Resources, Instruction, and Research

A CTP Working Paper

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Abstract

Education policymakers have long believed that conventional resources, i.e., books, bricks, class size, and teacher qualifications, directly affect student learning and achievement. This working paper builds on more recent research and argues that learning is affected by how resources are used in instruction, not by their mere presence or absence. If use is central to resource effects, research on the effects of resources should be broadened to include the chief influences on use, including teachers' and students' knowledge, skill, and will, and features of teachers' and learners' environments, including school leadership, academic norms, and institutional structures. We discuss how resource use is influenced by the management of certain key problems of instruction, including coordination, incentives to use resources, and management of instructional environments. Having framed the issues in a way that places use by teachers and learners at the center of inquiry, we then discuss research designs that would be appropriate to identify resource effects.

Introduction

For most of America's history, educators, parents, and policymakers assumed that familiar educational resources, such as money, curriculum materials, and facilities, and their regulation, directly influenced student outcomes. Many still do, writing about the "effects" of class size or expenditures on learning. This view implies that resources carry "capacity," such that schools produce better learning by virtue of having more books or teachers with more degrees. Regulation has been thought to work by steering resources and thus capacity, within and among educational organizations. These assumptions made school improvement efforts seem relatively straightforward: allocate more resources or regulate schools' allocation. But the last several decades of research suggest that relationships between resources and outcomes are not that direct. Researchers report that schools and teachers with the same resources do different things, with different results for students' learning. If so, resources are not self-enacting, and differences in their effects depend on differences in their use. That makes school improvement appear to be a much more complex enterprise, one that depends as much on what is done with resources as with what resources are provided. This complexity arises at a time when policymakers are more concerned than ever about how to improve schools, and when efforts to do so have risen to the top of many state and local agendas.

We reconsider the role of resources in instruction. We begin by briefly highlighting some critical developments in recent research on the impact of resources. We use this work to build a theoretical perspective on instruction, including resource use. We argue that resources have no direct effects, but that their effects depend on their use. If so, research on resources' effects requires designs that take use into account, and we conclude by discussing such designs.

Relating Resources to Outcomes

Resources have conventionally been conceived as either money or the things that money buys, including everything from books and bricks to libraries and the formal qualifications of teachers. For decades now, studies have focused on the allocation of such conventional resources and their relation to student learning. Until quite recently, education policy at all levels of government focused chiefly on the allocation of such resources. There is a great deal of data on such resources partly because it is required for official reporting. But 30 years of research on their effects on student learning raised fundamental questions about how schools worked and what education policy should do. The questions began four decades ago, with Project Talent, James Coleman's Equality of Educational Opportunity Survey, and Christopher Jencks et. al.'s Inequality.[1] Much to Coleman's and others' astonishment, the analyses revealed that conventional resources seemed to be weakly related to student performance. Differences among schools' libraries, teachers' experience and education, expenditures, science labs, and other facilities had weak or no associations with differences among schools' average student achievement. Despite large differences in average achievement across schools, and especially troubling achievement differences between schools that enrolled the children of affluent and poor parents, differences in the educational resources that most people thought significant were weakly related to student performance differences among schools. The most powerful predictors of student performance were parents'

educational and social backgrounds. In comparison with those, school resources had trivial effects. Schools with more conventional resources did not have substantially higher performance, once students' social and economic background was accounted for.

This research was often taken to mean that schools did not "make a difference," an idea which many conservatives embraced to support arguments against liberal social policy, and which liberals rejected in an effort to retain such policies. But the research dealt only with schools' differential effectiveness. The researchers' question was not whether schools made a difference-but whether some were better at boosting learning than others, given knowledge of students' social and educational backgrounds. They found that, on average, differences in schools' effects on aggregate measures of achievement were not related to differences in their aggregate conventional resources.

Most studies of such resources since then, prominently including the meta-analyses of Eric Hanushek,[2] supported Coleman and Jencks. But recently, a few researchers revived claims for some conventional resources that Coleman and Jencks had reported to be ineffective. Larry Hedges and his colleagues[3] reanalyzed scores of studies and found that money did make a modest difference to student performance, contradicting Eric Hanushek's reports. The Tennessee class size experiment showed that some students' learning benefited from dramatic class size reductions.[4] These reports seem to diverge both from Coleman and Jencks' research and from the studies summarized above, but it is not clear what accounted for the divergence. Researchers who have analyzed the STAR data from Tennessee disagree about why class size made a difference, and no convincing theoretical frame has been offered in the published discussions.

Research by Coleman and Jencks marked a watershed in educational thought. Public debate about schools previously had been focused much more on access to and allocation of resources than on results, even though the latter often were tacitly assumed to be implied in the former. The new work ruptured the supposed connection between resources and results, and by the mid-1970s, adding resources could no longer be assumed to affect student performance.

New Understandings About What Makes Instruction Work

In response to that shift, and often in deliberate opposition to the work of Coleman, Jencks, and Hanushek, several new lines of research focused more closely on what might make instruction work. These studies probed instructional processes and, deliberately or by implication, the resources used therein. Although these researchers did not necessarily say that they were studying resources, their work nonetheless offers clues to how resources are related to educational outcomes. Though most of the work that we summarized above appeared to focus on direct relationships between resources and learning, subsequent studies suggested a less direct relationship.

Consider, for example, the research in the 1970s and 1980s, which sought to figure out whether some teaching was more effective and, if so, why. In Jere Brophy and Tom Good's mid-1980s summary of the evidence, the practice of unusually effective teachers, as judged by students' gains on standardized tests, seemed significantly different than that of their less effective peers. More effective teachers planned lessons carefully, selected appropriate materials, made their goals clear to students, maintained a brisk pace in lessons, checked student work regularly, and taught material again when students had trouble

learning.[5] They also made good use of the time they spent on instructional tasks.[6] Such teachers seemed to have coherent strategies for instruction and deployed lessons, books, and other resources in ways that were consistent with the strategies. They believed that their students could learn and that they themselves had a large responsibility to help. These teachers could be seen as deploying resources that were consequential for student learning, but they were not the sort of resources that could be captured well in measures of teachers' formal qualifications, their schools' expenditures, or other such things.

Some research on schools during the same decades can also be interpreted from a similar perspective. Beginning with Ron Edmonds, researchers sought to distinguish more and less effective schools and to identify the causes. This effort led them to probe connections between schools' collective characteristics and student performance. These characteristics could be seen as resources, evident in some schools and not in others. Ron Edmonds,[7] Michael Rutter,[8] Susan Rosenholtz[9,] and others reported that faculty in unusually effective schools shared a vision of the purposes of instruction. They agreed that schools' purpose was to promote students' learning; believed that they were responsible for helping students to learn, and that all students had real capacity to learn. Teachers in such schools had a strong commitment to students' academic success, and their principals helped to create and sustain these beliefs and practices.[10] Anthony Bryk and his colleagues undertook the most comprehensive and sophisticated single study in this line, focusing especially on Catholic high schools.[11] They found that more effective high schools were more likely to have teachers who shared a commitment to their students' academic success, who had strong collegial relations, and who believed that they were obliged to help students learn. Fred Newmann and Gary Wehlage reached similar conclusions in a study of "restructuring" schools,[12] as did Milbrey McLaughlin and Joan Talbert in an extensive program of research on teachers' academic community in high school departments. Reporting a remarkable range in such communities within and among schools, McLaughlin and Talbert found strong relationships between teachers' community and sense of collective responsibility for students' work on the one hand and students' academic performance on the other.[13]

A third line of inquiry probed interactions between teachers and students around specific content and provided finer clues to the role resources play in instruction. Gaea Leinhardt, William Cooley, and their colleagues tried to map and unpack the domains that lay between such gross influences as the time that teachers and students spent on the one hand, and what students learned on the other.[14] They found that instructional time itself was not consequential; only when the nature of academic tasks was taken into account were effects on learning observed. The researchers then focused on teachers' task definitions and students' approaches to learning. Leinhardt and Zigmond defined several of those domains, including teachers' task definition, their task enactment, and students' performance of instructional tasks.[15] The researchers devised detailed measures of each and were able to show that students' performance of instructional tasks mediated between teachers' task setting and students' learning. One could see this work as an effort to track the paths by which a variety of resources were turned into instructional actions that had the potential to affect learning.

