

student TECH



interactions in NOLOGY-RICH classrooms

Does the use of individual laptop computers in the classroom create a barrier to student collaboration?

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Students are more likely to develop a deep conceptual understanding of mathematics when they interact with and discuss their thoughts with others (Cobb 2000; Cohen 1994; Davidson and Worsham 1992; Vygotsky 1978). The National Council of Teachers of Mathematics (NCTM) (1989, 2000) has recommended that students be active learners—communicating with one another, conjecturing, exploring, and justifying claims by using tools or manipulatives. NCTM specifically emphasizes the use of technology as a tool: “Electronic technologies—calculators and computers—are essential tools for teaching, learning, and doing mathematics” (2000, p. 24). Incorporating technology and cooperative learning in the classroom can deepen students’ learning of mathematics (NCTM 2000). Here I will discuss student interaction and discourse in an environment that includes Java-based, curriculum-embedded mathematics software.

When I was a high school teacher, I emphasized cooperative learning and used graphing calculators daily in my classroom, but I had fewer opportunities to use computers. As a doctoral student with dual interests in cooperative learning and technology, I set out to learn how the use of computers affects the types of student interactions in the classroom. For instance, I wondered whether laptop computers on students’ desks would form barriers between students, hindering their communication. I conjectured that if each student had his or her own computer, students might be tempted to work independently rather than collaboratively. This conjecture led to my study.

THE CONTEXT

The National Science Foundation has supported the development of mathematics curricula that address NCTM’s recommendations. One such curriculum is Core Plus Mathematics (Hirsch et al.

2008), a complete high school mathematics curriculum organized around units consisting of series of hands-on investigations, set in real-world contexts, that facilitate students' construction of important and meaningful mathematics. The lessons in these series promote oral and written discourse; the textbooks include sets of written questions or prompts for action, and small-group work is the primary medium for student learning.

In addition to providing a structure that supports collaborative learning, the second edition of the Core Plus Mathematics curriculum includes computer software as an integral part of the curriculum materials. The Java-based software designed for use with the curriculum is CPMP-Tools (Keller 2006), a suite of both general-purpose and custom tools developed for each mathematical strand of the curriculum (algebra, geometry, statistics, and discrete mathematics). The custom tools, designed for specific uses with particular investigations in the curriculum, may, for example, already have the data entered for a statistics problem or may already have a geometric figure drawn and ready to manipulate in prescribed ways. CPMP-Tools is free software accessible to students via the Internet, and thus students may use the software anywhere there is Internet access—in a school classroom, computer lab, or library or at home.

I chose to observe classes at a high school that is currently implementing the second edition of the Core Plus Mathematics curriculum and that also has laptop computers available for all students. In some instances, students worked in groups with their laptops in front of them, and at other times the teacher used CPMP-Tools on his or her computer and projected the display onto a screen in front of the classroom. Sometimes when the teacher was using his or her computer at the front of the class, students followed along on their own computers at their desks. The particular classes I observed were courses 2 and 3 of the Core Plus Mathematics curriculum. Course 2 students are typically tenth graders; course 3 students are typically eleventh graders.

STUDENT COLLABORATION

Three key attributes have been found to be necessary for successful group work (Cohen 1994, 1996). The first is a group-worthy task, and the second is assignment of group roles—both of which are components of the Core Plus Mathematics curriculum. Cohen (1994, 1996) identified several roles, including facilitator, reporter, materials manager, and recorder. The names of the roles may change according to the situation, but the important point is that each student has a role. Students who use the Core Plus Mathematics curriculum are taught to

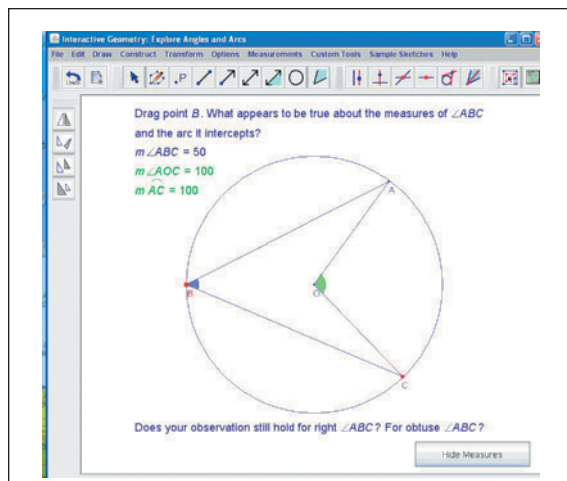


Fig. 1 Exploring the relationship between inscribed angles, central angles, and the intercepted arc led students to a conjecture.

