Case Problem Design Proposal

The Antarctica Project: A Learning Case

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August 13, 2003
ED 333a
Learning Problem
The Antarctica Project is an approach to mathematics learning structured around students solving real-world design challenges as a meaningful way to develop an understanding of middle-school math. The project begins with teams of students taking on the role of architects and designing a research station for scientists working in Antarctica. Through the process of designing the station, students “bump” into the need to use middle-school math concepts. The role of the teacher in this process is to identify these math learning opportunities and bridge students experiences in the project with the central conceptual structures of mathematical understanding.

In the field tests of the Antarctica project, it was found that the bridging between the real work design challenge and mathematics was incomplete. The researchers and curriculum developers were uncertain why teachers were not effectively or consistently bridging for students their experiences in the design challenge to the central concepts of the mathematics curriculum. The teachers were concerned that there were not enough bridging between the challenge and the math curriculum, and thus not enough math was being taught. The students were not bridging their design experiences with the math curriculum, and parents were not able to bridge what their kids were doing with the design work with their understanding of what middle school math needs to cover. All of this to say that bridging is a complex issue.

In our identification of the learning problem, we see three types of bridging issues that need to be addressed: mathematic, pedagogical, and cultural bridging.

**Mathematical Bridging**
In the Antarctica project, student’s development of the central conceptual structures of mathematics is dependant on them engaging in timely mathematical discussions that successfully link their efforts with the project-based curriculum to mathematical concepts. This discussion process must assist the students in bridging their tacit, experiential and intuitive mathematical understanding with the more explicit and abstract representations of mathematic concept knowledge and practice. If these discussions and related transfer to not take place within the Antarctica project, the math learning will be insufficient to support students in moving forward with abstract mathematical concepts and manipulations.

**Pedagogical Bridging**
The Antarctica project is generally conducted by student teams. It is expected that while student groups work on the project-based curriculum, the teacher will travel around the room, identifying math-relevant teaching moments and then provide timely problem-initiated math concept instruction. As students may be all involved in slightly different activities, and as there are up to ten groups of students and only one teacher, many of the opportunities transfer between the project and the concepts are lost in the pure logistics of the classroom interaction. This phenomenon is not likely to be improved through additional teacher training, as this problem stems not from the expertise of the teacher, but rather from the teacher’s physical limitations of not being able to be everywhere at the same time. This limitation also impacts how able the teacher is to constantly keep track of individual
student’s progress, group progress, and class progress through both the project and the mathematics curriculum.

**Cultural Bridging**
The concept of going from project-based identified math opportunities to conceptual understanding of math is not easily understood by parents or students. The Antarctica Project has an ambiguous relationship with the existing mathematics curriculum. It appears as though the researcher/curriculum developers value this ambiguity, but this does not position the teacher to confidently address parents or students attempt to position the new curriculum with regards to the previous curriculum. Parents want to know that their children are learning “math”. Additionally, students do not see themselves engaged in the practice of mathematics in their projects, and thus are not able to see their engagement in these projects as building their mathematical identity.

**Design Objectives**
Our design solution seeks to address the bridging challenges identified above. In order to address these challenges, the design solution must do the following things:

**Distribute the task of identifying mathematical opportunities**
The bridging role the teacher plays in the classroom can be shared such that the responsibility of bridging also becomes the responsibility of the students, parents, the curriculum and the physical environment. Some of this connection-making has already been integrated in the design of the problems and tools, in that the project-based curriculum has been created such that students will “bump up” against the need for middle school concepts math. However, this bridging responsibility can be further distributed with a scaffolded approach to both students and parents.

**Make thinking and progress visible**
In order to distribute the task of identifying mathematical opportunities, the criteria and frameworks tacitly utilized by the teacher in his or her process of identifying math opportunities must become explicit and accessible to students and other participants in the classroom. However, these explicit frameworks should not be used to constrain student exploration, but rather scaffold the broadening of their explorations. Additionally, strategies need to be utilized to make individual student, group, and class progress through the mathematics curriculum visible in real time to the teacher, students, and parents.

**Clarify the relationship between the Antarctica Project and the standard curriculum**
One of the challenges to the project-based curriculum is that it exists in tandem with a previously established math curriculum. The characteristics and interaction patterns of this established curriculum are significantly different from the practices represented by the new curriculum. Regardless of if individuals find the change in the curriculum to be positive or negative, the fact remains that there is a significant change that needs to be made sense of. The first step in this sense-making process
is enabling participants to differentiate between roles and functions of each the
curriculum.