At roughly the same time, Annemarie Palincsar and Ann Brown began to identify practices that seemed to distinguish more from less effective readers.[16] In a major contribution that came to be termed "strategy instruction," Palincsar and Brown defined the practices that seemed to make some students

more effective readers and taught them to teachers who in turn taught them to students. They found that teaching the practices had positive effects on students' adoption, and that students who used the practices performed better in reading.[17]

In related work, Carol Dweck showed that learners' attributions about intelligence and learning also played a key role in their classroom practices and learning.[18] Children who viewed intelligence as fixed tended to avoid intellectual challenges that might publicly reveal wrong answers, while children who viewed intelligence as expandable through effort sought out and used those challenges. Her experiments also showed that children could be taught to change their attributions for negative feedback from teachers and found that when they did their effort increased and they made better use of differentiated feedback from teachers. The children learned how to study better, in part, by learning to think differently about their academic efficacy.

New Conceptions of Resources

This brief account suggests a movement in scholarly interest away from conventional conceptions of resources, such as money, teachers' qualifications and school facilities, toward particular instructional practices and organizational arrangements, and the actions, strategies, knowledge, skill, and culture that they entail. The studies sketched here and others examined practice-embedded knowledge, action, and attributes and reported that they had significant effects on learning. Teachers' knowledge, skills, and strategic actions can be seen as resources, as can students' experiences, knowledge, norms, and approaches to learning. These resources attach to the agents of instruction and appear to mediate their use of such resources as time and material. Through these studies, one could further understand the organizations and cultures in which teachers and students worked—including administrators' leadership, the collective will to take responsibility for students' learning, schools' academic organization, the collective embrace of academic goals, and the nature of collegial relations—as potential resources in the environment of instruction.

These studies locate teachers' and students' practices between the conventional resources that schools and school systems deploy on the one hand and learning accomplishments on the other. Researchers previously had tended to treat teaching as though it directly provoked learning, but the work summarized here showed that effective teaching encouraged and closely supported what students did during instruction, and that students' work then helped them to learn—or not. Teaching was portrayed as a set of activities that enabled students to use materials, tasks, and other resources, more or less well. These studies thus imply that resources depend on use in instruction to become effective, and that what students and teachers do with resources is no less consequential than the resources which schools deploy. Moreover, a great deal of instruction, which researchers had associated with individual teachers' work, turned out to have collective features; it was shaped and supported by teachers' work together, by educational leaders, and by the organizations and cultures in which students and teachers worked.

If these things are true, instructional quality cannot be created simply by collecting a stock of conventional resources such as books, formal qualifications, or money. Neither does quality arise simply from attributes of teachers, curricula, or facilities. Instructional quality instead would depend on the mobilization of a complex collection of knowledge and practices, collective action, and the conventional

resources on which those actions and practices draw. This implies that there are many kinds of resources, and that their use is crucial in understanding their effects on learning and teaching. For example, well-educated teachers spending time on academic lessons would not be enough, for research showed that only if they used the time in academically productive ways did student learning seem to benefit. Such benefits also depended on students knowing how to apprehend and use the tasks and materials which teachers deployed, and on school leaders focusing, encouraging, and supporting the practices with which teachers and students make use of each other and materials. This, in turn, suggests a complex and interactive picture of the processes by which conventional resources become effective for teaching and learning. It also suggests that schools could not be improved simply by intervening either on individuals' stocks of knowledge or on schools' stocks of conventional resources. Improvement would instead depend on improving students', teachers', and school leaders' use of resources, improving knowledge and skill in using resources for instruction, improving resources' usability, and enhancing conditions which enable resource use.

These ideas offer a major challenge to research. The studies we just discussed used increasingly direct and complex measures of teachers' knowledge, skill, and strategic actions, the time devoted to academic work, norms of professional conduct, and students' use of instruction. Such evidence is difficult to come by in part because it requires the observation and measurement of complex social and intellectual processes, which is expensive even on a small scale. Evidence on such matters is included in no official reports, in part because it does not fit well with the disciplines that have dealt most extensively with policymaking, or with the interests of those who make policy. One reason is that any ensuing advice for policymakers would be complex and may even seem beyond the reach of government. In contrast, studies of conventional resources are relatively easy and affordable because the resources with which they deal are familiar and easy to observe. Such work also accords with the intellectual orientation of the fields—economics, sociology, and policy analysis—which have dealt most extensively with policy making. And it fits well with the interests of those who make policy because the influences observed and measured are those that decision makers can most easily manipulate.

Thus, the research that promises better understanding of the operation and effects of specific resources and more salient advice for the education professionals who manage and deliver instruction is difficult, expensive, and hard to use to advise those who steer schools and policy. In contrast, the research that is least likely to deepen understanding of resources and assist educators is easy, relatively affordable, and readily put to use. One challenge for educational research will be to link these traditions. In the next section we offer a theoretical frame that links the two sorts of work, and then outline an approach to research that would deepen those links.

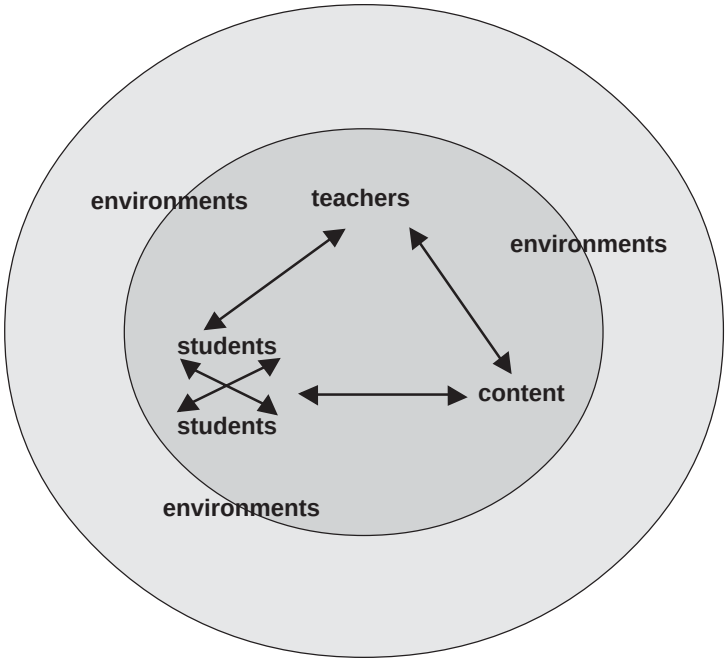
Toward a Theory of Instructional Resources

The research summarized above suggests that conventional resources are used or not, depending on the nature of instruction and the actions of teachers and students. Researchers wishing to adequately model the effects of resources therefore need a theory of instruction, because it is in instruction that resources are used or not, in ways that could influence learning. Accordingly, we focus on instruction, and the role of resources therein.

Resources within Instruction

Although many people think of instruction as what teachers do, it consists of interactions among teachers, students and content, in environments. The interactions occur in such varied settings as distance learning, small groups in classrooms, informal groups, tutorials, and large lectures. Instruction is not created by teachers alone, or students, or content, but in their interactions (see Figure 1). "Interaction" does not refer to a particular form of discourse but to the connected work of teachers and students on content, in environments.

Figure 1: Instruction as Interaction of Teachers, Students, and Content, in Environments[19]



The interactions extend through time. Although the figure seems static, we mean it to represent repeated interactions over minutes, days, weeks, and months.[20] Instruction evolves as tasks develop and lead to others, as students' engagement and understanding waxes and wanes, and as instructional organization changes. Instruction is a stream, not an event. That stream flows in instructional environments and draws on its elements, including other teachers and students, school leaders, parents, professions, local districts, state agencies, test and text publishers, and more.

In order to ground our discussion of the practice conventionally termed "teaching" and to consider how resources figure in instruction, we drop briefly into a hypothetical classroom in which second graders are working on mathematics. This particular district has made mathematics a focal area for improvement and has recently adopted a new mathematics curriculum series. Every teacher received a complete set of the materials. To support the initiative, the district math coordinator arranged for 10 professional development sessions for teachers. In several of the elementary schools, principals have devoted faculty meeting time to work on instructional and curricular issues in math. A district committee also developed a map, indexing the goals and benchmarks of the new textbook and the state proficiency test, to help teachers connect the two in their instruction. The school board, however, has been divided on issues related to the mathematics program and recently cut the district mathematics coordinator position from full to three-quarters time in order to fund additional computer support at the middle school. A few teachers have considered applying for state funds available for mathematics curriculum development.

