

Case Study #2:
A Classroom Re-design

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Learning Problem:

The researchers of MMAP were disappointed with the unexpected learning outcomes of the Antarctica unit. There are three aspects of the learning problem experienced by the teachers, students, and researchers during implementation of this unit:

- teachers thought that the unit insufficiently covered the needed math content
- students were unable to recognize connections between the content of the Antarctica project and formal mathematics
- researchers believed that teachers did not maximize the teachable math opportunities that presented themselves naturally during the group activities
- parents were concerned about the change in the instruction of mathematics

Goals:

We believe the visions of MMAP are important but the outcomes unexpected. We have designed a program that incorporates the current Antarctica unit with traditional mathematics. We hope that teachers, students, researchers, and parents find value in this curriculum. To achieve this, our curriculum is grounded in our desires to:

- permit teachers to feel confident and comfortable with the content being taught by stating clear math objectives
- permit students to apply basic skills learned through computational operations to real-life problems and applications
- engage parents in the learning process

Proposed Redesign:**Parent involvement:**

We understand that the parents may be surprised at the seemingly changed math curriculum. We intend to alleviate their anxiety by keeping them informed about the objectives and progress of their children and involved by having them participate in the expeditions. We suggest that teachers send a parent letter before the unit begins to inform them to expect changes in the types of homework and activities during math class. Besides information, rationale should be supplied as to why these changes are occurring. Parents need assurance that the change is guided by sound reasoning. Parents will also be encouraged to spend time in the classroom helping students as well as observing the math curriculum. Not only will this participation provide assurance, but also it will provide parents with an accurate understanding of their child's math skills.

Teacher training:

One aspect of the learning problem was that researchers believed teachers missed many teachable math opportunities. An explanation for this is that many teachers are not familiar with the different methods of teaching required of such a curriculum. In order to better prepare teachers to succeed in a more flexible

curriculum, we propose a series of workshops to educate teachers. The training structure will mirror the proposed structure of our curriculum to provide teachers with an authentic experience. A facilitator will lead the teachers in group activities as well as directed instruction.

In order to motivate teachers to embrace our proposed curriculum, the facilitator will present the objectives of our curriculum, clearly linking the concepts and skills to be taught with state standards. In this way, teachers will feel confident that the necessary math skills will be accounted for.

Teachers will be asked to solve the actual expedition problems working in small groups to simulate what the students' experience. Teachers will also engage in role-plays allowing for them to practice their new role as both a facilitator and instructor. After experiencing the expedition problems and role-playing, the teachers will collaborate to create a teaching agenda to be used within their classrooms. By working as a group to create this guide, teachers will be able to incorporate new perspectives and methods. Similar to student journal use, teachers will also be encouraged to use journals throughout the year to reflect on successful or unsuccessful activities of methods. By recording this feedback, researchers and teachers can improve the curriculum in a subsequent redesign.

To support teachers in the class, a technology expert will be available to solve any technical software troubles. Incorporating the consistent use of computers into teaching can often make teachers feel uncomfortable and leery. By making a *person* available, teachers should feel more secure in the proposed curriculum. With comprehensive, motivating training workshops we hope teachers will enjoy the proposed curriculum and seize the many math opportunities to build students' skills and understanding in unique ways.

Summary of curriculum:

The curriculum we propose involves a synthesis of drill and practice of computational skills and open-ended, complex application problems. -The important math ideas include proportional reasoning, algebra, mathematical communication, computation, geometry, and measurement (Goldman and Berg, 1997). The specific skills that will be learned include:

- Area and perimeter
- Units of length and conversion of units
- Conversion between Fahrenheit and Celsius
- Scale
- Independent and dependent variables
- Reasoning with "constraints"
- Analyzing graphs, spreadsheets, and equations

Simply by incorporating this element of structure into the curriculum teachers and parents will feel confident and comfortable that all necessary math facts will be learned.

We propose that the curriculum be divided into weekly units, called expeditions. Each expedition will revolve around a complex, open-ended problem that students will work to solve in teams of three or four. Expeditions will progressively get more difficult throughout the course of study as students grasp various complex concepts and skills. In this way, students will gradually build upon their foundation of math skills. Teachers will use guided instruction, drill and practice, and collaboration to teach students the specified math skills. Each expedition will involve manipulatives and actual construction of models to enhance students' mental models. We propose the following framework for each expedition.