Design Rationale
Our approach to the design solution is based on the following four understandings:

1. **Activity systems constrain the roles available to participants**
   Situative view of knowing involving attunements to constraints and affordances of activity systems suggests a fundamental change in the way instructional tasks are analyzed. (Greeno, 1996)

   The current Antarctica Project positions the teacher as the sole resource available to students to facilitate their transition from a rich project-based math understanding to a comprehensive conceptual understanding. In this manner, the teacher is positioned as a bottleneck to potential student learning. Additionally, the curriculum does little to empower students to actively take on aspects of this bridging task.

2. **Knowledge is distributed, thought is mediated by artifact**
   Knowledge is distributed in the world among individuals, the tools, artifacts, and books that they use, and the communities and practices in which they participate (Greeno, 1996)

   Thought is mediated by artifact, the styles of thinking exhibited in a particular culture are based on the tools used within that culture. (Bellamy, 1996.)

   Our design solution is premised on a central tenet of activity theory, the notion that interventions in to the physical learning environment can influence how knowledge within a system is constructed and exchanged. We believe that there is the opportunity to introduce new materials, constructed in collaboration with teachers that create an explicit location for collaboration between students, groups of students, the teacher, and potentially parents as well. These shared problem spaces enable all members of the classroom community to co-construct their current locations in the intersection between the application of math and the creation of math concepts. Additionally, the shared problem space enables all parties to reflect on their activities to date, further informing how understanding is co-constructed within the environment.

3. **Students are capable of legitimate peripheral participation**
   PEA (1991) and Lampert (1986) have demonstrated that students are capable of speaking about conceptually complex and technical materials during and after their participation in carefully designed and supported activities. (Case Packet)

   At the core of our design solution is the belief that the students engaging in the Antarctica project are capable of participating in scaffolded metacognitive acts of recognizing the questions and potential concepts that connect the project-based learning activities with the general conceptual structures of the middle school mathematics curriculum.
4. Motivation is a sequence of events that include attention, relevance, confidence, and satisfaction (Keller’s ARCS model of motivational design)

In order to leverage student successes with the Antarctica project to the larger domain of mathematics, students need to be able to map feedback from their projects onto their own mathematical identities. This requires students to see the learning taking place within the Antarctica project as relevant to their existing understanding of what it is to be “good at math”.

Design Solution

Since our goal is to establish a connection between the curriculum components and statewide standards, and to distribute opportunities amongst teachers, students, and parents, we propose a multi-level solution. The goal is to provide teachers with a standalone curriculum kit that maintains flexibility while providing support materials and suggestions on how teachers can use them in the classroom.

Since the class is divided into groups, we have considered group participation and assessment in our design. Because this curriculum is designed to have student groups, we propose that groups be static throughout the project and have an identifier (shape, color, name, mascot, symbol, etc.) with which each student can identify membership and participation. This will be useful to the teacher in tracking. We are not sure if static groups are the most ideal, but it makes assessment easier for teachers in our solution.

Phase I: Identify standards

1. As part of the curriculum design, the team composed of researchers and teacher consultants will investigate the state standards and attach the competencies to lessons and skills within the curriculum. This provides teachers with the standards associated with the curriculum from the beginning. (Excerpts chosen that demonstrate similar goals to the basis of the MMAP design from 7th grade math standards of VA and MD are included in appendix.) In this process, teachers and researchers should make it a goal to rewrite the standards in a manner that those outside of the assessment field (teachers, students, parents, etc.) will understand them. (Eg. “identify mathematical concepts and processes as they apply to other content areas” is edited to “Uses skills beyond example problem that student learned it.”) This is important because these statements will be used widely throughout the student and parent experience of the curriculum. Translation would serve as a mental obstacle because the language is foreign and hard to decode, so we want to remove that obstacle of communication that influences understanding.

