Case Study:
Redesigning MMAP Curriculum Implementation

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I. Learning Problem

The MMAP curriculum, in particular its Antarctica Project, is an ambitious, application-oriented approach to teaching mathematics to middle-school students. The project’s success relies on the assumption that students learn most effectively when skills are taught as needed during the course of real-world problem solving. Teachers are instructed to explain math concepts (such as scale, area and perimeter, units of length, etc.) to their students when they “bump up against” them in the course of designing a science center to be built in Antarctica. But studies of the MMAP curriculum showed that the theory wasn’t working perfectly in practice – different groups of students were learning different concepts, students were unable to make connections between the applications and math concepts, parents were concerned their children weren't learning the necessary grade-level math skills, and teachers were missing opportunities to teach new skills and felt overwhelmed by the project's lack of structure.

The learning problem, then, is significant: New MMAP teachers are not prepared for the major changes in teaching that the curriculum requires, and they are passing up “relevant moments” to make learning meaningful and specific for their math students. That problem contributed to the other issues, skeptical parents, inundated teachers and uneven learning between groups.

We intend to suggest changes in three broad categories to address this core learning problem: teacher training, curriculum and software changes, and parent and community involvement in the project. We will then assess whether our changes have had the intended impact.

II. Teacher Training

In order for the new curriculum to be a success, the teachers not only need to be trained to best utilize the curriculum, but they also need to be sold on the idea of it. Two days of teacher training will be designed and implemented. It is recommended that this training occur prior to the school year when teachers have required in-service. If this is not possible, a grant proposal should be written in an attempt to pay teachers to complete two days of training in the summer.

The two days will consist of a variety of activities to familiarize the teachers with the process and procedures to take advantage of mathematical moments in the curriculum as well as convince the teachers of the value of incorporating this curriculum. Teachers will complete this training in teaching teams that will eventually provide support to the individual teachers throughout the school year.

Activity 1 – Sample Activity

Design Principles:
Modeling – Building on the cognitive perspective, teachers will observe an expert in action in the curriculum they will be adopting.
Active Learning – Teachers will actively interact with the environment to build an understanding of their role in the learning situation.
Role Playing

Activity: Teachers will participate in a similar learning experience to what their students will participate during the school year. Teachers will be grouped and asked to solve one of the design problems presented in the curriculum. The instructor will model how the teacher could interact with the student teams. The instructor will explicitly identify opportunities for mathematical moments and explain how to take full advantage of those situations. At the end of the session, the teachers will be asked to reflect on what signals a mathematical opportunity in the classroom.

Activity 2 – Example Videos

Design Principles:
Practice with Feedback – Teachers will practice identifying mathematical learning opportunities and receive detailed feedback from an expert instructor.

Scaffolding - The instructor will prompt the teachers to develop a deeper understanding of the processes and procedures of the curriculum.

Authentic Learning – Teachers will work with authentic examples of the new learning environment in order to better understand the constraints and opportunities of the curriculum.

Building on what the teachers observed and reflected on in the first activity, teachers will watch a series of videos containing class vignettes. The teachers will be asked to identify mathematical moments and recommend a way to take advantage of those moments. The instructor will prompt the teachers to consider other math content that may be relevant and provide feedback on their suggestions and timing of intervention.

**Activity 3 – Detailing Objectives of the Curriculum and Presentation Order of Math Content**

Design Principles:
- Collaborative Inquiry – Teachers will work with each other to discover the content objectives for each unit of the curriculum.
- Mental Map of the Curriculum – Teachers will continue to build on the mental map of the curriculum they have begun to form.

We will use participatory design to divide the project into individual units. Each unit will be comprised of an activity (“application”) required to complete the project, and a series of concepts that students will have to “bump up against” during the course of solving that part of the problem. To choose the most appropriate activity for each unit, we will meet with all the teachers who have been involved in the Antarctica Project, and ask them to recall the “math opportunities” related to those concepts that they frequently observed. This will allow us to identify an activity for each unit that seems to naturally fit into the Antarctica project and leads the students toward necessary math challenges. By assigning those as activities for each unit, we believe that we can meet the first two goals. It will have the added benefit of the teachers' approval and support, since they will have been involved in the design and decision-making process.

