NCTM Standards in Action Process Standard: Connections

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NCTM's *Principles and Standards for School Mathematics* (2000) identifies 10 standards that form an essential and comprehensive foundation for students from Kindergarten to Grade 12 to learn mathematics. The standards are divided into five content standards (number and operations, algebra, geometry, measurement, and data analysis and probability) and five process standards (problem solving, reasoning and proof, communication, connections, and representation). This article focuses on one process standard: connections.

The revisions to the K–12 mathematics curricula in Alberta have consciously incorporated investigations of the connections and interplay between various mathematical topics and their applications. *Principles and Standards for School Mathematics* (NCTM 2000) suggests that the mathematics instructional programs for K–12 should include the connections standard so that all students

- recognize and use connections between mathematical ideas,
- understand how mathematical ideas interconnect and build on one another to produce a coherent whole, and
- recognize and apply mathematics in contexts outside of mathematics.

The ability to connect mathematical ideas, transfer skills and concepts to other mathematical areas, and apply mathematics to areas outside of mathematics and to practical situations will lead to a deeper and more lasting understanding of mathematics. Students will also come to understand that mathematics is not a collection of separate topics or strands but, rather, an integrated whole. This view of mathematics can only be developed if teachers provide opportunities to study connections within the mathematics curriculum of a particular grade and between the grades. Knowing what has been studied in previous grades and what will be studied in the following grades is essential for teachers.

How do we teach students to recognize and use connections between mathematical ideas? The simple answer is by emphasizing mathematical connections. This implies that teachers need to link conceptual and procedural knowledge, relate various representations of concepts or procedures to one another, recognize relationships between topics in mathematics, use mathematics in other subject areas and apply mathematics to real-life situations. Such emphasis will lead students to see mathematics as an integrated whole rather than as an isolated set of topics.

As students progress through the grades, investigating connections between various mathematical topics should include recognizing equivalent representations of the same concept, using connections between mathematical topics, and using connections between mathematics and other disciplines. Teachers also need to guide the process carefully by asking appropriate questions, such as "How is our activity today related to our discussion yesterday or last week?" or "How is this problem or mathematical topic like things you have studied before?"

How do we teach students to understand how mathematical ideas interconnect and build on one another to produce a coherent whole? Students must have many opportunities to observe the interaction of mathematics with other subject areas and with everyday problems outside mathematics. As students progress and mature, their mathematical experiences with connections should provide not only different settings but also gradual increases in difficulty and complexity. Using a variety of solution processes would also lead to a deeper understanding of the connections among the various mathematical ideas. Teachers need to be mindful of the importance of linking conceptual understanding with procedures,

and such linking should be central in the teaching/learning process.

It has also been suggested that an important part of the connections standard is teaching students to recognize and apply mathematics in contexts outside of mathematics. How is that best achieved? The Applied Mathematics 10-20-30 stream is a step in the right direction. This is not to suggest that applications to areas outside of mathematics cannot be included in the Pure Mathematics stream or the other grade levels. In fact, they should be included in all mathematics programs if students are to develop a view of mathematics as a connected and integrated whole.

The mathematical experiences of K–12 students should include opportunities to learn about mathematics by working on problems arising in contexts outside of mathematics and within their own experiences. The connection to the real world is particularly critical for students at the primary level. The level of difficulty and complexity related to connecting mathematics to the real world increases as students progress through the grades. At the high school level, the Applied Mathematics stream challenges students with complex applications and the use of sophisticated measuring devices. These experiences allow students to see the connection of mathematics to the worlds of engineering, architecture, commerce, social sciences, building industry and many other areas. Teachers have to take great care in selecting appropriate problems, activities and projects because students are unlikely to learn to make connections unless they are working on problems or situations that have the potential for suggesting such links. As a means of emphasizing the connections between mathematical ideas, new concepts should be introduced, when possible, as extensions of familiar mathematics and previously learned concepts and skills.

The connections standard derives its importance from the fact that students learn to see mathematics as an integrated whole, increasing their potential for retention and transfer of mathematical ideas. Furthermore, emphasizing connections helps to instill in students an understanding of and appreciation for the power and the beauty of mathematics. Connecting mathematics with other disciplines and with the real world also underscores the utility of the subject.

The three articles that follow provide examples of making mathematical connections. The first article is an example suitable for the junior high level and the other two articles demonstrate the connections standard at the high school level.

Bibliography

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In how many ways can the fraction ½ be written as the sum of two positive fractions with numerator equal to 1 and denominator a natural number?