At the end of the previous class, the teacher had posted this problem on the board:

> **Suppose you have pennies and nickels in your pocket. If you pull out two coins, how much money might you have in your hand?**[21]

She had asked the children to copy the problem into their home-school notebooks and to try to find some possible answers to this question for homework,

The teacher opens class on this day by asking who had come up with some possibilities for the problem. Danya announces, confidently, "You would have six cents. Me and my mom figured it out." The teacher pauses, and then asks the other students, "Do others agree?" Several hands shoot up. "That's what I got, too!" exclaims Timmy. Darien raises his hand hesitantly. "It could be two cents. If you pulled a penny and another penny. Danya got a nickel and a penny, but you could also pull out a penny and a penny." Several children nod. "What do you think, Danya?" asks the teacher. Danya nods. "Mmm-hmm. I agree."

The teacher asks whether there are other possibilities. "Ten cents," suggests Kim. "How did you get that?" asks the teacher. "She used two dimes," Louis calls out.

"Are there other possibilities?" The teacher looks at the children, waiting, and sees that Ruben is slumping down in his seat. "What do you think, Ruben?" she asks. "I didn't do it," he says softly. "This is stupid. This isn't math. My dad told me I should be doing math, and so he told me not to do it."

The teacher puts a new problem up on the board:

> **Suppose you have pennies, nickels, and dimes in your pocket. Now if you pull out three coins, how much money might you have in your hand?**

"I want you to work alone on this for a few minutes, and this time try to find all the possible amounts of money you can have." She pulls out trays of coins and asks a few children to help distribute them. While the children start copying the problem onto their regular notepads, she stoops down beside Ruben to help him get started. She knows that his father is quite upset with the new math program and is worried about how this is affecting Ruben's work.

She helps him read the new problem and works with him to get one solution. He lights up. "I could get three dimes!" he exclaims. The teacher smiles and asks Ruben how much money he would have. "Thirty cents!" he replies, happily, "And that is the most money I could get." Pleased, the teacher tells him to see whether he can figure out others. "What is the smallest amount of money you might pull out?" she asks.

The teacher notices the school principal standing at the door and beckons her to come in. She enters the room and watches the children at work. When she sees Ruben, she asks the teacher how he is doing. The principal says that Ruben's father had called her to complain that his son was not getting enough math skill practice. The teacher suggests meeting with the father to show him some of the work they are doing. "Or perhaps we should plan a meeting for more parents, since he is not the only one," muses the principal. They agree to discuss this later.

In this brief example, what we casually call teaching is not what teachers do and say and think, which is what many researchers have studied and many innovators have tried to change. Teaching is what teachers do, say, and think with learners, concerning content, in a particular organization of instruction, in environments, over time. What we often mistakenly refer to as the practice of teaching is a collection of practices, including pedagogy, learning, instructional design, and managing instructional organization.[22] There are more instructional practitioners than teachers, and more practices than pedagogy. Moreover, the environments in which teaching and learning are situated are not simply outside the classroom, but often are implicated in teachers' and students' interactions.

The effects of resources in teaching and learning depend on how teachers, students, and others solve four central problems. These are resource use, instructional coordination, mobilizing incentives for performance, and managing environments. We discuss each below.

Resource Use

Our interactive view of teaching and learning implies that resources of any sort only become active in instruction if they are used by students or teachers.[23] Even the best curriculum materials are of little consequence if teachers cannot turn them to advantage in framing tasks for students, or if students cannot understand or engage them. Ample school budgets will have little constructive effect on learning if they are not used to hire good teachers and enable them to work effectively. Independent observers might report that such classrooms and schools had rich resources, but their potential to affect instruction would be unrealized.

One critical set of influences on teachers and students' transformation of resources into learning outcomes is their instructional knowledge and skill. Teachers who know a good deal about a subject and how to make it available to learners will be more likely to frame productive tasks from the available materials and to turn students' work and ideas to fruitful use. For instance, our teacher used knowledge of combinatorics and mathematical problem solving to exploit the task in the questions she posed to the class and to Ruben. Discovering that Ruben was alienated from the work and stuck, she used the material to bring him into the task, drawing on her knowledge to help him see how to use the task to learn. She helped him get one solution to the problem and then built on his own mathematical observation when he identified the largest possible amount of money. She was able to see what was obstructing his engagement with the work and was able to use her knowledge of mathematics to help

him get from being stuck to making good use of the task. Her mathematical insight was critical, for she was able to exploit the arithmetic and problem solving dimensions of the problem without sacrificing either. Had she seen this as only a matter of getting answers or of strategies, her interaction with students and their work would have unfolded quite differently. The quality of teachers' resource use bears on their efforts to coordinate instruction. Teachers whose knowledge of subject matter was superficial would be unable to use knowledge of mathematics to work with students like Ruben, to connect their understanding to instructional tasks.

Similarly, students who have learned how to reflect on their ideas, listen carefully, and express themselves clearly are likely to be better users of materials, teachers, and other students' contributions. They also are likely to make it easier for other students and teachers to use their ideas. How students and teachers organize their interactions also shapes resource use. Students and teachers whose classroom cultures support the respectful expression, explanation, and scrutiny of ideas will generate more usable material for instruction, and thus will have more resources to use than classrooms in which conventional lecture and recitation are the rule.

Realizing resources' potential also depends on the settings in which teachers and students work. The classroom in our example is a place where children volunteer their ideas and conjectures and where the teacher listens attentively and teaches the children to use each others' ideas. But there are many schools in which principals would discourage such work in favor of more conventional drill on facts and procedures.

Quality in instruction thus does not inhere in teachers' formal qualifications or the caliber of materials, but in how the knowledge and skill for which formal qualifications presumably stand, and materials, are used in instruction. Teacher quality is determined less by a teacher's formal qualifications and more by that teacher's ability to make pedagogically fruitful use of materials, students' work, and their own subject matter knowledge. Similarly, the quality of materials depends both on how accessible and engaging they are for learners and on how well they enable teachers to make sense of and use them.

One important entailment of this view is that students' ability depends partly on how well teachers probe, understand, and use their work. Even the strengths or disadvantages that students are said to "bring" to instruction are partly a matter of what their teachers can see and hear in students' work and how skillfully they recognize and respond to them. Students' ability is in part interactively determined. In another classroom, perceived and questioned by a teacher who knew or could use mathematical knowledge less well, Ruben might have been seen as "not ready" and given a simpler assignment. What reformers and researchers term "instructional capacity" is not a fixed attribute of teachers or students or materials, but a variable feature of interaction among them.

Variation in resource use also stems in part from the versions of knowledge, teaching, and learning at play in instruction. If knowledge is treated as fixed, teachers' and students' use of materials will focus on facts, algorithms, and formulas. But if it is treated as something learners re-invent, students will use materials to frame interpretations, discover relationships, and apply knowledge in new situations. The latter is more complex and opens up more uncertainty, while the former enables teachers to simply use materials as they appear, as scripts or assignments.

Similarly, if learning is treated as assimilation, resource use for teachers can be restricted to extracting formulas, algorithms, and lists for presentation to learners. But if it is treated as re-invention or discovery, teachers must use materials to invent tasks that enable reinvention and discovery. Creating materials that are usable in the second sense is more complex and demanding than creating materials that are usable in the first sense. Using the second sort of materials also is more complex and opens up much more uncertainty for teachers and learners, than using materials of the first sort. When learning is treated as discovery, teachers have more difficulty knowing if they have made good use of their knowledge or students' work.

Coordinate Instruction

Using resources well also depends on solving problems of coordination. For if instruction consists of interactions among teachers, learners, and content, there will be many opportunities for un-coordination because the interactions can be so complex and easily disorganized. The most fundamental feature of coordination concerns teachers, students, and content. The teacher in our example was trying to work on discussing the coin problem, but some students may have been fiddling with their pencils, passing notes, or drawing. When she begins class, a couple of her students will likely have forgotten their homework, and the students who were absent the day before may not understand what is being discussed. Ruben's father has disparaged the work, and Ruben did not do it. A new student may be pulled out for testing. In the midst of class, the principal may enter and raise an issue about parental support for the mathematics curriculum. Even if everyone works on the task, and knows what to do, some teachers might address it algorithmically while the curriculum developers intended to support the development of mathematical ideas. Teachers may address the task as the text does but not probe students' ideas and so remain unaware of how they understand it. Teachers may agree on the task with half the class without knowing that the other half remains in the dark.

Instruction occurs over time, and that creates another fundamental problem of coordination: How, for instance, do these coin problems connect for each student with the work tomorrow and whatever happens two weeks later? How do students and teachers make the small bites of lesson work develop into learning over time, despite absences and forgetting?[24] Other dimensions of coordination are among subjects within classrooms, among classrooms within grades, from one grade to the next, and between home and school.

