Adapting Culturally Based Curriculum for use in Classrooms of Other Cultures

A Case Example from Nenana, Alaska, USA

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In this paper we examine how a Caucasian teacher in a mixed Athabaskan (Native American) and Caucasian community has successfully implemented the *Math in a Cultural Context* (MCC), developed from the knowledge of Yup'ik Eskimo elders and teachers. This case describes how the teacher, Michelle Opbroek, facilitates the embedded Yup'ik cultural knowledge into lively, mathematical communication and learning made relevant to this non-Yup'ik group of students. Observations, video analysis including insights from Yup'ik consultants, teacher interviews, and student test scores provide the evidence used in this example

In the United States, the academic gap between American Indian and Alaska Native (AI/AN) students (Meriam et al., 1928) and their Caucasian peers as well as the rural-urban divide (Johnson and Strange, 2005) have been well documented. AN majority, rural school districts continue to typically score between the 10th and 20th percentile on reading, language, and math on the Alaska's state benchmark exam, while urban schools fall between the 40th and 70th percentile (Alaska Department of Education & Early Development, 2005). Less well documented and of primary importance to the field are cases that reverse these trends for both rural (Silver, 2003) and AN/AI populations (Demmert, 2003).

Of primary focus, this case provides an interesting example of how culturally based curriculum developed from one culture and used in another can effectively reverse these academic trends and be used to develop students' mathematical thinking needed for excelling in western mathematics schooling. In particular, how does the teacher use and adapt cultural components of MCC to develop meaningful math understanding for students of another cultural group?

Originally this lesson was identified as a possible case example because we observed the enthusiastic engagement by the students around mathematics and mathematical communication and argumentation. The case became more compelling once the test scores were compiled: students' pre- and post-test results showed strong gain scores as well as high absolute post-test scores. Opbroek's class raised their pre-test scores of 66.90% to a post-test average of 82.50% in comparison to other rural treatment classes who scored 37.56% on the pre-test and 68.25% on the post-test. Further, they outperformed their urban treatment counterparts who started at a 57.18% and scored 63.45% on the post-test. Control groups were also tested using their standard curriculum and all treatment groups outperformed their control counterparts who each lost points from pre-test to post-test (rural control: 35.75% to 32.17% and urban control 67.33% to 58.29%).

Case Overview

This case example discusses lessons observed in Michelle Opbroek's classroom while she used an MCC module titled *Star Navigation: Explorations into Angles and Measurement*, appropriate for the sixth grade. The math of the module was created from knowledge shared by Frederick George, an accomplished navigator and Yup'ik elder from Akiachak, Alaska. Frederick has worked tirelessly with our project for over 10 years, developing this module as well as others.

This case builds directly on Frederick George's everyday use of mathematics, in which he makes explicit measuring angles and relative distance used in navigating during the day and at night. The *Star Navigation* module uses Frederick's methods of measuring between objects at a distance using hand measures, knowledge of his surroundings, and his self-learned patterns in the movement of shadows and the stars as a basis for understanding angles and measurement.

Imagine being on the frozen, seemingly undifferentiated Alaska tundra in the middle of the night with only the stars to guide your way. Frederick does this year after year in all kinds of weather, using the embedded mathematical knowledge he learned from his elders.

All transcripts in this case are extracted from a lesson videotaped on November 18, 2004. However, this lesson was not an anomaly. For two years, one author has been observing Michelle's classroom as she uses both MCC modules and other curricula. Furthermore, the co-author also observed this same fifth- and sixth-grade classroom with previous teachers and did not see the same type of classroom enthusiasm. The examples provided within this case are just a small piece of what was observed throughout the entire school year.

Background to the Case

Nenana is located in the cold climates of the US state of Alaska. It is in the interior of the state at the confluence of the Nenana and Tanana rivers, near the city of Fairbanks. It has a population of 549 (Alaska Department of Commerce, 2005) and includes a mixture of Athabaskan Indians and non-Natives.

