick competition. By requiring each group member to quickly draw a different polynomial function, students collaborated and learned in a fast-paced fun environment.

In summary, the addition of an overarching theme, hands-on activities, and oral presentations significantly increased both student interest and comprehension. Students scored 16% higher on unit test when the three principle research teaching strategies were employed. Students scored higher, but more importantly, were able to answer the critical thinking questions during the second oral presentations. Based on observational logs, student interest increased when manipulatives and oral
presentations were employed. Student questionnaires indicate that a majority of students agreed they learned from giving oral presentations.

References
Hamayan, E. V., Perlman, R. (1990), Helping Language Minority Students After They Exit from Bilingual/ESL Programs: A handbook For Teachers. NCBE Program Information Guide Series, Spring (1).