



RESEARCH REVIEW

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The importance of understanding student misconceptions

► THE STUDY

Hill, H.C., & Chin, M. (2018). Connections between teachers' knowledge of students, instruction, and achievement outcomes. *American Educational Research Journal*. Advance online publication. doi. org/10.3102/0002831218769614

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Professional learning strategies often rely on the belief that teaching and learning outcomes are best when teachers have a clear understanding of students' thinking. This may seem like common sense — after all, students are active participants in the learning process, so their thinking impacts the outcome. But does research support the assumption that teachers' knowledge of students' thinking matters? Researchers Heather C. Hill and Mark Chin address this issue in a study recently published in the *American Educational Research Journal*.

Hill and Chin consider what they call “incomplete evidence” in the research literature on teachers' understanding of student thinking, including whether it can be measured reliably and how it stacks up with other areas of teacher knowledge such as subject matter content.

They acknowledge that some studies find a positive link between teachers' understanding of students and outcomes, but they worry about what they call “weak and inconsistent” evidence that this knowledge is really related to teacher practices and student learning.

To make the evidence base more robust, their study asked these specific research questions:

- Can we measure reliably what teachers know about students' thinking?
- Is instructional quality higher when teachers judge students' mastery accurately and when

they understand the nature of students' misconceptions?

- Are student learning outcomes better when teachers understand students' thinking in these ways?

The study's findings have important implications for professional learning directors, coaches, and school leaders as these professionals consider how to incorporate students' development and learning needs into strategies to make the most of curriculum and materials. As Learning Forward has codified in the **Implementation standard** of the Standards for Professional Learning (Learning Forward, 2011), effective professional learning takes into account the process of change over time, and understanding how teachers' and students' thinking interact could lead to richer conversations among leaders and staff about how learning can change and grow.

WHAT DO WE KNOW?

Research has long suggested that teachers' understanding of students and their learning experiences has an impact on student outcomes. Understanding students is also often emphasized as a way to support students' social and emotional learning, increasingly understood as a critical component of overall success. Of course, there are many ways that teachers develop an overall understanding of their students and the most relevant and useful teaching strategies.

Decades-old research, such as that of Lee Shulman, highlights the complex nature of teacher knowledge that includes content knowledge, pedagogical content knowledge, and knowledge of students and their characteristics. Deborah Ball has found that the kinds of teacher knowledge that matter include students' conceptions and misconceptions about academic content and students' expected reactions to content and tasks as well as knowledge of the subject itself.

Hill and Chin focus on two areas of teacher knowledge that have been understudied: how attuned teachers are to students' mastery levels in the subject they teach, and how well they recognize and understand students' misconceptions about the content they are learning. Knowing where students are in mastering the content can inform teachers' decisions about pacing, assessment, and other teaching elements. Understanding why students make frequent mistakes can inform how teachers plan their lessons and tailor their feedback to support students' shift in thinking.

For example, the teacher might recognize that many students erroneously believe that when dividing fractions, they should divide the denominator by the numerator. Anticipating this can help teachers tailor their approaches to help students head off such errors.

In practice, this means that it could be very helpful to infuse



professional learning discussions with an examination of common student misconceptions as revealed by the research as well as by teachers' own student artifacts.

HOW WELL CAN TEACHERS UNDERSTAND STUDENTS' THINKING?

The researchers' first question was whether it is possible to measure how well teachers understand students' thinking. The first step in their measurement process was developing a multiple-choice math test for students that included not only a correct answer but also incorrect response choices that reflect common student mistakes about math concepts.

The researchers then used this test to generate two measures of teachers' understanding about students:

1. **Accuracy in judging student knowledge:** Teachers were asked to estimate the percentage of their students who would get the correct answers on the math items. This served as a measure of how attuned teachers were to their students' understanding of math content. Teachers whose estimates closely matched the real percentage were considered to have higher levels of accuracy.
2. **Knowledge of student misconceptions:** Teachers were asked to rate which of the incorrect responses students were most likely to choose. This was a measure of teachers' general knowledge of why students tend to make certain kinds of mistakes. Teachers who correctly identified the most popular incorrect responses were considered to have higher levels of knowledge of student misconceptions.

Hill and Chin validated and examined these measures, including

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whether the measures effectively differentiated among teachers and whether teachers' scores remained stable over time. The researchers used data from 284 4th- and 5th-grade math teachers included in a study by the National Center for Teacher Effectiveness conducted from 2010 to 2013. The teachers had an average of 10 years of teaching experience and worked in schools with students who were 40% black and 23% Hispanic; 63% of students qualified for free or reduced price meal plans.

Accuracy appeared to be reliable and stable over time. Knowledge of student misconceptions was less stable, but the researchers continued to study its potential relationship with teaching strategies and student outcomes. Interestingly, the researchers found that teachers with higher-achieving students tended to be more accurate in judging student knowledge.

In addition, the authors noted that teachers' predictions of student performance are impacted by many variables, including students' language proficiency and classroom management issues. Teachers with more black and English language learner students tended to be less accurate.