At the time of this lesson, Opbroek was in her second year of teaching at NCPS in Nenana and her sixth year teaching total. Opbroek brings with her the fundamental philosophy of constructivist teaching, which does not fit easily with the curriculum that her school has adopted. Her degree is in elementary education through junior-high with a science emphasis, and her methods courses all used the constructivist approach. In her own math studies, she has progressed through calculus II.

The classroom in this case is a fifth- and sixth-grade multi-age class with 16 students; 14 of them have been together for most of their schooling. The class has 10 sixth-graders and six fifth-graders. One new sixth-grade student came from another village at the beginning of the school year and the other new sixth-grade student came from a military home just a few days before this lesson. This year only three students are Athabaskan and the rest are Caucasian. Nine of the students are in their second year with this teacher, including one fifth-grade student who was held back. These nine also participated in a different MCC unit the previous year. There are two sets of siblings in the class. Three students have repeated a grade at some point in their elementary career and one was home schooled for at least a year. This multi-age student group with familial relations or long-time jointly schooled students is typical in rural Alaska, both on and off of the road system.

According to the school, only one out of 16 students in the class this year is considered advanced mathematically. Four of them are considered poor and/or struggling, and the remainder of the students appears to be about average on paper. In 2003 when the sixth-grade students were tested as fourth-graders on the Terra Nova, their standardized test results of 77% placed them above the state average of 65% in math and slightly below the state average in reading (69% vs. 71%). When these students were tested using the Alaska Benchmark Exam in 2002 as third-graders, NCPS had 93% of students meeting or exceeding standards in reading, a 79% for math and 57% in writing (American Institutes for Research, 2004). Rural sites in Alaska can be coded as single-site districts, multiple-site districts, or hub sites. Hub sites are typically larger villages that act as a travel centre from the major cities (Anchorage, Fairbanks, and Juneau) to the smaller villages. In Alaska, most rural school district rank low on standardized tests; however, many of the single-site and hub-site rural school districts tend to score higher. NCPS is a typical single-site district in that their test scores are closer to urban sites than their other rural counterparts.

Star Navigation Module

In the first section of the *Star Navigation* module containing Activities 1-3, students are introduced to Frederick George, navigating in general, gathering observational data including shadow measurements, and experimenting with various ways of measuring at a distance. At the time of this lesson, students had used the module for about 10 days and were still completing Activities 2 and 3.

In the module, a tool is designed to connect the mathematical idea of an angle to Frederick's method of measuring at a distance. The tool, a straw angle, simply consists of connecting two straws together with a brass fastener. The activity then follows: Pick two far-away objects outside the window and place two objects on the desk in the same line of sight as the far-away objects. Note that the outside objects do not have to be an equal distance from your location. Placing the straw angle on the desk, show from your perspective how the objects form the same angle or how the outside objects fall on the same ray paths as the inside objects. Once students have the straw angles, objects on the desk, and the far-away objects in line, ask them if they could place the straw angle in another location and still keep all the objects lined up. Explain that Frederick uses his hand measurements to estimate the distance between the objects and the angle they form in relation to his location (Like, et. al, 2004 draft).

Mathematically, there are several ideas that can be investigated. First, if the same hand measure is used for both sets of objects from the same original point, then the hand measures are approximating an angle measurement and the focus is on perspective. Second, if the viewpoint is changed, producing a different perspective, the measurement is changed. Third, if different measures are used for the far-away and nearby objects, then the activity measures the arc length of the angle at different points on the rays, which is not the same as measuring the actual angle or the amount of rotation formed by the rays. Fourth, in the cases when the arc length or the straight line distance between the objects can actually be measured it will provide a measurement that differs from the angle measurement thus possibly causing confusion. Together, these ideas bring to light the issues of what is an angle and what is being measured.

