Mathematics for life

Professor Peter Kloosterman discusses his research which evaluates the implications of the National Assessment of Educational Progress results for mathematical curriculum and policy development

Firstly, could you contextualise the National Assessment of Educational Progress (NAEP)?

Although the US has commercially produced assessments for prospective college students, they are optional. Thus, NAEP is the only assessment that evaluates exactly what students across the country know. By looking at student performance on the wide variety of items that NAEP uses, we obtain an excellent picture of the skills most students have and the ones they still need to learn. Other researchers use NAEP data to answer policy questions such as the relationship between school size or parental education and student learning, or how the performance of students in urban schools compares to that of students in rural schools. We stand apart from most other research groups using NAEP data in that we pay very close attention to what NAEP scores show in terms of student understanding of specific mathematics concepts.

What have been your chief findings thus far and how are they directing the research?

In the US there is a prevailing myth that our students used to be among the best in the world, although international assessment data suggest that American students have always lagged behind many economic peers. The NAEP datasets provide cause for optimism in that they clearly show that at grades four and eight, current US students are as much as two grade levels better than their counterparts of 25 years ago. The political climate in the US right now focuses on the need to dramatically change mathematics instruction in schools, yet the improvements in recent years indicate that much of what we do is right so we want to be careful not to alter curricula in ways that cause us to lose the gains we have made.

When and why did you develop an interest in the policy implications of mathematics? What is the background to your career development?

I started my career as a high school mathematics teacher and found that many students came to me knowing isolated mathematics facts and procedures yet they had a poor understanding of how to put those facts and procedures together to solve problems. Over the years I realised that it is possible to help students see connections between different mathematics concepts and that when they discover those connections they are more likely to remember and correctly apply mathematical principles and procedures. I also realised that many policy decisions in education were based on anecdotal evidence, data from biased samples, or no evidence at all. I strongly believe that children learn best when curricula and instruction methods are based on research evidence, and NAEP provides the best data available about what students are learning.

What is your perceived notion on the knowledge of maths students today?

For a lot of people, knowing mathematics, especially at the elementary school level, means the ability to compute with whole numbers, decimals and fractions. Outside of school, computation with anything beyond two-digit numbers is normally done with a calculator or computer, thus the real question should be how well students use numbers to answer questions involving quantity. Most students are good at basic numbers facts and computations, but they are not able to make sense of large numbers or situations that require comparison of numbers. Unfortunately, most adults are not much better so we need to get everyone to be more adept with mathematics.

How do you define progress in the context of education? Why is it so important?

Progress usually means that students are learning more than their peers of several years ago but for us, the key is what students are learning more about. With the amount of numeric data available to anyone with a computer or smart phone, it is essential that students become better at deciding which data are relevant to the issues they face and then calculating with or interpreting those data accurately. If people stopped to think about just how much it is costing them to carry a balance on a credit card, I assume that many would quit charging items they did not really need. NAEP does not have any items that focus on credit card debt, but the poor performance on NAEP items that deal with similar complex issues suggest that getting students to use mathematics in more ways is essential to a large number of quality of life issues.
What mathematics do students know?

A research group centred at Indiana University is working to assess the data gained from a US nationwide mathematics assessment in order to help inform decisions around curriculum and educational policy.

THE NATIONAL ASSESSMENT of Educational Progress (NAEP) is a government-run programme in the US designed to assess the academic achievement of 4th, 8th and 12th grade students in a variety of subjects. NAEP differs to assessments such as SATs as it is given to a sampling of students from all sectors of society, not just those inclined to continue education at college level. Thus it currently provides the best overall indication of academic achievement nationwide. As the US does not have a national curriculum, thorough and accurate interpretation of NAEP data is essential for educators and curriculum developers.

Despite government administration, reports describing the information gathered from NAEP are limited in scope. Those that do exist focus on the overall scores of current students in comparison to those of previous assessments. Working with Crystal Walcott, Doris Mohr, Nathaniel Brown and three graduate students, Professor Peter Kloosterman of Indiana University has been analysing the data on the mathematical knowledge of students generated by NAEP. Their focus is on how mathematical skills and abilities of students have changed over time. As Kloosterman states: “Our main goal is to report what concepts and topics students know well and what needs more emphasis”. Through careful analysis of NAEP data the researchers hope to inform curriculum and educational policy decisions that impact mathematics learning.

GAINS IN MATHEMATICS

There are two different NAEP testing programmes. The best known of the two is the ‘Main NAEP’ which, since 1990, has tested 4th, 8th, and 12th grade students on two-and four-year intervals. Contrary to the opinion frequently circulated by the US media, the results of the Main NAEP show that there have been large overall gains in mathematics performance of students in grades 4 and 8 in the past 20 years - much greater gains than in any other NAEP assessed subject. ‘Long-Term Trend NAEP (LTT)’ was begun in 1973 and given to students according to age rather than grade, testing ages nine, 13 and 17. As the items were identical from 1978 to 2004, the LTT provides the best data for long-term comparisons and performance over time.