Day 1:

Students are given a pre-test involving the skills to be learned in the expedition. The pre-test will be in an open-ended question format. Teachers will evaluate students' ability to reason and solve basic computational skills.

Groups of three or four students will be presented with a complex, open-ended problem. They will be given time to explore the problem, hypothesize, discuss, and argue various solutions. The groups will remain the same for the entire expedition.

Homework: Students will be asked to reflect on the group meeting in their math journal. Students can choose to describe the process undertaken, the possible solutions or the arguments raised.

Day 2:

Students will begin class with a warm-up activity led by the teacher. The activity can vary depending on many factors. For instance, if the pre-test results showed that many students completely did not understand the concept of area, the teacher could present a simple problem introducing area. The activity is intended to be a brief exercise to spark reasoning and thinking skills on a mathematical level. Each activity should be exciting and motivating, grabbing students' attention and interest in math. The correctness of the answer should not be stressed instead teachers should pay close attention to students' justification of answers.

After the warm-up exercise, the teacher will lead a guided discussion of a certain set of concepts and skills. The teacher will ask groups to share their initial ideas on how to solve the problem. The teacher will then clearly explain the principles behind a specific skill. Students will then independently practice the skills with worksheets. The teacher will move through the room answering questions and noticing mistakes.

Homework: Students will be asked to complete more drill and practice worksheets.

Day 3:

In groups, students will begin the day by taking a quiz. Collectively students will solve problems. By asking students to work in groups, peer teaching and collaboration will need to occur.

Students will spend the rest of the class period working in groups to solve the expedition problem. The goal is that students will apply the current skills they are learning as a class to the complex expedition problem. The expedition problem will require that other previously learned skills and skills perhaps not yet formally introduced be incorporated to solve the problem. In this way, teachers can capitalize on math opportunities as they arise.

Homework: Students will reflect in their math journals on what aspects of their group problem-solving process changed after day one. What accounted for these changes? Did the group arrive at a solution?

Day 4:

The class will begin with a warm-up journal activity. A guided discussion will follow reviewing key concepts and skills of the lesson. Students will spend the remainder of the class finishing the expedition problem.

Day 5:

Day five will culminate the math unit and involve an assessment activity. The teacher can assess students' mastery of expedition concepts and skills in many ways. Groups can present their solution and support to the class or groups and/or individuals can solve a near transfer problem. The evaluation will help teachers understand the specific skills or concepts still not mastered. This information can contribute to the design of future expedition problems.

Homework: Students will be asked to write about the skills and concepts learned in the expedition. By reflecting on their learning, students will solidify their mental models of explored math ideas.

It should be noted that the five-day plan outlined above should be used as a framework. Some math concepts may be too complex to effectively cover in a week's time. Expeditions can span over extended periods of time so long as a balance between guided instruction, drill and practice, and collaboration is achieved.

Elaboration on key features of the class:

We want to ensure that computational drills are taught in the context of real problems rather than in isolation. To achieve this, we suggest the following components be implemented:

Key feature	Rationale
Journals	<ul style="list-style-type: none"> • Allow students to respond to computational and open-ended questions. • Can be used as an assessment tool for individual work • Can be used to communicate about group projects • Can be a quick assessment tool by the teacher to determine the climate of the class • Teacher can collect journals and share with the class various ways that students solve the same problem • Accommodate different learning styles by allowing students to participate in his/her own way
Team building	<ul style="list-style-type: none"> • Essential part of Antarctica unit • Adolescent students want to feel valued and respected by their peers • Team points will be awarded for individual improvement on quizzes to empower and motivate all students. As Bellamy states, "Part of the power of collaboration appeared to be increased self-assessment of work because it was being subjected to peer assessment." (Bellamy, 1996)
A variety of materials and manipulatives	<ul style="list-style-type: none"> • Include journals, building materials, teacher directed lessons using the whiteboard to accommodate different learning styles and presentation of material in a variety of ways
Homework	<ul style="list-style-type: none"> • Spiral content to reinforce previously taught concepts • Review in class 5 minutes while students respond to a journal prompt. Assigned homework should be doable by the students with relatively few problems.
Software	<ul style="list-style-type: none"> • Drill and practice activities will allow for students to practice computational skills
On-going, varied assessments	<ul style="list-style-type: none"> • Students have multiple intelligences and should be evaluated by such • Pretests to determine individual learning plans. (If student already knows concept, can do enrichment activity. All enrichment activities will be available to all students.) • Group tests to promote inter-group reliance and conversation of ideas. • Journal responses to open-ended questions. • Checklists about group project