Methodology

The research methodology parallels the collaborative work of the overall MCC project by including two of the authors, other university researchers, retired school district administrators, and several Yup'ik consultants. Qualitative data consist of (1) three classroom observations, (2) videotapes and transcriptions of those lessons, (3) teacher interviews, and (4) transcriptions of discussions among consultants during video analysis meeting held March 2005. The video analysis included a group of retired Yup'ik teachers who have been part of the project for many years, providing their unique perspective. At first we only sought to explain through the analysis how the teacher enacted the curriculum through specific pedagogical strategies that increased students' mathematical understandings somewhat absent of cultural connections. We did not expect the seemingly Western framework of the classroom to resonate as strongly as it did with the Yup'ik consultants. To our surprise, Opbroek's class also fit into their Yup'ik framework for a productive classroom in both process and output.

Case Analysis

Before the lesson begins, the chairs are in rows and the room is empty. As students arrive back into their classroom, Michelle explains that they will be working on their star navigation unit. She asks them to clear the floor so they can start with a discussion reviewing yesterday's activity. The students choose to move their desks out of the way and rearrange their chairs into a circle instead. Opbroek makes a quiet exclamation that this was not what she expected. The lesson begins with Opbroek asking students to review the previous activity, relating back to what happened the day before. Alice[1], a sixth-grade Athabaskan student, volunteers to demonstrate how Frederick George would use his hand measures to measure the distance between two far-away objects. After Alice shares this, Michelle asks the class, "Does anyone want to add anything else?" She is already structuring the class for students to share and allowing students to respond to other students. Collin adds, "It also changes depending on how you move your hands." Kathy, another sixth-grade student, not only extends the developing math discourse but opens a new line of inquiry that the curriculum itself does not address at that time by applying the hand measures in a vertical rather than horizontal direction. Two more students share other aspects that relate to Frederick's method of measuring. The above took place within the first two minutes of the lesson.

Opbroek says, "I would like to do a little bit more review but then also some more discussion on the activity we did. … So we created this angle, right, with our small objects and our large objects far away. What is the name of this piece of this drawing?" She draws on the board an angle, relates it back to what the students were just talking about, and asks students to identify parts of an angle using mathematically correct vocabulary. Some students say it is a straw and others call out "ray." Shortly thereafter she asks, "What were we measuring? If you look at this angle here with the two rays, what do you suppose we were measuring in relation to this angle? And if you want to come to the board and draw you may."

After a few student responses, Opbroek begins a discussion on angles that may seem unconnected to the previous dialogue. She states, "We haven't really talked about it yet. We haven't talked about it at all. But all of you thought about your definitions of an angle. What is an angle, right?" She is referring to when students were asked to write in their journals their first definition of an angle at the end of Activity 2. As Opbroek transitioned into a discussion on the definition of an angle, she shared with the class an anonymous summary of what many had written, such as "an angle is a degree." As Opbroek leads the discussion connecting Frederick's method of using hand measures to an understanding of angles, the following dialogue transpires.

Transcription: Minutes 9:30–10:27 **Amy's Question**	**Notes**
T: When you do this method are you measuring the angle?	Teacher points to the drawing on the board of fingers used to measure between two far-away objects to refer to as the method.
Students: No.	Several students respond sporadically.
T: No?	Opbroek is patient and allows the students to think and respond. She does **not** give away the answer with her tone.

[1] All student names have been changed.

Collin: Yes	Confidently spoken.
T: Yes?	Again, she does **not** give away the answer with her tone.
T: If you say no, we're not measuring the degree of the angle. Then what are we measuring?	She pauses after asking this and then walks to the board.
Students: the distance … the distance in between two objects… that's what the angle is.	Several students respond in overlapping speech but somewhat quiet and reserved.
Amy: Isn't the distance the same thing as the angle?	As the teacher is at the board, but not speaking yet, Amy asks inquisitively. Opbroek stops what she is about to do, turns around and addresses this new question.
Students: No	Several quiet voices respond to Amy's question, some even whispering.
T: Those of you who said no raise your hand. Why? She said isn't the distance the same as the degrees of the angle and you said no.	Several students raise their hands as requested. She pauses before asking why. When no one begins to answer right away, she restates the question.