The areas of mathematics covered are: number properties and operations, algebraic thinking, geometry, measurement, data analysis, statistics and probability. In the NAEP tests, knowledge and performance of these areas is measured using a combination of multiple-choice items, questions requiring a single word or number answer, and questions where students need to explain their thinking and justify their solution to a problem. The type of questions students find most difficult are those which require an explanation of their comprehension. Kloosterman asserts: “Part of this may be because those problems require more thinking, but part is almost assuredly due to the fact that students are usually assessed in their classes on whether an answer is right, rather than on showing why an answer is right”. When teachers expect students to explain their thinking, evidence indicates that they learn to provide good explanations.

CURRICULUM SHIFT

Kloosterman and his team are providing objective data on the mathematics knowledge of students and how performance has changed over time. However, it is not enough to know simply that there has been improvement in students’ mathematics knowledge over the past 20 years: to identify effective aspects of the curriculum the data must be explored to discover which particular areas have improved and to what degree. For example, Kloosterman notes that: “Although students are not very good at solving problems that require complex thinking, substantially more students can solve such problems now than was the case 20 years ago”. In other words, the increased emphasis on problem solving in the curriculum has had a positive effect. It is worth noting that in correlation with this improvement in problem solving, other mathematical abilities such as computing or knowledge of terminology were measured to be as good or better than previous years and the emphasis on problem solving did not have a negative effect on basic mathematical skills.

DEMOGRAPHIC VARIABLES

NAEP collects information about a range of demographic variables, such as gender, race or ethnicity, the size of the community in which a school is located, the level of teacher experience in a school and how often a student changes schools. Although the investigation mainly focuses on the performance of the student body as a whole, they look at specific items or topics in order to disprove prevalent illusions about data or to offer recommendations to curriculum changes for specific groups of students.

For example, although there are high and low performing students in all racial and ethnic groups, white students as a group perform better than black or Hispanic students. Kloosterman states: “After the 2011 NAEP data were released, some people were making the claim that the gap in performance between white students and their black or Hispanic peers was narrowing”. The study demonstrated that this was true looking back just 10 years but when 1990s results were analysed it became clear that the gap between the groups widened significantly during the 1990s. Assessing the data over 20 years demonstrated that in fact the gap has changed very little, and thus continues to be a major concern.
INTELLIGENCE

THROUGH CAREFUL ANALYSIS OF NAEP DATA THE RESEARCHERS HOPE TO INFORM CURRICULUM AND EDUCATIONAL POLICY DECISIONS THAT IMPACT MATHEMATICS LEARNING

LEARNING PROGRESSION

The group shares its research findings with current and future teachers alike to help them understand the significance of such data and the beneficial way the information can be used for educational progress. A good example of the effect teachers can have is the proposition made by the National Council of Teachers of Mathematics in 1989. The Council recommended focusing mathematics instruction away from heavy emphasis on traditional computational skills and towards encouraging students to solve problems and understand mathematical concepts. “Although the proposal was a recommendation rather than a policy, it has had significant impact on US mathematics curricula and teaching over the last 20 years,” Kloosterman notes. Results support the positive impact of this policy recommendation.

Despite the argument of some groups for a return to more traditional mathematical instruction, the improvement of students’ ability to solve complex problems in the past two decades shows that the push toward problem solving has been effective. “We clearly have a long way to go to make all students proficient users of mathematics, but given that gains in other content areas are much smaller than gains in mathematics, it is hard to agree with arguments for a return to the mathematics instruction of the 1980s or before,” explains Kloosterman. The team’s research into NAEP data continues giving the public, educators and policy makers the knowledge and tools to talk realistically about the subject of mathematics teaching and test scores. Their work demonstrates just how important it is to use the data we have to make important decisions.

Through careful analysis of NAEP data the researchers hope to inform curriculum and educational policy decisions that impact mathematics learning.

THE RESEARCH GROUP

WHAT MATHEMATICS DO STUDENTS KNOW? IMPLICATIONS FROM NAEP FOR CURRICULUM AND POLICY

OBJECTIVES

This project involves secondary analysis of secure data from the Main and Long-Term-Trend mathematics assessments of the National Assessment of Educational Progress (NAEP). Specifically, the project investigates the issues of: (a) current knowledge and change over time of grade 4, 8 and 12 students on specific mathematics skills; (b) the extent to which the performance is related to specific mathematics curricula; and (c) the connection between courses taken in high school and mathematics performance.

KEY COLLABORATORS

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