Once defined, the curriculum objectives should be outlined for all involved teachers, parents, and students. While the order of presentation of math content may vary in each classroom, the teachers may discover a logical order of presentation. Looking over the list of mathematical content found in the curriculum, teachers will work together to build a logical sequence of introduction of concepts. They can use this list as a checklist for each unit. In addition, the list will act as a scaffolding support for the teachers when they are in the midst of the chaos of instituting a new curriculum.

**Activity 4 – Discussing the Value of the Program**

Design Principles:
- Collaborative Inquiry: Working together, teachers will scrutinize the value of the curriculum.
- Motivation – Teachers need to comprehend the value of the curriculum in order to be motivated to successfully adopt and incorporate the program into their classrooms.

Working in teams, teachers will examine the pros and cons of the curriculum and contrast it with other methods of presentation. They will be asked to address learning issues including motivation, transfer, and content.

**Activity 5 – Building Support Teaching Teams**

Design Principles:
- Building a Learning Community – Teachers will benefit from working together by having an established learning community and support system.
- Varieties of Expertise – The varieties of expertise of the teachers will be used to their full potential by allowing them to benefit from each other’s strengths.
The teachers will return to their teaching team groups. They will spend the remaining time reflecting on what they have discovered during the training and building a plan to support each other throughout the school year. Over the next year, the teaching teams will have regular meetings to discuss learning issues that have arisen in their respective classrooms. The teachers can provide their insights and suggestions to each other to help promote the success of the curriculum.

III. Curriculum Changes

The changes we propose to the curriculum are intended to meet the following three goals:

- To make sure that the state requirements for seventh grade mathematics are met
- To set the stage for “math opportunities” to occur, which in turn will help achieve the first goal
- To make sure students see the connection between the activities (“applications”) they are engaged in and the mathematics concepts underlying them

Design principles

Sequences of conceptual development (cognitive) – the curriculum is transformed into a progressive sequence of units, each of which aims to teach students one mathematical concept. When students have successfully completed a task, showing that they understand and can apply the concept, they move on to the next, more advanced unit.

Scaffolding, guided learning by discovery (cognitive) – the discovery process of the students is guided by the teacher and scaffolded by specific assigned activities to ensure that they “bump up against” the “right” problems and “stumble across” the intended discoveries.

Participatory Design – teachers, the ones delivering the curriculum, are involved in the design of the individual units.

Tutoring/apprenticeship, physical modeling and real-world application – invite architect to work with students on building physical models of their computer constructions. Have her explain how she uses math in her job

Activities

To meet the first goal, we propose to introduce progression into the curriculum. By doing so, we hope to use more scaffolding and guidance in the students’ discovery process. First we will identify the math concepts that students are meant to learn through the Antarctica Project: area and perimeter, measurement units, scale, cost efficiency, marginal costs, etc. We will cross-reference these with the required content of seventh grade mathematics classes to ensure that a reasonable number are met. The concepts will then be organized into a progressive sequence, such that the easier and more intuitive ones come first, and the harder, more complex ones that may require knowledge of the easier ones, come later. The curriculum will then be broken into smaller units, one for each concept that the students have to learn. These units will be taught in sequence to ensure that students learn all the necessary concepts.

For example, let’s say the first unit is on measurement, units and scale. Teachers might find that “opportunities” to talk about measurement units arise when students are asked to measure the dimensions of a space, and “opportunities” to talk about scale arise when students first have to draw a building in the accompanying software package. The students would be given the assignment of using the software to create a room of the same size as their classroom. They would have to measure their classroom’s length and width and then draw an identical structure with the software program. This activity should raise many questions for the students, such as what measurement units to use, what the differences are between them, and what difference it makes in using the software. These should all become “math opportunities”. Scale should also come up as an issue as students try to draw the room.

To ensure that students understand the connection between each activity and mathematics, teachers will make the math concepts involved in the activities explicitly known at the beginning of
each unit. In the previous example, she would tell her class, at the outset of the unit, that their activities in this unit will revolve around measurement, units and scale.