Within these first 10 minutes Opbroek strategically leads the class from review of the previous activity of using hand measures to the physical setup of the activity with the straw angle, objects up close and objects in the distance. She then moves to the abstract mathematics of an angle and its definition in a way that forces the students to connect all of these ideas together to help work out the conflict of what is being measured. From the teacher interviews it was evident that when she was asking students, "What are we measuring," she was assessing their understanding of an angle. She was also providing the discord students needed to struggle with, because she is aware of several angle misconceptions that exist and that the students will need to resolve.

Although Amy's question becomes the main focus of the remainder of the discussion, the teacher remains in control of the classroom communication. During the next seven to nine minutes, students continue to share reasons why they think measuring the distance between two far-away objects is the same as measuring the degree of the angle or not. More students begin to explain their thinking to Opbroek, sometimes even confusing themselves. Students use protractors to point out the meaning of a degree, physical arguments such as, "it's like saying every degree is a mile," and connections back to the actual experiment of measuring with their hands. The class remains engaged in the conversation as seen by students mimicking hand measures while a classmate presents, students gazing at the presenter, and students moving around in their chairs to see better. Further evidence of engagement include other students speaking aloud during the presentations with affirming information, students reminding the presenter of the question to discuss, and some independently discussing their ideas with their neighbour. Students begin to say things like, "I agree with Amy" or "I want to change what I said before."

The following transcription highlights how the students have an increasingly large role and responsibility for finding ways to convince other students about their understanding of an angle.

Transcription: Minutes 17:28 – 19:00 **The Conflict Continues**	**Notes**
Mark: Okay. If you have two targets you can	Mark demonstrates on the board as he speaks by

count the objects between them, but you can't count the degrees because it's like counting feet or miles. And you can't turn degrees into miles.	drawing two circles for the targets or objects. He addresses the whole class.
Aimee: Or can you?	Spoken in a mysterious voice
Collin: You can't turn degrees into miles. Uh, can I? (asking permission to talk) That right there, that ain't a mile. If we want to change degree into mile, we have to go like this (demonstrates). It would have to go over what it could possibly go.	He begins to speak and then asks for permission by the teacher ("Can I?") before continuing. He demonstrates using his hands starting together and then spreading apart further and further.
Jake: That's 180 degrees. Jared: Not true, not true! Collin: Yes, true!	Lots of overlapping speech here. Students are calling out with lots of conviction and these three say the same thing over and over.
Jared: Not true. When we were measuring with the straws and the stacks and everything. When we were doing the little thingy. And we went like this. You could get on an open plane and you could have people measure it. And you go like this and you look at it. It could look like only two inches but it looks like two miles maybe.	Jared takes over the discussion and walks to the front as he speaks. The class gets quiet as he states his case. He models with his hands and acts out how to view from the vertex and how the measures might look different.
Collin: It depends on how you are measuring it though!	Collin speaks directly to Jared with determination.
Aimee: No it doesn't. Collin: Yeah it does. Kellie: I agree with Aimee. Collin: It depends on how you are measuring it though.	Others begin to add in their responses with lots of overlapping speech as Jared sits down. Even the teacher is carrying on a conversation with Malcolm only.
Jared: I decline my case.	Jared gives up as he is sitting down.
Thomas: I feel like I'm at a meeting.	This fifth-grader states his continued frustration.
Collin: I have one argument that I think everybody should understand.	Collin's exclamation towers over the low ramblings of the class as he raises his hand but is not addressed.
Amy (to observer): My question?	In the background Amy's question to the observer is heard.
Malcolm (to teacher): Well, it seems like that because it's the distance between two objects.	Then the conversation between Malcolm and Opbroek becomes louder.
Amy (to observer): Are we still on my question? Holy cow!	Again asking the observer and when she sees a head shake "yes" she is beaming with pride.
T: (to Malcolm) Say that again. (to the class) You guys, listen to what he says.	As the conversation between Malcolm and Opbroek comes to a close, she feels it's worth everyone hearing. The class falls silent.
Malcolm: Aren't we measuring the distance of the degrees?	Malcolm places his elbows on his knees and asks the whole class.
Students: no, yeah [overlapped speech]	Loud disagreement.