Each dimension of coordination contains a set of potential problems and barriers to learning. If students and teachers are not focused on the same task, learning is likely to suffer. If students' learning is not paced so as to maintain appropriate cognitive demand, students may be either overwhelmed or bored and learning will suffer. The fewer steps that are taken to insure coordination of these and other sorts, the more diffuse and less effective instruction is likely to be.[25] If our teacher had merely assigned the task and later collected and graded papers, as mathematics teaching has typically been done, she would have had a very different lesson than she did. What she did enabled her to mediate the un-coordination in many ways, including her trouble-shooting work with Ruben, her use of the home-school notebooks, and her staging of the increasing difficulty of the problem, from the two coin to the three coin version.

The difficulty of coordination varies with the conceptions of knowledge, teaching, and learning which are in play. Knowledge, for instance, can be treated as fixed or constructed. In the first case it is a given, while in the second it is at least partly a matter of invention and interpretation. Teachers' efforts to coordinate their work with students' in the latter case is more difficult than in the former, for when knowledge is a matter of invention and interpretation, it is more complex. Learning also can be treated quite differently, as a process either of assimilation on the one hand or discovery or re-invention on the other. Coordination is much easier in the first case because teachers need only check to see whether students remember the proper formulas, algorithms, or procedures, and can work them satisfactorily. To learn is to have mastered such things and to produce them on demand. Teachers can know whether students are learning what they are teaching with a quick check in recitation or homework. But if learning involves students in uncovering the material through their work and discussion, it is much more difficult for teachers to ascertain if students are learning what they are trying to teach. Such teaching is much less direct. As in our example, teachers set general tasks or problems, and invite students to work them out. There often are many solution paths, and while some may be more efficient, others may be more inventive. It is much more difficult for teachers and students to know if students are on a productive track when they have much more complex and ambiguous tasks to manage.

Mobilize Incentives

Using resources well requires effort, and effort often creates friction within and among members of instructional groups. Incentives are required to engage the effort needed to overcome friction. Mobilizing such incentives within instruction is a third sort of instructional problem, and it is complicated by conflict about effort. Teachers have incentives to press for ambitious work and exert themselves, for their professional success depends on learners' success—or on explaining why learners could not succeed. Learners also have reasons to work hard, for it could satisfy their curiosity and wish to learn, enhance their sense of competence, and enable them to meet teachers' and parents' hopes. But teachers and learners also have incentives to do less ambitious work, for that increases effort and friction, as learners encounter more difficulty, uncertainty, risk of failure, and more chances to disappoint themselves and others. The coin problems our teacher is using are of this latter sort, for the tasks entail ambiguous and challenging work for second graders. Teachers who press for such work are more likely to encounter learners' resistance, frustration, and failure, even if greater success beckons. Learners and teachers who do less ambitious work reduce these problems and increase the chance of some success. Teachers and students thus face a dilemma: Should they aim low, accepting modest results in return for some success, or aim high, risking difficulty, resistance, and failure in hope of greater improvement for learners and impressive accomplishments for teachers? Incentive conflict is internal to teaching and learning, and to teach and learn is to manage the conflict.

In our example, the teacher posed a challenging task when she asked her students to find all the solutions to a combinations problem. Her decision to introduce the task as a homework problem allowed students to get started and build confidence. Her choice to leave one last step open stimulated interest. She also offered students support as an incentive to persist.

The difficulty of mobilizing incentives for ambitious performance depends in part on the conceptions of knowledge, teaching, and learning in play. If knowledge is treated as fixed and learning as assimilation, students need only focus on facts, algorithms, and formulas. But if knowledge is

constructed and learning is re-invention, students have much more complex tasks as they frame interpretations, discover relationships, and apply existing ideas in new situations. The first conception of knowledge and learning is less engaging for some, but more secure and less trouble for others, as it is less complex, and entails less uncertainty, invention, and cognitive demand. Had our teacher passed out a basic facts drill sheet, the work would have been more constrained, and what it took to complete the task would have been much clearer. The conceptions of knowledge and learning embedded in the coin problem require more of teachers, for they must hold knowledge in more complex and flexible form, engage with more complex and uncertain work from students, and cope with greater difficulty, risk, and resistance.

Manage Environments

Instruction cannot be separated from seemingly external influences, including other teachers, school leaders, parents, district policies, state requirements, professional education, and much more.[26] To teach and learn is to enact or reject, and thus in some sense to manage elements of the environment. When teachers and students solve problems of coordination, resource use, and incentives, they do so in and with elements of their environments.

For example, teachers and students are more likely to want to do quality work in schools that are linked to institutions of higher education or to firms which offer strong incentives for ambitious performance than in institutions that do not offer such incentives. Teachers and students who work in schools whose principals urge ambitious performance will be more likely to do such work themselves and to press each other for it, while equally able colleagues in schools whose principals prefer less ambitious performance will have more difficulty mobilizing incentives for demanding work. While some U.S. schools, families, principals, firms, and institutions of higher education encourage demanding schoolwork, many more offer little or no encouragement.

Similarly, coordinating teaching and learning is less difficult in environments with coherent organization and guidance for instruction, and more difficult in those that lack such coherence. The U.S. presents distinctively incoherent organization and guidance for instruction. These environments do exist outside of instruction, but they also exist inside it, affecting interactions among teachers and students. For example, as our teacher tried to develop mathematical concepts and skills, she also sought to deal with parents' questions about the district's new emphases in math. She suspected that Ruben and perhaps others were doing less well than they might partly because their parents disparaged the math assignments. She also was aware of multiple signals about instruction, including the upper-grade teachers' expectations, her principal's exhortations to make sure all students develop basic skills, the district's investment in the new curriculum focusing on concepts, and the new state assessment that tests speed and accuracy. Fragmented organization within and among an extraordinary number of education agencies produces profuse, uncoordinated guidance for instruction and impedes collective action. Lacking strong and focused leadership at the school and district level, students and teachers find it difficult to fashion coherent instruction.[27]

Resource use also depends partly on instructional environments. Other things being equal, teachers who work in schools that focus on students' work and offer opportunities for teachers to learn how to interpret it will be better able to make sense of students' ideas. Similarly, principals who structure their

schools' budgets around supporting instruction help to bring resources to bear on teaching and learning, making the resources more usable. Professional education that focuses on knowledge of the subjects teachers will teach, and how to make them pedagogically usable, are more likely to enable teachers and learners to be artful users of materials and each other. But most U.S. teachers do not have such professional education, nor do most work in schools in which resources are focused on instruction and teachers' learning. In our example, the district cut the mathematics coordinator position just as it made mathematics instruction a priority, thus reducing the resources available for teacher support as it increased the need for such support. Since resources traditionally have been seen as a matter of mere provision, not as a matter of use, those working in the environments of U.S. schools have had little reason to strongly support effective resource use.

Though teachers and students help to shape environmental influences by what they notice and how they respond, action in the environment can affect their attention and response. When school and district leaders place high priority on improving teachers' work with disadvantaged students by raising the incentives for such work—rather than ignoring the matter or arguing that nothing can be done— the chances are greater that teachers will try to overcome the effects of students' disadvantages. If school and district leaders go further and coordinate efforts to solve the problem by engaging the teachers and offering them opportunities to learn how to improve, the chances that teachers will constructively deal with student disadvantage increase further. Managing environments depends on clarity and authority in environmental priorities, on teachers' and learners' attention, and on their will and skill to respond.

From a conventional perspective, environments and practice seem separate. Since teachers practice on and with learners, and cannot work without them, it seems sensible to think of teachers and learners as doing technical work inside practice, and of environments as outside influences. Many researchers and educators portray economic and social differences among families as causes of differences in student performance. But these environmental differences become active inside instruction, as learners import elements of the environment. Ruben's father tells his son that the work in school is not worthwhile, and so Ruben does not do his homework, and is less ready to use the day's instruction. National debates about the goals and means of mathematics education thought to be external to the classroom enter the transactions between Ruben and his teacher, affecting his learning and her teaching. Teachers pick up many signals about quality instruction that influence their decisions about how to use instructional materials and what to emphasize with their students. Both the messages and their reception shape incentives for teacher and students to work in particular ways, toward particular goals.

Students are delegates from worlds beyond the technical and professional, yet they are essential to work in that technical world. Teachers do similar things, as do materials.[28] Teaching and learning cannot be conceived simply as internal technical work which is influenced by external environments, for as teachers and learners work together they work with and on elements of the world conventionally thought to lie beyond practice. The outside is in certain respects inside, and work inside is, in certain respects, work with and on elements of the outside. Teachers and learners work on a boundary, where they habitually manage often difficult relations between the inner and outer worlds of practice.