We also intend to invite a working architect into the project classrooms at the end of the project. They will have the chance to explain to students how they use the math concepts in their jobs – making the application of learning explicit. This situative learning will help students understand that their project is authentic, and based on real-life work. They will also work together to construct (out of balsa wood or similar easy-to-manipulate material) a manipulative model of their design, allowing them to not just visualize but experience “scale,” and other math applications. The experience of working with an expert will also follow the cognitive tutor/apprentice model that helps students construct a mental model of the task.

IV. Software changes

Design Principles

Scaffolding and fading (cognitive) – we will introduce levels into the software. Earlier levels will scaffold the students’ learning and use of the product more. Later levels will give more user control as the scaffolding is faded away.

Drills (behaviorist) – the software will have students drill the application of mathematical concepts by having them do all the calculations themselves.

Clear and instantaneous feedback and reinforcement (behaviorist) – as students do mathematical calculations, they receive instant feedback on whether their answer is correct or not. If it is incorrect, they are given hints to figure out what they did wrong and correct their answer (this is also scaffolding).

Activities

In order to support the above changes to the curriculum, certain changes will also have to be introduced into the software package used by the students in the Antarctica Project. To support the progressive sequence of units of the curriculum, progression will also have to be introduced into the software. We propose to do this by adding progressive levels to software. In the earlier levels, only a restricted set of all features will be available to the students in order to limit the actions they can take. These limited actions will be the ones necessary for accomplishing the activity assigned for the current unit. As students progress into later units, they will also be promoted to higher levels, which in turn will give them more options and more control. Limiting what students can do is a form of scaffolding – it makes the software less complicated and simpler to use. In addition, gradually increasing student control by giving them more options will motivate since control is a motivator (Lepper & Malone, 1992) and because it will have them wondering what more the software will allow them to do next.

In the example given above (in which students use the software to create a room with the same dimensions as their classroom), the students would have access to level 1 of the software. In this level they could draw walls and set the scale, but not add insulation or do anything else. When the teacher has reviewed the students’ completed activity and verified that everything is correct, he would promote them to level 2. If their solution were incorrect, she would give them feedback on what they did wrong and use that as another “opportunity”.

To further improve the software, we will require the students to do all calculations by hand instead of letting the software do it for them. Though the aim of the project is to teach math concepts to these students, it is nevertheless important that they have opportunities to practice calculating results when applying the concepts. Detailed, dirty work allows students to “interact” with abstract concepts, use them as they are meant to be used in a real-world context, and is the first step to making the application of these concepts second nature. The software will help them with their calculations, asking them direct questions so they know what they have to do and giving them direct feedback on their answers. When a student creates a building, for example, the software would ask her “What is the length of the building?”, “What is the width of the building?”, and “What, therefore, is the area of the building?” In addition to giving the numeric answer, students
would have to chose the right unit (m, in, ft, m², etc.) If the answer is correct, the software will say “good!” or play a sound. If the student errs, the software would say “Take a closer look at the scale and at the number of squares along the wall” or “Remember: area is length x width”. With complicated shapes that do not follow the grid, such building with “diagonal” walls, the software could ask the students to estimate the length or width, and if their answer is within 1 unit, give them the exact answer.

The software will continue to encourage learning through experimentation and discovery. To do so, it will record and keep track of students’ correct answers and display them in a table. That way, students can change the lengths and widths of building and see how that affects perimeter and area. The software could challenge them to make changes without changing the area and display the results next to each other in a table to help them “discover” that buildings with the same area can have different perimeters.

Finally, to strengthen the ties between their activities and mathematical concepts, when the student finish an activity and move on to the next level, the software will give them a short slide show or animation summarizing what they have accomplished, and showing what concepts they have used and how.

V. Parent and Community Involvement

It will be critical for parents to get involved in the student activities within this program from the inception so that they can understand the foundation of the designed curriculum. By partaking in meetings that are held between teachers and parents at the onset of the new program, parents have an opportunity to address concerns and apprehensions they might feel with this new system before the children are fully engaged in the curriculum.

The parental connection will persist throughout the duration of the project, since their engagement with the students and the teachers will be an important part of assessing the unique associations to mathematical concepts that students will develop inside and outside of the classroom. Parents will be part of the learning resource for students as they progress through the curriculum. The participation by parents will provide open forums in which to address any concerns that might arise as they observe their children during the school year. In addition, parental involvement will encourage them to fully engage in their child’s mathematical learning process while feeling closely connected to the classroom activities.