Malcolm: Yeah! Because here's the degrees and here's the distance between them.	Malcolm's "yeah" is louder than the others. He demonstrates with his hands by making a V to show degrees and then taps the air at imaginary points along a straight line farther away to show distance between them.
S: It's like the same thing.	A student out of the camera's view chimes in.
Jared: But we're measuring how far apart the objects are.	Jared argues with Malcolm directly.

During this segment, around minute 19, students begin responding to each other and the teacher supports this shift in communication. Students begin to team up with those who think similarly on the idea to convince the other school of thought to change. Opbroek no longer called on students to share or added in her comments after each student, but rather allowed the students to carry the conversation. She was no longer acting as the operator but just a facilitator who jumps in when needed. Students energetically run to the board, wanting to be the next one to share their proof and reasoning in favour or against the idea of the distance being the same as the degree of the angle. Students also take control of the conversation from their seats, and others turn their attention over to the one who is the loudest or seems the most convincing. We even heard from some of the fifth-grade students who have not shared much (Thomas and Jake). Although their comments tend to be less content oriented, it was evident that these students were still involved in the conversation.

During the remainder of the class, 1 hour and 10 minutes longer, the conversation continues with the students controlling the flow and discussion with minor interruptions by the teacher, usually reminding the students of the actual question at hand. By about 40 minutes into the lesson while several students still want to share new or revised ideas and are begging for their time in front of the class, Opbroek suggests taking a bathroom break and several students resist saying things like "no, we are not taking a break," or "we are not taking recess." While Collin starts looking for physical objects to set up an experiment and other students continue teaming up and discussing the topic, Opbroek insists on a break and students accept it but run back excited and ready to continue.

Students come back from a bathroom break while Collin has been setting up his experiment. Opbroek helps to pull the class together to get them to focus on the task. She explains that this experiment was set up to answer a different question than the original one. The experiment will address if each person gets the same hand measure for both the nearby objects and the far-away objects. Opbroek is well aware of how this concept should help students understand the original question and is willing to allow the students to go in this direction.

As students continue gathering their data from the experiment, Thomas asks the quintessential math question, "Is Collin right or is he wrong?" As Opbroek tries explaining that she never gives the answers, students even at this time are answering each other by saying [overlapped yelling] "right, wrong, Collin is <u>so</u> wrong, he's right in one way and wrong in another."

The lesson now morphs into the students taking turns measuring with their hands and recording their two different measurements—for the close objects and the far-away objects. Engagement continues to remain high as all students either eagerly line up to be part of the experiment or watch their classmates take measurements until it is their turn. Further, students continue to work with each other and discuss their conjectures and proofs. As students share their data, Opbroek then leads them to try answering the question by looking for patterns. As a whole class, they organize the table into groups—those with the same measurements and those with different measurements (this organization was suggested by Charles, the new student). Opbroek concludes the class by using this setup and the students' ideas and responses to help model how to design a project for the science fair, a requirement all the sixth-grade students must do within the next week. She writes on the board: "Is measuring the distance between objects the same as measuring the angle's degrees?" The class ends with journaling on this question.

Discussion

How did Opbroek use and adapt cultural components of MCC to develop meaningful math understanding for students of another cultural group? On first analysis of this lesson, we thought that students related to the Yup'ik knowledge because they are Alaskan and many live with relatives who do outdoor activities such as hunting, fishing, camping, etc. However, cultural components beyond our scope and thinking became apparent when our Yup'ik consultants viewed the video. The following statements and summary are compiled from the transcription of the video analysis meeting conducted March 1–5, 2005, in Fairbanks after 12 MCC project consultants viewed this lesson, five of whom were retired Yup'ik teachers.