* * * * *

Our discussion has highlighted four problems that teachers and learners must face: using resources, coordinating instruction, mobilizing incentives, and managing environments.[29] We call them problems because teaching and learning are practical activities, and many practitioners attentively deal with them as problems. But these problems often are solved inattentively, implicitly, in the course of practice. In either case, they make visible several key domains of instructional practice.

Types of Resources

Our analysis implies different sorts of instructional resources: conventional, personal, and environmental. Conventional resources include teachers' formal qualifications, books, facilities, expenditures, class size, time, libraries and laboratories, and more. Each can be consequential. Students in classes of 35 or 40 are less likely to have access to teachers' time and expertise than students in classes of 15. Students who study in schools with ancient texts probably have access to less substantial and engaging content than those who work with more up-to-date materials. And students in less developed nations who work with uneducated teachers and no books have access to many fewer resources than those in wealthy and industrialized nations who attend modern schools with well educated teachers and contemporary materials. But these resources only make a difference to teaching or learning as they enter instructional interactions, and they cannot do so unless they are noticed, seen as resources, and used by teachers and students.

They enter by way of teachers' and students' personal resources: their knowledge, skill, and will affect their perception and use of conventional resources. There could not be much school learning without schools, books and other materials, but only teachers and students can use them, and what they know and are able to do influences what they use, and how well they use it. Even a single learner working alone needs tasks or materials, the knowledge and skill to use them, and norms. Teachers' knowledge of the subjects they teach, the will to improve learners' work, the skill to elicit students' ideas and the knowledge to understand them, all affect what they notice and use.

Environmental resources, such as leadership, academic norms, and institutional structures, also influence whether and how teachers and students notice and use conventional resources. The social organization of teachers' and students' work, such as arrangements for coordination within schools, can affect the resources that they notice and use. The building principal in our example sought to influence teachers' and students' engagement with mathematics by attending to substantive issues or mathematics instruction herself—such as parental understanding of the math curriculum—and by making mathematics a focus of collective discourse in the school. School and district leaders can support or inhibit effective teaching, as can state and federal policy. They can offer teachers opportunities to learn through professional development, as in our example. Since teachers' and students' use of resources is central to their influence on instruction, the chief means by which actors in the environment can influence teaching and learning is by shaping what teachers and students notice, and their knowledge, skill, and will to use various resources.

These three kinds of resources interact. Conventional resources make a difference, for most teachers could not do well without schools, or books, or quiet places to work, and most students could not do well without books and teachers. But these and other resources only bear on instruction when teachers and learners use them, and what they notice. How well teachers and learners use them depends on the

particular mix of personal and environmental resources which are in play. There is no *primum mobile*—no one resource that causes all others. Rather there are interdependencies. Since teachers and students are the agents of instruction, they play a central role in what gets noticed and used, but agents in their environment influence what they notice and use.

We illustrate these ideas in a discussion of class size. It is a conventional resource that could affect learning only as teachers and students use it. Consider a hypothetical state in which teachers had 50 students in each class and taught in didactic fashion. In 1990 the legislature reduced class size to 25, while assuring that teacher quality remained constant over the expanded labor force. Our frame leads us to expect that learning would improve only in classrooms in which teachers and learners used existing personal resources to turn smaller classes to good effect. Teachers in these classes might spend more time with each student, or take more time to read students' work, or probe students' thinking, or offer comments on students' work. Students might make better use of their teachers or instructional materials. These teachers and students would notice the opportunity to improve practice, and it would be an incentive for them to act.

Class size reduction also could enable some teachers and students to learn new knowledge and skills on their own, which would improve teaching and learning. Such improvements would occur if those in the classroom saw the new conditions—like students' greater access to teachers or teachers' time to probe students' work—as an opportunity to learn how to better use their own knowledge or other resources. Such teachers and students would use what they already knew to learn more and leverage their own improvement.[30]

Students in other classrooms would not learn more if they and their teachers did not use existing personal resources more intensively. Teachers given a smaller class might not spend more time with each student; instead assigning more seat work, having students correct their own worksheets, and doing other tasks themselves. Students might not make better use of their teachers because they chose not to, did not know how, or were discouraged from doing so by their teachers or other students. These teachers and students would not notice this opportunity to improve practice, or would notice but not take it. This might be because they did not believe improvement was possible, because they did not have the required knowledge and skills, or because they did not care to make the effort. Opportunities to improve practice are not always accompanied by incentives to act. These classrooms might improve only if agents in the school, district or elsewhere help teachers take advantage of the greater exposure to students' work and ideas and provide incentives to act.[31] Principals or district leaders could organize efforts to help teachers learn how to make more efficient use of time or how to elicit and interpret students' work. They might help teachers learn how to teach students to be more effective users of materials and tasks. And they might make clear to students and teachers that taking advantage of improved conditions would be rewarded, while failure to do so would be noticed and perhaps penalized. In some fraction of these cases, teachers and students would learn how to use more effectively the added resource, and learning would improve.

On this account, students' and teachers' resources mediate between class size and learning, as they would mediate the effects of any other conventional resource. Any mix of personal and environmental resources opens some possibilities for, and contains some limits on the use of any conventional resource. Given any particular configuration of personal and environmental resources, research could show that

added conventional resources appeared to independently affect learners' accomplishments, other things being equal. But that apparent independent effect actually would express an interaction among personal, environmental, and conventional resources. The instructional effects of conventional resources depend on their usability, their use by those who work in instruction, and on the environments in which they work.

When added conventional resources appear to affect learning accomplishments, then, it is because they were usable, because teachers and students knew how to use them effectively, and because environmental resources enabled or did not impede use by these particular teachers and students. The effects of conventional resource increments are in reality an average computed over the classes in which the resources are available and within classes over the students attending those classes. In the case of class size, we know that teachers vary in their capacity to use this resource, that students vary both in their exposure to the resource and in their capacity to use it, and that environmental resources vary over both. Given this, the potential effect size of something like the Tennessee class size experiment is greater than this average, perhaps much greater, if teachers and students who make weak spontaneous use were taught to do better. The experiment offers an estimate of the average effects of the use of one conventional resource, but only further analysis could weigh the effects in classrooms which made good, poor, or no use of that resource.

This discussion also implies that when added resources lie outside the range of teachers' and students' practices, knowledge, norms, and incentives, they will have no discernable effect on learning. For instance, our hypothetical legislature might instead have mandated that teachers use innovative academic content standards to engage learners in creative discussion of more demanding academic content. The legislature might have provided money to write and disseminate the standards and to support discussion of them. We expect that research on the effects of such a policy would show that the new resources had no average positive effects on students' learning, for the policy would have required most teachers and students to work well beyond their skills, knowledge, and will, without providing opportunities and incentives for them to learn much more.[32]

When researchers fail to find effects for particular conventional resources, it should not be seen as evidence that such resources are ineffective until several other explanations are ruled out. One possibility is that teachers and learners did not know how to use a given resource, and ruling that explanation out would require research on the effects of teaching teachers and students to use it. Another possibility is that the change in conventional resources was not enough to enable significantly better use of existing practices, knowledge, and norms. The evidence on class size suggests that only large reductions enable changes in teaching and learning, given teachers' and students' extant knowledge and motivation. A third possible explanation is that some conventional resources simply are not salient to the learning in question, or to learning generally. Science laboratories might bear on learning in science, but it would be surprising if they were salient to learning literature or history. Building two gymnasiums, three pairs of bathrooms, and a larger playground for every school could have many good effects, but they may not be academic effects.

* * * * *

Our formulation does not deny the significance of instructional materials, facilities, teachers' qualifications, and other conventional resources. Nor does recent research that focuses on students' and teachers' practices and personal resources "refute" James Coleman or Christopher Jencks' work, which found little differential effect of school averages of such resources on variance among schools in students' performance.[33] Both lines of work could be accommodated in research which was based on a view of interdependent relationships between resources and users.

Instructional Interaction and Research

The interdependence of which we write is a major challenge for any effort to investigate resource effects. For when teachers and learners use resources they make judgments about which to use, how to use them, with whom, and to what end. They make these judgments based on what they know and believe about themselves, one another, and the content. Though some teachers judge with great care and seek evidence with which they might revise, others judge quickly. In either event, teachers calibrate instruction to their views of their capacities and their students' abilities and will to learn. Teachers and students also work in organizations that formalize such calibration in ability groups, grade retention or promotion, and related practices. These groups and policies allocate resources within classes and schools, and even within the same student across subjects, on the basis of judgments about students' capabilities, aspirations, motivation, etc. Students make judgments about instruction and use resources based on estimates of teachers' and parents' wishes and on their own preferences and expectations. Ruben, the student in our example, navigated between his father's expressed disdain for the school's math program, and his teacher's instructional interventions. His father did not help with his homework, and so Ruben was less prepared for class. He was also less interested since his father told him that the work was not worth doing. Ruben's teacher had to act as though she believed he could do the work; she had to convince him that this work was worth doing; and she had to help him to make use of what he knew and could know. In the end, Ruben's work and willingness reflected features of his school environment.