work in groups within these roles: reader, experimenter, recorder, and quality controller (Hirsch et al. 2008, p. 4). Cohen (1994) described how each role fosters group interaction and discourse, avoids problems of nonparticipation and interpersonal difficulty, and facilitates completion of a task. The third key attribute of successful group work is the development of positive norms of behavior (Cohen 1994, 1996), such as asking questions, listening, helping others, responding to others' questions or ideas, giving ideas, and explaining.

As students worked in groups on their individual laptops, the most common behavior I observed was building on others' ideas (Sherin, Louis, and Mendez 2000). In the example of dialogue that follows, students used a custom tool in the CPMP-Tools software to discover the fact that the measure of an inscribed angle in a circle is half the measure of its intercepted arc (see **fig. 1**). After students had explored the situation with the software, they began to reason about the angles in the diagram. The isosceles triangle they refer to is formed by the two radii that make up the central angle and a third segment connecting them (not shown in **fig. 1**). In the dialogue excerpt, the first student voices an idea; the next three students build on that idea.

Kelly: If the radiuses are the same, then it's an isosceles triangle.

Brad: So the angles have to be the same.

Gina: Yeah, because you know angle AOC, and then you have an isosceles triangle ...

Brad: So the other two angles are the same. [*writing*] In isosceles triangles, two angles ...

By building on one another's ideas, these students were able to figure out the measure of the two congruent angles in an isosceles triangle given the

measure of the other angle (referred to as “angle AOC ” by Gina). This building on others’ ideas was the most frequently occurring student interaction, an encouraging sign.

Students’ discourse while using computers in groups also contained many good examples of asking and answering one another’s questions. One such example is given in the following dialogue. In this exchange, students were using software to explore the SSA condition for triangles. (Figs. 2a, 2b, and 2c, which will be described later in more detail, show the particular CPMP-Tool that they were using.) The question was, “Is the triangle shown the only possible triangle determined by $\angle A$, \overline{AB} , and \overline{BC} ?” (Hirsch et al. 2008, p. 499).

Audrey: Is it yes?

Kent: I say no, it’s no.

Audrey: Why is it no?

Kent: SSA [*side-side-angle condition*].

In the course of my observations, the four predominant types of interactions exhibited by students working on laptop computers in groups were building on other students’ ideas, asking questions, giving ideas, and answering others’ questions. These four types of interaction are all behavioral norms that have been identified as desirable for effective groups (Cohen 1994, 1996). Thus, even while students were working on their individual laptops, the three key attributes for effective group work were evident.

Another revealing observation was that much of the student collaboration seemed to be prompted by the use of the laptops. Many times two students collaborated by comparing the display on one screen with that on a neighbor’s screen; the ability to move the laptops next to each other was an advantage. At other times, one student got up to point at the screen in front of another student. In addition, the results displayed on the laptop often generated discussion. The use of the laptops seemed to act as a magnet to draw students together.

During my observations, students seemed to collaborate more frequently when they were using computers than when they were not. Using the same software created an additional need for students to work together and appeared to be a motivating factor for some students in articulating their thoughts. As a result, my conjecture about computers hindering communication or collaboration was shown not to be true.