These findings and ideas could inform a rich professional learning discussion at the team, school, or district level about how teachers adjust their expectations for students (positively or negatively) and whether and how those expectations impact student engagement, motivation, and, ultimately, achievement.

IS TEACHERS' KNOWLEDGE OF STUDENTS RELATED TO QUALITY TEACHING AND LEARNING?

Perhaps most importantly, the researchers assessed whether teachers' accuracy about student mastery and knowledge of student misconceptions related to the quality of their math instruction and students' performance on both the study-developed test and a state standardized achievement test.

Quality of instruction was measured, in part, by an observation component of the study that consisted of data from multiple raters viewing and coding seven-minute videos of an average of six lessons per teacher. These observations focused on how teachers remediated students' mistakes and the degree to which the teachers incorporated student thinking into the lessons.

In their analyses, the researchers took into account factors that might impact the analysis of the data, such as the way student achievement levels affect teachers' predictions of future outcomes, and adjusted teacher scores accordingly.

In general, teachers' knowledge of student misconceptions and judgments about student performance were surprisingly low. However, the study's results indicated that there was a positive relationship between accuracy and some measures of instructional quality, including teachers' effectiveness in correcting student mistakes and misunderstandings. Accuracy also predicted student outcomes as measured by scores on the two math tests.

Knowledge of student misconceptions, on the other hand, was not clearly related to instructional quality, and predicted scores on the state math test but not the other student test. Interestingly, there was no correlation with students' reports of how well teachers provided monitoring, evaluation, and feedback.

These findings suggest that

professional learning that supports teachers to develop understanding of student perspectives could lead to better instruction and more tailored supports for students. It appears that teachers can benefit from learning about both general student tendencies as well as the needs and performance of their specific group of students.

Ideally, this kind of learning, including about predicting students' performance levels, would occur regularly throughout the year in coaching and feedback conversations. This strategy is what undergirds Learning Forward's **Learning Designs standard**, which emphasizes how developing a better understanding of learning strategies through professional learning can lead to improved teacher and student outcomes.

A FEW CAVEATS TO CONSIDER

It should be noted that the researchers weren't able to look at the directionality of these relationships. It is possible that effective, high-quality instruction enables teachers to have more accurate knowledge of students' thinking and understanding rather than the reverse.

In addition, the researchers note that teachers do not develop their understanding of student learning and misconceptions as a whole body of knowledge at one time. Rather, they build this understanding incrementally as they teach different levels of students or as they work with a group of students with particular misconceptions and gradually develop their own "bank" of common misconceptions.

This kind of knowledge, Hill and Chin acknowledge, can be difficult to measure. In other words, the study supports the need for both the Learning Forward **Data standard** (using multiple sources of student and teacher data to inform professional learning opportunities) and the incorporation

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of professional experience and wisdom, which cannot always be easily quantified.

To help bridge these types of information, the researchers suggest additional qualitative studies such as observation-based case studies, which constitute an area rich for exploration for researchers and especially for research-practice partnerships in which teachers share in the development and analysis of the research study.

PUTTING THE FINDINGS INTO PRACTICE

In short, the study found that teachers' understanding of students' thinking does matter. Importantly, such understanding has a direct relationship to student outcomes independent of teachers' expertise in the subject matter they are teaching. As Learning Forward's **Outcomes standard** underscores, there is value in teachers being aware of students' thinking and mastery levels and reason to include these factors in professional learning so that the focus is always on improving student learning.

The Hill and Chin study can serve as a helpful resource for leaders and instructional coaches to examine the content of their conversations with teachers — for example, to consider whether they look at how teachers reteach content or seed class discussions. The study also provides an interesting perspective on examining student data in professional learning conversations, which we recommend in

Learning Forward's **Data standard**.

The study found that teachers with an understanding of student thinking were more likely to adjust teaching strategies (such as remediating misconceptions or weaving student thinking into instruction), whereas teachers who focused more on data were more likely to employ classroom management strategies (such as grouping).

Of course, a mix of strategies is important, but this provides support for the idea that professional learning that addresses content, data, student thinking processes, and misconceptions could meet a broader range of teacher learning needs. In addition, the findings about teachers' predictive accuracy varying based on student characteristics and classroom management issues provides a good starting point for discussions about ensuring supportive conditions for all students to learn.

Lastly, the researchers also point out an additional implication for teacher educators as well as professional learning facilitators in terms of overarching expectations for educators: "These results suggest that a construct roughly titled 'knowing where your class is in terms of mastery of content' belongs in contemporary delineations of teacher knowledge." Spending time on understanding not only how to determine where students are but also how to determine where to expect them to go next seems to be a worthwhile endeavor.

REFERENCE

Learning Forward. (2011). *Standards for Professional Learning*. Oxford, OH: Author.

Do you have thoughts about this study or have recommendations of other research you'd like to see us cover? Email me at elizabeth.foster@learningforward.org. ■