One cannot imagine instruction without such calibration—even computer-based instruction entails versions of it. But if teachers adjust instruction within and among students based on their estimates of students' will and ability to learn, there will be significant differences in the resources which teachers use with individual students among subjects, among students within classes, and among classes within schools. If this is so, how can researchers identify, observe, and measure the resources that are used in instruction? If teachers adjust the tasks they assign and the materials they use, correct estimates of resource allocation and effects would depend on valid evidence of variable use. The evidence also would depend on teachers knowing and articulating what they did and having the time and inclination to do so, or on researchers' valid observation of teachers' reports and practices, or both. Such evidence would not be easy to define or collect, especially since teachers often adjust their own knowledge, skill, and will as they apply them. How can teachers be aware of such things? If they are, how can researchers learn about such extensive and continuing variation in resource use? Lacking valid and reliable evidence on such matters, how could we make valid inferences about the effects of resources on learning? Non-experimental studies of resource effects on student outcomes that fail to take account of how teachers adjust instruction in light of their judgments about students will likely mis-estimate and confound the resources used, those merely present, and their effects.

Recent research on "dynamic treatment regimes" in medicine and psychotherapy bears on this matter.[34] In such treatment regimes, the dose, or treatment, is calibrated to the current status of the patient treated, based on some assessment of that patient's condition. The regime consists of one set of rules for assessing those to be treated and another for assigning interventions to them. One can arrive at strong causal inferences about the effects of any such regime, if those treated are randomly assigned to alternative regimes. Weaker causal inferences can be based on quasi-experimental comparisons of regimes. However, within a given treatment regime—which is where non-experimental research often operates—it appears impossible to make a meaningful causal inference about the association between dose and response. This is because in the continuing adjustment processes the dose is as much a consequence of the patient's current condition as it is the cause of his subsequent condition.[35] Research in medicine and psychotherapy shows that a regression of responses on doses, controlling initial status, will not give a reasonable estimate of a treatment effect.[36] It also suggests that the effects of interactive treatment regimes can only be accurately evaluated if: (a) there are different regimes that (b) consist of well-explicated rules for assigning doses, given particular statuses, and (c) the regimes vary across patients treated.

By extension, if teachers calibrate instruction to ideas of student ability, we could make accurate causal inference about instructional effects only by reconceiving and then redesigning instruction as a "regime" and comparing it to different regimes. That idea is consistent with the interactive view of resource use that we have been developing: resources are used within instructional regimes, and conventional resources are not the regime, for they cause nothing. Rather they are used or not, in particular regimes. Resource effects depend both on their availability and on their use within regimes. The central focus in research on resources should be the instruction in which resources are used—and how they are used and to what effect—not the resources alone.

Though this line of reasoning has theoretical appeal, it has several vexing accompaniments. The continuing and nearly always unobserved and unmeasured adjustment of resources within instruction calls into question a vast body of correlational research on relations between discrete instructional behavior and student outcomes, including most of the studies that we discussed earlier. And while research on dynamic treatment regimes may not require randomized experimentation, randomization to regimes would be optimal for causal inference. That suggests a more restricted role for survey research than has recently been the case in education and a larger role for experimental and quasi-experimental research. But if such studies offer a better grip on causality, they are more difficult to design and instrument, and more costly to undertake.

New Designs for Research

We have discussed two significantly different perspectives on resources that hold different implications for research and policy. From the inherited, dominant perspective, conventional resources are treated as if they were active agents of instruction, and the key problem is to first identify and then deploy the resource mix most likely to improve learning. From a more recent, emergent perspective, teachers and students, and features of their environments are treated as the active agents of instruction, and the key problem is to identify and mobilize the knowledge, practices, and incentives that will enable

them to best use resources. One perspective is grounded in established habits of thought and the durable realities of life in schools and politics, while the other is grounded in studies that probe behind those realities.

There has been some movement between these views. In the last decade or two some policymakers have begun to use new conceptions of resources, partly in response to research on instruction. For instance, state standards-based reform is premised on the view that schools and policymakers should focus on the schools' learning goals and use resources to achieve those goals. Some researchers and officials in some districts and states have tried to encourage schools to focus on the improved use of resources rather than simply on standard resource inputs.[37] There also has been growing interest in finding more direct measures of teacher quality and devising ways other than reliance on degrees and course credit to improve teachers' knowledge and skills through professional development. Each of these changes implies a recognition that resource use, and the conditions which influence it, are critical.

Conventional resources nonetheless remain in the foreground of research and policy. Much action and debate focus on class size, teachers' formal qualifications, facilities and equipment, and education budgets. These have long been the established means to weigh quality in schooling. Buildings, books and teachers—not knowledge, skill and will—are the features plainly visible to administrators, policymakers, and parents. It is easier to observe and quantify dollars and class size than teachers' knowledge of mathematics or their skill in using students' work, and it is much easier to associate these conventional resources with the taxes citizens pay.

The focus on conventional resources also is grounded in politics. Policymakers and school managers can much more easily manipulate dollars and class size than teachers' knowledge and skill. Their actions are scrutinized and contested in elections and require justifications that tax payers and voters can embrace. These things generate demands for evidence, and, as the dominion of research has grown, politicians have turned to it for help. Specialists in education, economics, politics and sociology have increasingly occupied themselves with the effects of schooling, and they attend chiefly to the visible resources that play a key role in policy, practice, and argument. Data are relatively easy to come by, have face validity, and are of interest to policymakers.

As a result, the resources with which policymakers and researchers can most easily deal are the least directly related to students' learning. And the resources that are most likely to be directly related to learning are those with which policymakers and managers can least easily deal. We propose to devise approaches to research that will help to bring the two closer together.

The Frame

Given our theoretical position, the overarching research question cannot be "Do resources matter"? No deliberate attempt to learn or teach is conceivable in the absence of conventional resources, and there is ample evidence that teaching is causally related to learning. The overarching question must be: "What resources matter, how, and under what circumstances?"

The required resources are significantly a function of the desired result. The question above can only be answered once an educational goal, and a strategy to achieve it, have been adopted. A better question thus is: "What do educators need to do the job?" Putting it that way helps to make clear that the answer would depend strongly on what "the job" was, i.e., what needs to be taught and how best to

teach it. The requisite conventional resources are not prescribed simply by defining an instructional goal, for there is a considerable scope for debate: could the instructional tasks required to achieve any given goal be accomplished with somewhat less skilled teachers, somewhat larger classes, or a somewhat smaller budget for materials and equipment, or by investing somewhat less instructional time than might seem ideal?

This line of reasoning implies that the question for research should not be the one which most researchers concerned with school effects or the economics of education have asked, namely: "How do the available resources affect learning?" Rather, the first question should be: "What instructional approach, embedded in what instructional goals, is sufficient to insure that students achieve those goals?" A second question follows from that: "What resources are required to implement this instructional approach"? It may be necessary to modify desired instructional goals if the available resources turn out to be insufficient to achieve the goals; educational policy and practice inevitably involve negotiation among goals, instructional means, and resources. But if resource levels constrain instructional aims and methods, it is logically incoherent to conceive of resources as the "cause" and learning as the outcome. Instructional regimes are the direct cause, and resources are facilitators or inhibitors of instruction.

These ideas entail a sort of Copernican revolution, elements of which have been developing for several decades. Rather than placing conventionally defined resources at the center of inquiry, and trying to identify how each affects performance, or what the best mix is, we propose to place teaching and learning at the center of inquiry and to devise ways to identify the resources which best support particular instructional goals. Resources are means, and they can only work in relation to instructional ends. It could not be otherwise unless we envisioned One Embracing Outcome, which all resources would cause, and we cannot imagine either such an outcome or the resources.

This frame would impose a kind of theory of relativity on discussions of resources. For if we are roughly correct, one can only conceive the effect of resources *relative* to a specified instructional aim, and a strategy to achieve it. Building a new lab may be essential to one approach to science instruction but irrelevant to another. Class size probably is salient to literacy instruction if it entails frequent, high-quality feedback on student writing and serious class discussion of the writing, but that approach also requires literate, motivated teachers. Class size probably would be less important for other educational aims and means. Research on resources would be more fruitful if it was grounded in conjectures about such relationships and evidence on them.