**Activity 1 – Initial Introductory Meeting**

*Design Principles:*
Active engagement and introduction – Parents are invited to engage with the teachers by attending a meeting to introduce them and make them comfortable with the curriculum.
Establishing community – Parents need to engage in the community (of education) just like their children do so that they can understand how to help their children develop

*Activity:* Teachers will invite (and strongly encourage) parents to attend an opening introductory meeting to address the new curriculum that will be implemented in the classroom. The strategies should be discussed in full, including dialogue about the theories behind this new learning procedure. Parents should be allowed to voice any concerns in an open forum and, by the end of the meeting, should have a foundational understanding of how and why this new curriculum is being introduced. Teachers will provide a meeting schedules and private hours during which parents can converse about issues that may arise during the course of the study.

**Activity 2 – Parents use Software**

*Design Principles:*
Teach back – Parents begin to engage in the product so that they can teach their children what they have learned in the same capacity
Activity: Parents will be given a copy of the software that the child will be referencing during class time. This interaction with the product itself will persuade parents to ask questions in regards to its function and usefulness. In addition, understanding how to use the software that their children are exposed to on a daily basis will help parents answer questions that children might ask, eliminating the frustration that many parents may feel when they are ‘tuned out’ of their child’s classroom learning experience. The most critical concept for involving parents in their children’s work is keeping them up to speed on how the child is progressing while fully understanding the problems on which they are working. They will not be outsiders in this study, but crucial connections to enhance the child’s learning experience.

Activity 3 – Parent Sit-in (observation during class)
Design Principles:
Observation – Parents engage from the sidelines of a class to view the classroom environment.

Activity: So that a parent can feel cultured to the child’s classroom learning environment, teachers will assign certain days that parents and guardians can observe the classroom environment to get a feel for how the students perform among other students. Their behavior inside the classroom environment may be much different than at home and it will be important for parents to understand the varied interactions and how those might prompt different learning engagements. If they are sensitive to the way their child operates in the classroom, they may be better equipped to develop an adequate learning environment in the home.

Parents will also get the chance to develop a relationship with the teachers. These relationships are an important start in developing a rapport, making parents comfortable with what is happening in the classrooms. It also provides a comfort-level that parents may need in order to address any issues that children may have with the teachers or classroom activities.

Activity 4 – Math Fair to show models
Design Principles:
Gestalt Theory: Deeper structural views develop, involving changes in functional meaning, the grouping, etc. of the items. Two directions are involved: getting a whole consistent picture, and seeing what the structure of the whole requires for the parts. Parents will be engaged in this process to determine how the children have developed their functional understanding of mathematics.
Experiential learning: Develop students’ understanding of how math relates to everyday procedures.

Activity: A culmination of activities will be in the format of the Math Fair at the end of the curriculum. Parents will be strongly encouraged to attend this fair so that they can see the result of their children’s work throughout the project. The parents will be given a chance to examine the final designs, determined to display a mastery of concepts.

Activity 5 – Homework requires parental assistance
Design Principles:
Collaborative Inquiry – when children have additional resources from which to draw information and understanding, they are likely to develop a better foundation for the projects. Parents too, are then more encouraged to assist in the child’s project when they know what the child is learning and how they’re learning.
Motivation – If the parents are actively engaged in the child’s work, there is more chance that the child will be motivated if they are able to ask the parent for assistance or feedback.

Activity: When parents are involved in a child’s school learning activities outside of the classroom, it presents not only encouragement to the child, but also allows the parent to examine the processes by which the child is being exposed to concepts and procedures. If a parent is
engaged in the child’s work at home, there is a better chance that they are fully aware of the curriculum as well as becoming a motivating factor for the child’s learning habits.

VI. Assessment

Our assessment phase will evaluate the effectiveness of our redesign in solving the learning problem we identified at the outset. We will attempt to analyze students’ and teachers’ progress through the lenses of the three perspectives on learning – behaviorist, cognitive and situative.