Summary of features, perspectives, and design principles:

Feature	Learning Perspective	Design Principle
Teacher training	Situative	Coaching, modeling
Teacher agenda	Cognitive, situative	Modeling, metacognition
Math journal for students	Cognitive	Mental models, metacognition
Math journal for teachers	Cognitive	Mental models, metacognition
Pre-test	Behaviorist	Sequencing
Warm-ups: introductory activity	Cognitive or behaviorist (depending on activity)	Mental models or drill/repetition
Wrap-ups: culminating activity	Cognitive or behaviorist (depending on activity)	Mental models or drill/repetition
Group work (teams)	Situative	Collaboration, reciprocal teaching, apprenticeship
Student presentations	Situative, cognitive	Collaboration, metacognition
Group quiz	Situative and cognitive	Collaboration, zone of proximal development
Manipulatives: models	Cognitive	Mental model
Expert visitor	Cognitive	Mental model, apprenticeship, authentic
Guided instruction	Cognitive	Scaffolding
Spiral learning	Cognitive	Scaffolding
Simple to complex sequence of concepts and skills	Cognitive	Scaffolding
Open-ended questions	Cognitive	Mental models, schemata
Parent conferences	Situative	Collaboration
Parent participation in class	Situative	Apprenticeship

Assessment of Design:

In order to evaluate whether the proposed curriculum solves the stated learning problems, formative assessments will be conducted. As students progress through the various expeditions, we will observe and record interactions within the class. We will pay close attention to the depth and content of mathematical discussions and arguments. Are students grounding their answers in mathematical, logical reasoning? Are students applying the skills learned in the drill and practice segments of instruction to the open-ended problems? Are students arriving at the correct solutions? Are students using equations to solve problems or are students relying on other methods? Are students successfully solving the near transfer problems individually?

We will survey teachers during the course of the program. Are teachers feeling more confident that certain math skills are being learned? What unexpected challenges have arrived in terms of group work and class management? Are students enjoying the expeditions? Are the assessments helpful and accurate? Did the training activities and role-plays better prepare you for teaching the curriculum? Have you used the teaching agenda as a tool for teaching? Have you used the journal to reflect on your experiences? Which common themes, challenges or success stories can you share?

We will survey students during the program as well. Are they enjoying the expeditions? What math skills have they learned? What aspect of the curriculum do they most enjoy? And why?

To gain a different perspective, we will examine the students' math journals. The journal entries will provide an insight into the students' sequences of thoughts, questions, reflections, and problems. Do the entries progressively reflect more analytical thought processes? Have students' attitudes and perceptions of math changed over the course of study?

We will complete the assessment process with summative evaluations. Students will be given a post-test at the end of the course of study to assess their skills. The results will be compared to the initial pre-test. Standardized test scores will be evaluated and compared to the previous year. We also hope that performance based assessments will be used as an additional type of formal assessment. By doing so, children's problem solving abilities and other higher order thinking skills can appropriately be measured.

Conclusion:

Our re-design supplements the Antarctica math unit in ways that will help solve our stated learning problems. Our goal is to create a community of learners that extends beyond just the students to include the parents, teachers, and administrators. We not only hope that the students will be exposed to authentic problem solving but that they find value in the computational skills they acquire. We also hope that the skills learned and practiced during the re-designed Antarctica unit transfer to standardized and performance base evaluations.

References:

Bellamy, R.K.E. 1996. "Designing educational technology: Computer-mediated change." pp. 123-146 in Bonnie Nardi (ed.) *Context and Consciousness*. Cambridge, MA: MIT Press.

Goldman, S.V., & Berg, R. (1997)*The Middle-School Mathematics Through Applications Project (MMAP): A case in learning design*. Menlo Park, CA: Institute for Research on Learning.