Active and Passive Research Programs

It follows that in conceiving programs of research on instructional resources, one should place well defined instructional regimes in the foreground. One example of such a regime might be a program carefully designed to improve reading in the primary grades, which links curriculum and teaching of phonemic awareness, text recognition, and comprehension, to specific assessments in those areas. A first line of research for any such regime might probe what effects it has for students, with respect to its central outcomes, when resources were plentiful. A second line of inquiry could test the effects of such regimes under various resource constraints, which would allow various modifications to the regime that enable its enactment under different conditions.

Pursuing both lines of work for any given regime would yield evidence about its effects under a variety of resource conditions, including those that might be optimal. Pursuing both lines of research for regimes that share outcomes, wholly or in part, would yield evidence about their robustness, generalizability, and ultimately, their cost effectiveness. As each was tested and modified, the research program would reveal the kinds and amounts of resources needed as well as how the resources must be coordinated to produce effects, given the regime. Our principle of relativity means that there could neither be "regime-free" answers to questions about levels, combinations, and coordination of resources, nor "regime-free" studies of their effects.

This active research agenda does more than passively discern the effects of extant resource configurations; it seeks valid causal inferences about designed instructional regimes. Once the efficacy of a regime is established, resources should be varied to discern the effects under alternative constraints.[38] Such an agenda would have profound substantive and methodological implications. It would give priority to research on designed instructional regimes, and thus would depend on excellent programs of regime development, field testing, and revision. A focus on regimes also would imply a high priority on experimental and quasi-experimental tests under varied resources constraints.

Given our analysis of interactive mutual adjustment within instruction, a focus on coherent regimes seems the most reasonable way to probe causal relationships between resources and learning. Our account implies that it would not be useful for researchers to attempt to disassemble regimes into their components and do conventional research on the effects of each component. Our frame improves understanding of the complex relationships within teaching and learning and opens up opportunities for more coherent research on instruction and its effects. But it also implies certain limits on some sorts of research that have become conventional.

Our frame also implies both crucial opportunities for, and limits on, passive research. Such inquiry cannot offer strong evidence on the effects of regimes in best-case situations or under resource constraints. For if instruction is a system of interaction in which students and teachers continually mutually adjust, it would be extraordinarily difficult either to uncover and delineate how a given resource is actually used, or to distinguish well defined regimes. Existing instructional arrangements and resources have emerged through historical processes of negotiation and accommodation. It is essential to measure student background and school context and statistically adjust for them in models that relate instruction to outcomes, if only survey data are available. But that will probably tell us little about what would happen if instruction were modified in deliberate ways. To the extent that regimes do occur naturally, they have developed in part to cope with the resource constraints of given settings. It would be difficult or impossible to answer the question "What resources are essential, given the regime" because of mutual adjustments around existing resources. Instructional practice within a given setting tends to involve a mix of individualized adaptations, and in natural conditions there would be little possibility of holding the regime constant while varying resources. Ethnographies and surveys can reveal how teachers and students think and act within a setting, but they cannot reveal how things would change if new regimes and resources became available. The deliberate development of regimes, and interventions based on them, would be much more efficient and powerful.

Another limit on passive observational research is that it rarely provides student outcome measures that express the aims of a well conceived regime. This is hardly surprising, given the difficulty of identifying well-conceived regimes in such studies. A well-conceived and deliberately designed regime will set clear instructional goals, and research on it would require outcome measures which specifically assess achievement of these goals. Broad-purpose achievement tests would be used within the agenda we propose, since it would be important to know both that new regimes help students achieve specifically defined skills and knowledge and that they at least do not impede more traditionally defined success. But conventional assessments are unlikely to capture the proximal outcomes of a well defined instructional regime.

Passive inquiry would play several significant roles in relation to activist research agendas. For example, large-scale surveys could provide estimates of the current range of instructional approaches and related resource availability and use within regimes. They also could enable researchers to discern the extent to which anything resembling coherent instructional regimes occur "naturally" in U.S. schools, and, if they do, to distinguish their configurations and roughly estimate their effects. Survey and ethnographic research also could illuminate what students know and can do over a range of naturally occurring regimes and settings and thereby focus attention on where educational effort must be directed. Micro-ethnographies could suggest specific ways in which instruction might be conceived and enacted for specific sub-groups and could yield important knowledge about the configuration and operational features of existing instructional regimes.

Though instruction is so interactive as to defeat treating resources as individual variables, we are not arguing that instructional regimes must remain black boxes. Though complex, there is much to be learned about what makes them tick from careful passive research. Survey and ethnographic research could help to clarify the internal dynamics of instructional regimes. That would be especially useful in comparing instructional dynamics across resource variations within regimes. Our agenda contains important roles for both active and passive research.

Thus, there are several key reasons for an active research agenda: it would give an explicit definition to regimes and resources, thereby creating a basis for valid causal inference; and it would create a useful context for survey and ethnographic research, which currently float largely free of knowledge-building frameworks. Extant instruction reflects accommodations to currently available resource levels, to views of student background, and to prior achievement. Valid causal inferences regarding instruction and resources are extremely elusive in such webs of mutual accommodation. Economists would describe this as a situation in which the causal variable of interest is "endogenous," that is, determined in part by current levels of outcomes and other unobservable factors that lead educators to make choices and compromises. Such endogeneity makes it extraordinarily difficult to separate effects of the key causal variables from the effects of a host of other observed and unobserved factors. Naturalistic survey and ethnographic research can help to advance understanding in several important areas, but are not well suited to producing defensible conclusions about causal relationships. Sound causal inference requires that the causal variables be made "exogenous," that is, varied independently of confounding factors. The best way to do that is through deliberate and well-defined intervention.

Exogeneity can be made complete in the case of randomized experiments. Though the random assignment of students to regimes may be feasible in some instances, we anticipate that schools or classrooms more often than individual students, would be assigned at random.[39] In other cases when the regimes are self-selected, a strong effort to explicate the regime and associated resources would be in order, as would more tentative causal inference. In either case, research on the dynamics of instruction within regimes could illuminate the role, and perhaps even the importance of various influences on instruction.

Resources—teacher skill, instructional time, materials, equipment, and facilities—are essential for the enactment of any instructional regime. A well articulated regime ought to be clear about the required resources and justify that claim by explaining how resources are used to achieve specific aims. It is possible to rigorously evaluate alternative regimes relative to common goals and to evaluate claims about the necessity of levels or combinations of resources within a regime. It is also possible to evaluate alternative versions of a regime for which resource requirements vary. Not only is such research possible, we think it is essential to learning about how to improve schooling in general, and more specifically to understanding the consequences of investing in resources and making them usable for instruction. The program of research that seems to follow from this view would use the results of passive research programs to generate plausible regimes and resource allocation within them and to help explicate their dynamics. At its heart, however, we have proposed an active program of research, in which deliberate interventions vary resources in relation to well-articulated regimes.

Conclusion

We have proposed a dramatic shift, from a frame that gives priority to research on conventional resources and asks how they affect learning, to a frame that gives priority to designing coherent instructional regimes and asks how resources are used within them. One premise of this approach is that because resources become active when used in processes of mutual instructional adjustment, they are unlikely to have a fixed value in instruction. Their value is likely to depend on the uses to which they are put, which in turn depends on the ends and means of instructional regimes. In order to understand the nature and effects of resources, research must focus on how instructional ends and means are defined, and on what resources are crucial to those ends and means. The research program that we have sketched is not a design for all educational research, but for inquiries that focus on resource and instructional effects.

Our proposals have complementary benefits and costs. On the one hand, our picture of instruction as a system of interactive mutual adjustment complicates understanding of the dynamics of teaching and learning and of the ways in which resources influence them. For in such a system, the value of resources is likely to depend on the ways they are used. That raises fundamental questions about the value of using conventional research to tease out the causal influence of particular resources, across a great variety of schools and classrooms. Though that may unsettle many researchers, it seems inescapable if our account of instruction is roughly right. On the other hand, our account offers a theoretical frame for research on instructional and resource effects that builds on several decades of research, that opens up promising research agendas, and that creates opportunities to lodge active and passive research within mutually reinforcing knowledge-building structures.