First, and perhaps most obviously, we will examine the change in students’ basic mathematics skills, through behaviorist-influenced pre- and post-testing. A computer-based pre-test will identify prior and prerequisite knowledge and the post-tests will analyze component skills and eventually build to composite rules. Scoring will be unambiguous, and the computers will provide students with objective feedback. In this testing segment, we will be able to identify students’ learning by sampling their knowledge in the specific math domain. Questions will be multiple-choice and short-answer, allowing us to compare scores of students from different MMAP groups, and even different schools where MMAP is in place. We will also compare their scores with another group of middle school students in the same school, learning the same concepts in a traditional mathematics classroom.

It will also be important to determine whether students are able to identify relevant terms and symbols in the subject domain. Has our decision to require students to do computation on their own enabled them to become more proficient through repetition? Can students identify what basic skills must be used in sequence in order to use more advanced skills? Are they learning the standards-based concepts that will be tested on a statewide level? What concepts are weakest? Where do we need to strengthen our instruction, or be more explicit in the concept’s introduction?

The short-answer questions will also help examine whether students have developed a conceptual framework of when to use mathematics concepts. Has our decision to introduce concepts and objectives at the beginning of phases of the project worked? This cognitive evaluation is necessary to see whether students will make good choices about when to use which new skills. Are they able to transfer their knowledge to new situations? In the testing, we will also give them several problem-solving exercises that determine whether the students can use their knowledge in new, foreign settings.

We will also spend a great deal of time observing and videotaping classroom interactions and interviewing students and teachers throughout the course of the project. We need to know whether they feel more confident with the work – are teachers building a conceptual framework that enables them to more quickly spot opportunities for introducing new math lessons? Can students explain why they learned a certain concept at a particular time? Can they offer different explanations for how to achieve their goals? Was the mentor architect a useful tool in helping students understand the real-life relevance of their learning? Were the physical models helpful in exemplifying learning through manipulative materials?

Students will also be asked to keep portfolios of their contributions to the project. This will enable us to examine whether all students in a given group are learning equally well. Are some of the group members simply relying on their peers to do the “heavy lifting”? The portfolios will track their skills progress, range of understanding and conceptual development.

Because the project – and our solution – relies heavily on situative learning principles, we will lean on participatory assessment to ultimately evaluate our redesign. Teachers will be asked to keep learning journals over the six weeks, sharing ideas out loud in their team teaching groups (which will be observed on a regular basis). Here, they can make notes for the future, jot down notes for improvement and validate successes. The journals will also enable us to determine whether teachers have developed new epistemic identities for the MMAP style of teaching. Have the videos and role-playing, as well as the more in-depth training, made teachers more confident
in their new role in the classroom? Do teachers have better instincts about when to take the opportunity to teach math? Do they feel they have enough scaffolding – through their colleagues and the MMAP curriculum guides – to take advantage of most, if not all, of the learning opportunities presented?

The Parents’ Night at the end of the project will not only be an opportunity for students to share their product – and explain out loud their process – but will also give a chance for community reflection. The middle school students are old enough to thoughtfully assess their own progress, and identify weaknesses in the program. What could have been done better? What are fair standards by which to judge their success? The night will also afford the opportunity for students to “show off” their new skills through an “on-demand” talk-aloud final exam. Teachers can present a new problem and students can offer steps they might take to reach a solution. Parents can also add their own opinions, creating a collaborative learning and assessment forum.

At the conclusion of the evening, parents will be asked to fill out questionnaires about the project. Do they feel their student learned basic skills? Did they talk about the project at home? Did the students engage parents in homework activities? Where were the weaknesses? Was there enough communication about the project’s goals? Parents will also be given the opportunity to meet individually with teachers and/or our team, to provide particular feedback or anecdotal evidence about the project.

Finally, we want to determine whether the project was the most effective tool for teaching the concepts that emerged. We will compare the results of this assessment to another group of middle school students in the school, who are studying the same math skills in a traditional classroom setting. Does the real-world learning enhance retention and transfer? Did it, in fact, make learning more palatable for students? Did students have fun with the project – letting their imagination guide them as much as their teachers?

The results of this series of assessments will enable us to once again redesign the MMAP curriculum to address emerging problems and concerns for teachers, students and parents. The goal of this iterative process will be the evolution of an even more powerful, effective tool for teachers.