STUDENT INTERACTIONS PROMPTED BY CPMP-TOOLS SOFTWARE

The following dialogue excerpt illustrates some interactions prompted by the use of the CPMP-Tools

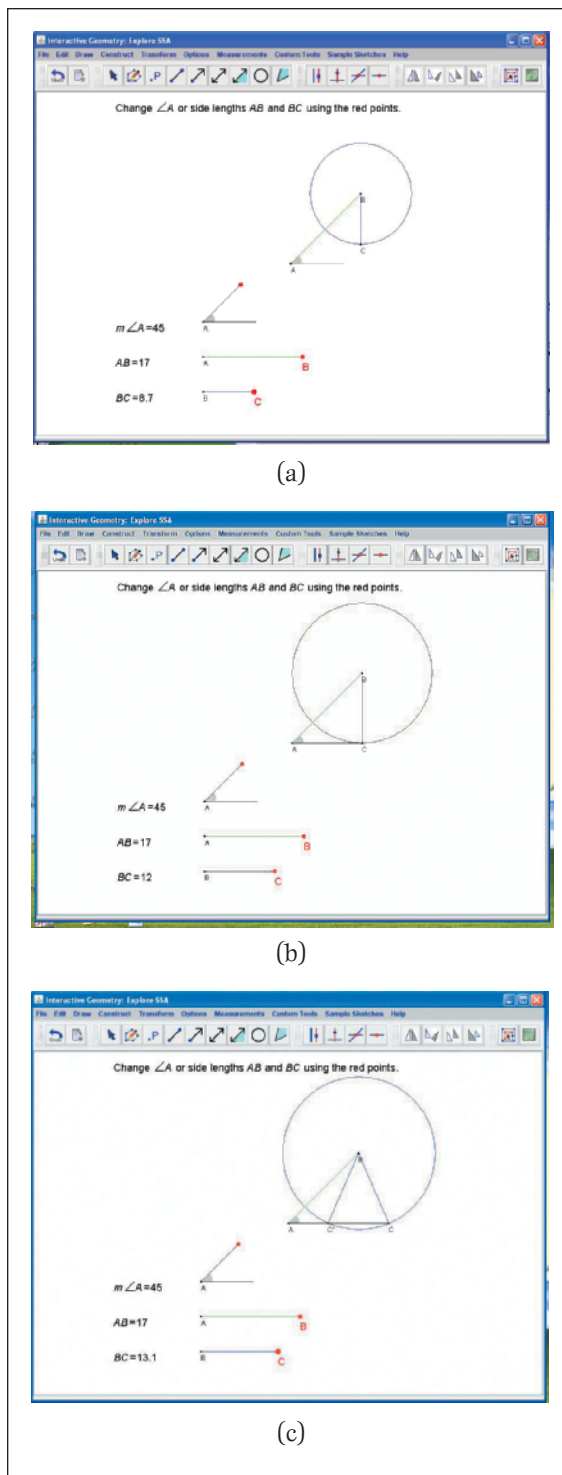


Fig. 2 The Explore SSA custom tool can be used for situations in which no triangle is formed (a), a right triangle is formed (b), or two triangles are formed (c).

software. The topic of this investigation was the SSA condition for triangles, for which the Explore SSA custom tool was specifically created. With this software, students are given an angle A (a fixed measure) and side AB (a fixed length) and are asked to experiment with various lengths of side BC to see what triangles are formed (see figs. 2a, 2b, and 2c).

The main goal is to find a length of \overline{BC} such that two noncongruent triangles can be formed, thus illustrating that the SSA condition does not guarantee congruence of triangles.

When the following discussion occurred, the teacher had a computer set up on a desk in the front of the room; it was connected to a projector, so that the image on the computer screen was projected onto a screen at the front of the room. In the dialogue, Gwen and Claire are student volunteers who are controlling the computer.

Teacher: What happened there? [see fig. 2a]

Gwen: Our edges don't touch.

Teacher: Why did it—it doesn't touch—why did the triangle go away?

Gwen: Because it's too short.

Teacher: Okay, keep going just very slowly until we get something.

Gwen: Like this way?

Teacher: There you go, go back a little bit, keep going.

Jorden: Back.

Teacher: There you go, whoops.

Gwen: Go back?

Claire: No, you have to get the triangle back.

Teacher: A little bit smaller, perfect. What do you notice about this? [see fig. 2b]

Chloe: It's a right triangle.

Teacher: A right triangle? Does it appear to be a right triangle?

Students: Yeah.

Micah: Yes, sir.

Teacher: OK. When that got smaller, what happened? When Gwen made \overline{BC} smaller than that—go a little bit smaller than 12, please.

Hannah: Oh, the line went away.

Teacher: The line went away.

Gwen: Do you want me to make it smaller?

Teacher: Right after that. It's too short to touch.