Phase II: Create Supplemental Documents

2. Using the non-pedagogical language created above, make these links plain to teachers by creating supplemental materials that can be adapted for their classroom. Documents we describe below serve as templates that can be duplicated, reproduced with teacher creativity, and ideally used for display in the classroom. Also, we would like to create a supplement that describes skills covered through
project assignments for parents to receive at the beginning of the curriculum that they can review over the course of the project with their children or use as a reference. This will be included in the curriculum kit that teachers can distribute as-is or adapt per their unique curriculum method.

a. **Skill Grid**

*Allows discussion between student groups and instructor and display of range of skills associated with each problem component*

Figure 1. Skill Grid

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<thead>
<tr>
<th>Project Problem</th>
<th>Subskill 1</th>
<th>Subskill 2</th>
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The skill grid is to be used after introduction of the project or problem as an initiator of community discussion about student understanding of concepts and skills involved in solving the problem. Teachers are to give student groups the design problem, and together they figure out their initial hypothesis as to which competencies and subskills are involved in solving the problem as they solve individual parts. One way of doing this is to find out what key questions are important to solving the problem and map that back to a competency or subskill, then mark it on the grid. The skill grid is also a class display that serves tracking purposes and lets groups change the locations of their hypothesis as they change and develop ideas or strengthen math opportunity recognition. It is to be filled out at individual group pace by placing and/or moving the group identifier (shape, color, name, symbol, etc.) in the grid. Many group identifiers can be placed on the grid simultaneously so the teacher can also monitor class progress, and groups may learn from each other. The grid can also be used for individual students in portfolios, if the teacher desires. This allows groups to move at their own pace and the teacher to see what groups (and members) have connected competencies and subskills to the individual project parts. This directly addresses mathematic bridging for the students and pedagogical bridging for the teachers. A filled in skill grid is in the appendix.
b. **Standard Scoreboard**

*Shows standards in easy language that students, parents, and teachers can understand and is displayed via three-dimensional boards in the classroom.*

The standard scoreboard may be a bulletin board, cork board, hanging display, or anything the teacher chooses to create based upon how it would fit into their classroom. There will be a scoreboard for each competency. We have a layout for a standard scoreboard that has three parts:

i. **Competency and subskill list:**

The major heading on the scoreboard should be the competency and the subskills should be listed underneath it. Most states breakdown competencies into identifiers or subsets, so this should be a very effective way of covering all math skills deemed necessary. All of this can be done using the same language and competencies and subskills created for parent, teacher, and student understanding from Phases I and II. The purpose of this section of the scoreboard to show big picture goals and the smaller pieces that create the big picture. It allows everyone (parents, students, and teachers) to move back and forth between contextual Antarctica Project and explicit competencies.

ii. **Context attachment section:**

This section is an initially empty section on the board where students may reflect on which parts of the problem address any of the related competencies in section i. Such examples include problems, key questions, similar examples of transfer, and outside examples, etc. The students can begin to build bridges between real-world applications and competencies as they see where the competencies and skills are applied over the course of the curriculum and connect their schema to build new pattern and relationship hierarchies and apply metacognition. To scaffold this, when the teacher uses the skill grid and together they find the key questions, the teacher can enter that on the scoreboard to demonstrate what students will do when they make their own contextual attachments.

iii. **Group and student checklist:**

This section of the board allows student groups to be assessed and individual members of the groups to be assessed. Since the groups are static and have identifiers, there is a receptacle (slot, envelope, Velcro box, etc.) for each group. This receptacle holds a group competency checklist and individual checklist. This checklist has the same information as section one of the display. As the group moves through project problems and encounters specific competencies or skills, they are now more aware of their own mathematical
opportunities because they participated in the skill grid exercises and eventually (if not immediately) use the context attachment section to help them in this manner. When groups recognize a topic, they are to retrieve their checklist, and check off the skill that was covered. This also gives the student visual assessment cues because they can track what they are learning based on standards. This distributes the responsibility of recognizing mathematical opportunities, and supports assessment techniques that are formed by teacher, parent, and student. Additionally, in this slot are individual checklists for members, but this checklist is not checked off until they have been assessed.

Phase III: Use in the classroom

3. We imagine that there is an ideal use of these materials in the classroom, where the flow of information and responsibility of opportunity recognition is high, and student identity is growing within the environment. We see three types of learning opportunities taking place within this environment and teacher-student and parent interaction.
   a. Unstructured opportunities: artifact placement in the environment allows for continuous, indirect interaction with educational information
   b. Semi-structured opportunities: This is student-initiated and spontaneous based on group progress and dynamic learning goals. It may not occur in the beginning of implementation, but hopefully as identities of the groups as learners change, this will increase. An example of this is moving markers on skill grid, writing on the standard scoreboard.
   c. Structured opportunities: This is teacher-initiated and semi-spontaneous. Teachers may use the displays and built-in assessments to inform lesson plans or order, and guide or support students by providing paralleled math instruction within the curriculum. An example of this might be the teachers using the skill grid to see that in floor plan design, the students do not recognize that perimeter is an important concept, and revisit discussion or create a lesson to introduce them to perimeter.