Some may argue that these agendas would be insufficient to illuminate policy makers' decisions. To know what resources are needed to teach a given approach in mathematics does not prescribe what resources are needed in general. Small classes might be needed to enact a given approach in literacy, but teachers' subject matter preparation, rather than small classes, might be the crucial ingredient in teaching an effective math curriculum at the same grade. To achieve small classes taught by highly knowledgeable teachers also may not be fiscally feasible. Hence various studies would tend to send mixed signals about how many teachers to hire and what qualifications to require. But in fact, that is exactly what non-experimental research on class size has done. Our argument is that one of the chief tasks of a coherent educational research agenda is to make just such trade-offs visible as the result of sound empirical study. If our approach is correct, policymakers would be well advised to adopt more complex approaches to resource allocation, which capitalize on the role of resource use.

Others may argue that developing such an agenda is infeasible because well-specified instructional regimes could not be devised or because experiments could or should not be done, or because the entire enterprise would be too complex or costly. We disagree. The last decade's work in reading at NICHD and in some whole-school reforms has produced impressive evidence that carefully designed experimental research programs are possible and that instructional regimes can be designed and developed.[40] There would be many difficulties in doing the sorts of work which we have proposed, but if educators and researchers took the ideas seriously, a great deal that seems difficult today could become feasible. One reason for our confidence is that the rising demand for solid evidence on the effects of such interventions suggests that there may be a market for the sort of work that we propose. Another is the recent experience with reading research and some whole-school reform models. Still another is the success of several seemingly impossible experiments in health care, housing, and welfare. And another is the enormous progress which evidence-based medicine has made, after facing similar problems several decades ago.

The sorts of research and instructional design that we have sketched would take careful planning because such work must be strategic. Researchers cannot investigate everything; the goal of our proposal is to investigate a few key issues well. It also would require a broad and energetic constituency that included public and non-public supporters and more capable management than educational research has yet had. All of this could be done if researchers and others concerned with education turned their attention to the work. The resulting research would not prescribe decisions about resources, for those decisions require interactions among a range of persons and groups whose qualifications to decide are civic rather than scientific and whose values often differ. Research on instructional resources could provide a stream of credible evidence regarding the resources required to attain a variety of educational aims and, thus, inform thought and debate about the aims of schooling and levels of investment in education. Over time, it might tend to close out unfruitful arguments as well as highlight new problems. Research could inform but never replace a broad discourse about schooling and school improvement.

ENDNOTES

[1] Coleman (1966), Jencks et al. (1972).

[2] Hanushek (1981, 1989).

[3] Hedges et al. (1994).

[4] Finn and Achilles (1990); see also Mosteller (1995).

[5] Brophy and Good (1986).

[6] That was first reported by Cooley and Leinhardt (1978).

[7] Edmonds (1984).

[8] Rutter et al. (1979).

[9] Rosenholtz (1985).

[10] Edmonds (1984, 1979).

[11] Bryk et al. (1993).

[12] Newmann and Wehlage (1995).

[13] McLaughlin and Talbert (in press).

[14] Leinhardt and Cooley (1978).

[15] Leinhardt, Zigmond, and Cooley (1981).

[16] Palincsar and Brown (1984).

[17] In the same line, Carol Sue Englert conducted several experiments in which students were taught to understand the processes of writing (including outlining, drafting, revising, editing), to monitor those processes as they wrote, and to develop strategies to push the process along. Englert taught learners how to be more effective students, boosting learning by improving their academic practices. See Englert et al, 1991.

[18] Dweck (1986;1988).

[19] This depiction of instructional relationships is familiar: Dewey relies on the idea, as did Jerome Bruner and his associates in creating MACOS, David Hawkins, Milbrey McLaughlin and Joan Talbert, Theodore Sizer, and others. But it also is strange, for many researchers and practitioners refer to teaching as though it was something done to learners.

[20] Lampert, Teaching Problems.

[21] This is a variant on a problem in the National Council of Teachers of Mathematics Curriculum and Evaluation Standards for School Mathematics (1989), (p. 28).

[22] For convenience we often refer in what follows to "instruction", in which we comprise this clump of practices, rather than either teaching alone, or the more clumsy "teaching and learning with materials".

[23] Allan Odden's extensive research on school finance and school improvement develops a version of this view. See, for example, Odden, A, and Busch, C., Financing Schools For High Performance: Strategies For Improving The Use Of Educational Resources. San Fransisco: Jossey-Bass, 1998.

[24] See Lampert, Teaching Problems, for a discussion of coordination problems.

[25] There also are structural features of coordination, including the ways in which time and instruction are organized in periods, days, school years, vacations. Student mobility within and between schools also bears on coordination.

[26] As an analytical matter, this problem is not distinct from those of coordination, incentives, and resource use. But as a practical matter it is so important that we treat it as distinct.

[27] State standards-based reform has sought to order the confusion, but it has not much reduced the proliferation of guidance and in some cases has increased it. New guidance that calls for coherence has been overlaid on many earlier layers of less coherent guidance. Or new conventional guidance was added in response to the more ambitious guidance of standards-based reform. This reform also never offered a way to reduce the variety of organizations which act on schools and the guidance which they direct at classrooms.

[28] Materials often frame content so as to manage the boundary between instruction and its environments—as in the case of U.S. textbooks intended for sale in southern states, which fail to mention evolution

[29] We use "solve" in the sense of manage, or cope with, and imply no satisfactory solution. Nor do we suppose that all teachers and students address these problems attentively. The problems are a rhetorical device which are use to define the conceptual terrain of teaching and learning.

[30] This analysis implies that, were new studies done on class size, it would be useful to collect evidence that would allow researchers to learn three sorts of things: (a) the content and dynamics of teachers' responses, including those sketched above; (b) the patterns of student learning growth that were associated with those responses; (c) the attributes of students and instructional environments that were associated with differences in teachers' response and student learning growth.

[31] Giving teachers access to the improved student work which would likely follow from teachers' learning to make use of reduced class size would become such incentive, since such knowledge would capitalize on teachers' success through students' success.

[32] The same sort of argument can be made about research which shows that teachers with higher test scores, or who know more about a subject, have students with higher test scores (Coleman, 1966; Jencks et al, 1972; Ferguson, 1991). If we think of teachers as people who stand and deliver, teachers who know more about a subject have more to deliver. But the very words are deceptive because knowledge is not self-enacting. If students benefit from teachers' greater stock of knowledge, it probably is not only because they can use greater knowledge to better advantage in teaching. The connection between students' scores and teachers' knowledge must have something to do with teachers' use of their knowledge. For many teachers who know plenty of mathematics can barely use it for purposes of teaching. Teachers who knew more of a subject probably are, on average, able to make better use of texts, to set better problems, and to better understand students' work, class comments, and the like. Knowledge of the subject would have been a necessary condition of such use — teachers cannot use knowledge they do not have—but it would not have been sufficient.

[33] For example, Brophy and Good argue that their research has "refuted" the earlier work of Coleman and Jencks (1986). But their work talked past the earlier studies: Brophy and Good made large strides toward defining a new class of educational resources, which Coleman and Jencks had not been able to investigate, owing to the sorts of data collected in Coleman's study.

[34] Robins et al. (1999).

[35] The causal effect of treatment A relative to treatment B is defined as the difference between the potential outcomes of a student under A or B. Causal inferences are thus meaningful only when a student is potentially exposable to alternative treatments (Holland, 1986). If a regime were strictly enacted, only one possible "dose" would be conceivable at any moment for a particular student. There is a treatment A but no treatment B! This means that such a student would have only one potential outcome, so that no causal effect can be defined. In practical terms, this means that, within a strictly enforced regime, it is not possible to find or even imagine a student who is similar to the student of interest but who receives a different dose.

[36] The renowned "pygmalion" experiments (Rosenthal & Jacobson, 1968) in classrooms can be read as a scheme to change the instruction (read "dose", or "treatment") which teachers offered students by experimentally inflating evidence on students' IQs (see Raudenbush 1984, for a review).

[37] See Odden and Busch, op.cit.

[38] Medical researchers make a clear distinction between efficacy trials and effectiveness trials. Efficacy trials establish that a new treatment can have significant positive effects in carefully controlled settings with plentiful resources. Effectiveness trials take efficacious treatments to the field where implementation is more challenging and resources are more constrained. Our recommended approach to studies of educational improvement is similar. We recommend, however, that effectiveness trials deliberately vary key resources so that their effects can be rigorously evaluated.

[39] For example, in evaluating whole-school reform efforts, one might envision assigning schools rather than students randomly to treatments. This could be done ethically if many schools expressed interest in adopting a reform but resources allowed implementation in only a restricted number of sites at any given time. In this setting, intervenors could promise all schools that they would have the opportunity to participate, but the timing of participation would be decided via lottery. A randomized "wait-list" control group of schools would then be available.

[40] Cook et al. (1999).

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