Now, make it longer, please. What's happening here? [see fig. 2c]

Hannah: There are two possibilities.

Teacher: Why are there two possibilities?

Hannah: Because there are two \overline{BC} s. It can be on the left or on the right.

Teacher: Do you see that there [are] two triangles in here, guys?

Many students: Yeah.

This dialogue contains observations about the occurrences on the computer screen: “Our edges don't touch,” “The line went away,” and “... there are two \overline{BC} s.” This common student interaction I categorized as making observations, a category I applied only to statements that implied that students were noticing something that they saw on

the computer screen. In these instances, students would often be dragging some figure, such as an angle, and stating their observation to other students. The software often assisted students in making observations by providing a tangible object that they could manipulate easily and by immediately displaying the change in measurements.

In addition, this dialogue excerpt reveals students engaging in inquiry using the software, an interaction that occurs when students use the software to explore an idea or test a conjecture. The dragging feature allows students to change lengths and other measures quickly and easily, enabling them to reach conclusions without having to redraw the picture with pencil, compass, and protractor and thus interrupting their train of thought. By clicking on and dragging a red point on the screen, students can easily change lengths and measurements and thus conclude that when segment BC was greater than 12, two triangles were formed.

These interactions combined with statements made by students during the interviews—“It is helpful to *see* the concept being discussed” and “It helps you *show* your thinking”—indicate the visual benefit of using computer software to learn mathematics. All the students were engaged throughout almost the entire whole-class discussion. Their attention was fixed on the action on the screen in front of the class.

COMPUTER ANIMATIONS

I also observed student interaction in a course 2 classroom during the unit “Coordinate Methods,” in which students discover the rules for transforming the coordinates of a figure in the coordinate plane by using translations, reflections, rotations, and dilations. Students make this discovery by applying rules—for example, the rule for rotating a point 180 degrees around the origin is $(x, y) \rightarrow (-x, -y)$ —and then later through the use of matrices. By the end of this unit, students can create their own figures using coordinates and some simple draw commands. Then they choose transformations to perform with matrices and create an animation using their figures.

As students learned the transformations and rules for them, there were days when their computers were shut off. I observed students working in their groups on these days as well as on the days when they were working on their computer animations, when there was a marked increase in the activity and energy level in the classroom. Students were helping one another with their programming code and showing one another the drawings they had made. Their creativity blossomed, and new strengths surfaced. Some students who were very quiet before became more vocal. Students who were

technologically savvy and those who caught on quickly to the programming code became new leaders; other students would walk across the room to ask them questions and seek their input.

Another gratifying observation involved students who struggled to come up with an idea to draw and animate or who struggled with the programming code: They displayed even more of a sense of accomplishment when their animation was finally complete. Here are a few of their comments:

- “Now I even understand transformations!”
- “I was frustrated at first because I couldn’t get it to do what I wanted it to. But now that it works, I am so excited! You get a sense of accomplishment when you’re done. And you know if you ever go into computer business, you know how to make designs.”

On the last day of the unit, when the teacher projected each of the students’ animation projects on the screen in front of the class, there was much excitement in the room.

CONCLUSION

Using computers in mathematics classrooms provides more opportunities for students to be active learners. With the advent of more affordable laptop computers, the presence of computers in mathematics classrooms may soon become as widespread as graphing calculators are today (Poulsen 2005). Computer software can perform the same operations as a graphing calculator or serve as a manipulative to explore mathematical concepts.

However, the use of computers has advantages over calculators and physical manipulatives. The dynamic nature of software such as CPMP-Tools engages students and has the power to illustrate mathematical concepts clearly. Other advantages are the ease of manipulating the objects on the computer screen (clicking and dragging), the accuracy of measurements, the precision of movement of the objects, and the colorful visuals. In addition, students today are comfortable using computers. They type their papers on the computer and use the Internet for many other school assignments. Now, they can use their computer in mathematics class to copy and paste screen shots from software into their homework papers and save their work, just as the students I observed did.

My observations suggest that use of the computer may actually enhance communication among students and increase students’ ability to make conjectures and explore concepts. An increasing potential exists for computers to help teachers make further changes in their instructional practice and to achieve the vision set forth by NCTM.

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