Phase IV: Assessment

4. Since our design solution addresses many concerns from the Antarctica Project’s original implementation, assessment must be broad. We must answer the following questions:
   a. Does the solution assist teachers in recognizing mathematical opportunities by providing competency links to problems in the curriculum?
   b. Does the solution help parents understand the ‘math’ that their children are learning?
   c. Do the students recognize the math skills that they are learning?
   d. Can this all be assessed in one manner or must it be done separately?

Teachers
Reviewing the Skill Grid and Standard Scoreboard will give us information about how mathematical opportunities are being recognized by students and teachers based on quantity of competencies and subskills covered.

Parents
Parent evaluations through comments at parent-teacher conferences or at the end of unit will give us feedback on their perceptions. We shall include within the supplemental parent materials periodic evaluations that they can fill out as their children move through the projects and units. This will hopefully facilitate additional review by parents of what their children are doing and will provide opportunities to reflect and participate through suggestions or comments throughout the course instead of just at benchmark points.

Students
The checklists will help students identify what they are learning out of context. The inclusion of a journal will assist students in reflecting upon and identify what they have learned. Through the journaling process, we hope to learn how students identities as math learners changes both through this self-assessment, and through the Antarctica Project as a whole. The journals will be discussed with the teacher, and shared with parents and other students for discussion and to promote satisfaction and confidence in progress.

Our other question is how to assess how well the students have learned the material because covering the skills does not imply mastery. Shall we do group, individual, or both? How fair would that be? What type of testing shall we do to satisfy the conventional methodology while not requiring students to give back in a way that in no way resembles how they learned? At this time in the project, it is uncertain, but we propose a hybrid assessment to address this concern. The hybrid assessment could be a parallel test that introduces problems that students must solve in discussion answers and working out the problem, and provides idea options and equation choices where students must identify concepts, equations, variables, etc. as they solve the problems. In this way, the strategic thinking can be assessed, and standardized requirements can be assessed simultaneously.
APPENDIX:

Standard Scoreboard

Competency

7.1 Subskill
7.2 Subskill
7.3 Subskill

Competency 7

Context
Attachment

Checklist 1 2 3 4 5
Excerpt from VA Standards of Learning Seventh Grade Math

Computation and Estimation

7.4 The student will
a) solve practical problems using rational numbers (whole numbers, fractions, decimals) and percents; and
b) solve consumer-application problems involving tips, discounts, sales tax, and simple interest.

7.5 The student will formulate rules for and solve practical problems involving basic operations (addition, subtraction, multiplication, and division) with integers.

7.6 The student will use proportions to solve practical problems, which may include scale drawings that contain rational numbers (whole numbers, fractions, and decimals) and percents.

Measurement

7.7 The student, given appropriate dimensions, will
a) estimate and find the area of polygons by subdividing them into rectangles and right triangles; and
b) apply perimeter and area formulas in practical situations.

7.8 The student will investigate and solve problems involving the volume and surface area of rectangular prisms and cylinders, using concrete materials and practical situations to develop formulas.

Table 1. One 7th Grade Maryland Core Learning Goal

<table>
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<tr>
<th>Standard 10: Process of Connections</th>
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<tr>
<td>Students will demonstrate their ability to relate and apply mathematics within the discipline, to other content areas, and to daily life.</td>
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Indicator(s)

A grade 7 student will be able to:

- identify and use the relationships among mathematical concepts as a basis for learning additional concepts
- identify the relationships among graphical, numerical, physical, and algebraic mathematical models and concepts
- identify mathematical concepts and processes as they apply to other content areas
- move beyond a particular problem by making general conclusions, summary statements and posing new, related questions and comments
- use mathematical concepts and processes to translate personal experiences into mathematical language
- identify the contributions of men and women of diverse cultures to the development, understanding, and application of mathematical concepts and processes
## Draft Skill Grid for the Antarticia Project

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<thead>
<tr>
<th>Project</th>
<th>Perimeter</th>
<th>Surface Area</th>
<th>Volume</th>
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