The consultants were impressed with how often throughout the discussion, both the teacher and the students connected back to Frederick George and his knowledge. The teacher facilitated the embedded Yup'ik cultural knowledge into lively, mathematical communication and learning made relevant to this non-Yup'ik group of students. Frederick's knowledge is not everyday or cultural knowledge for anyone in the classroom but stems from a general theme of tapping into people's everyday surroundings while living in Alaska. As evident from literature, incorporating these elements into the mathematics curriculum can contribute to a more meaningful appreciation of mathematics (Gerdes, 1994). Further, the work of Gravemeijer (1994) on developing realistic mathematics education and Treffers' (1993) work on realistic mathematics education support this argument by demonstrating the need for realistic contexts. Students also relied on their own knowledge of measuring to pose conjectures and offer proof. Using the information in the MCC curriculum, Opbroek provided the framework of information for students to connect and fostered their thinking by never giving away the answer, being patient with the discussion, and allowing students the freedom to share ideas and offer a variety of proofs. As research suggests, when students are given problems set in realistic contexts, the students can use their knowledge of these contexts to formulate mathematical ideas in meaningful ways and then formalize them (de Lange, 1992; Gravemeijer, 1994).

The idea of ownership came up several times among the Yup'ik consultants. "She didn't own anything—everybody had ownership and she allowed the kids to own the lesson too. She respected their input." This is an emerging idea in our research and refers to the kids not only having ownership of something created, but also of the flow of the lesson and the knowledge used within and developed from the lesson. "The kids owned the lesson and that's where real learning occurs." The teacher facilitating the lesson by using guiding questions was even considered a way to allow students ownership of the lesson and the knowledge. "She started using words and questioning and then when the questioning started coming from the kids she didn't give answers, she let them answer. If she were telling all the answers, the lessons would still be hers."

Further ideas began developing, such as the comfort level of students and how that relates to their discussion, proofs, and willingness to agree and disagree. "All the students were comfortable with one another, saying I disagree." Other consultants pointed out that the students were not afraid to speak out and did not seem to be afraid of being wrong. "No one laughed at one another; they respected one another."

The discussion became extremely exciting when the Yup'ik consultants related Opbroek's actions to those of the elders. This idea began with a reference to the teacher stepping out of the conversation and allowing the students to carry it; she would intervene when needed and then would step out again. Evelyn Yanez said, "The teacher was like us; she taught like an elder. The way she moved away from the blackboard and became a listener, a participant is how we teach. When I was in the classroom, I would teach, then step back and become a participant. I would go down to their level and be a part of the learning." The phrase "like us" refers to being like a Yup'ik teacher. Further she said, "The men act like that in Togiak [a Yup'ik village in southwest Alaska], the way they discuss real life things … and then after all that discussion with the other men, then everyone will leave and my dad and his brother will be there still discussing. But they still don't know what the answer is. But they think they know how to get there. They are not sure, but they think they know the question." One consultant made the connection between what the elders teach, survival skills, and what the lesson was using for students to relate back to physically. It was also brought out that the classroom setup (the way students were sitting in a circle) and the quality of student discussions were similar to a *qasgiq* (men's community house) because each individual student acted as part of the whole group.

As the discussion continued a new concept began developing: that of harmony. Everyone was working towards a common goal, even if they seemed like they were arguing. This relates back to a phrase and idea that we have heard from many elders over the past decade: if we are of one mind then we can accomplish our goals. Despite what seemed like arguing, the Yup'ik consultants saw harmony in the video since everyone was aiming for the same end result of understanding. All students were comfortable with one another. They were not afraid to express their ideas and there was harmony, respect, and trust among the students and between the students and the teacher. This is essential for student learning.

During interviews with Opbroek, she expressed many of the same ideas as the Yup'ik consultants. Michelle said that the description of harmony given by the Yup'ik consultants is "exactly what it means to have a constructivist classroom: same end goal but each kid constructs their own path."

Conclusion

This case example provides evidence that various cultural groups can learn from other culturally based materials. The enactment through the teacher helps determine the validity of the material and the usefulness to the children's lives. We can do more than just see that other groups have mathematics in their culture. We can actually learn that mathematics and use it as another way to connect to learning school based mathematics derived and imposed on students from the western culture.

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