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ABSTRACT

There is dissonance between the lives of adult students in rural Nepal in a subsistence-level agrarian community and their participation in school. The concept of "transfer" has several shortcomings from the standpoint of understanding relations between mathematical reasoning in the classroom and in the workplace. It is more helpful to use the concept of consequential transition when describing how learners apply classroom knowledge of mathematics to workplace situations. Consequential transition involves reconstruction rather than replication of knowledge and also entails a conscious change in identity and changes to the relationship between the individual and his or her social context. Attempts to get mathematical reasoning to generalize by making the learning of mathematics in classrooms more like math at work or by teaching core concepts "in the abstract" are misguided and not particularly effective. Thinking about differences between school and work as presenting opportunities for mathematical learning and development is more productive than is viewing them as boundaries to be overcome or transferred across. Learning mathematics in classrooms engages adult learner identities quite differently than it engages younger students' identities. (The author discusses the concept of consequential transition in the following scenarios: students and shopkeepers in rural Nepal; the computerization of traditional industrial machining; and high school students at work in the fast-food industry. The document contains 7 references.) (MN)

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Transitions Between School and Work: Some New Understandings and Questions About Adult Mathematics

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Like many of you, I began my career in education as a mathematics teacher. A year of teaching in the United States and three years teaching in a school in rural Nepal moved me to wonder about the relation between what my students were learning in the classroom and what they did and learned in their lives outside of school. My experiences in Nepal in particular led me to examine the now often talked about distinction between learning in school and out.

Nepal did not have a national system of education prior to the 1950s. In fact, schooling had been outlawed in most parts of the kingdom for over a century. During the 1950s and 1960s teams of educators and development specialists from the United States were invited to help create a national system of education from the ground, drawing heavily on American and British systems of instruction and curricula. Thus schools as an entirely new form of social organization were rapidly introduced into Nepali communities. The dissonance between my students' lives in the subsistence-level agrarian community and their participation in school raised concerns for me as a teacher. Here are a few examples of what raised those concerns.

- Primary students attempting to mimic the elaborate finger calculation strategies of their older family members are reprimanded by classroom teachers. Such reprimands are supported by students' families because children are sent to school to learn "real math" that cannot be learned from family members.
- Village farmers describe their mental and finger calculation strategies as "guestimation" rather than *hisaab*, or math. When asked to explain why, they say that what they do was once considered to be *hisaab*. With the introduction of schooling to the village, though, *hisaab* has become exclusively that which you do with pencil and paper.

Learning transfer was one of the few concepts that seemed to have anything useful to say about learning across different contexts such as schools, homes, and workplaces. However, the concept of transfer did not help me much in puzzling through the complicated relations between culture, history, and mathematics that intertwined school with other institutions, and that seemed to be at the heart of my students' and their parents' struggles with *hisaab*. These sorts of struggles are perhaps more transparent in rural Nepal than they are elsewhere, but they exist in some version everywhere that people move between school and participation in workplaces, communities, and families. I suspect that many of you who are practitioners have spent far more time than I struggling with how to best support mathematics learning that is relevant to adult lives beyond the classroom—particularly in the workplace.

I would like to begin by talking about some shortcomings of transfer for understanding relations between mathematical reasoning in the classroom and the workplace. This will set the stage for the bulk of my talk where I will describe an alternative to transfer—that of consequential transition—and will illustrate it with three studies from my research group at Michigan State University. These are studies of school-work transitions in rural Nepal, the introduction of computerized machining into American manufacturing, and high school students' part-time work in fast food restaurants. I will conclude with a brief discussion of what this new conceptual tool of consequential transition might buy us in understanding and facilitating mathematics learning during transitions between school and work. As with any new conceptual tool, it generates new unresolved questions, and I will raise a few of these too.

Shortcomings of the Transfer Metaphor for Understanding What Happens Between School and Work
Our everyday use of the term "transfer" has a powerful metaphorical bearing on how we, as educators and researchers who also happen to lead everyday lives, think about learning transfer. In our everyday usage of the term, transfer involves the movement of a person, a transaction, or the shifting of an object from one place and

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time to another. As a construct in educational psychology, it refers to the appearance of a person carrying the product of learning from one task, problem, situation, or institution to another. It is here that the metaphor begins to break down.

- Commonsense suggests that generalization happens regularly on a moment-to-moment basis in our lives. Yet when we seek to study or facilitate it as transfer, we are rarely successful. This suggests that though the underlying phenomena are quite real, the transfer concept is inadequate for understanding them.
- Transfer either defines an extremely narrow and isolated aspect of learning (that learned on task/situation A that is applied on task/situation B) or is no different from "just plain learning," i.e., all learning involves transfer. Both make the concept relatively useless.
- Transfer environments are assumed to be static and pre-given. This excludes the creation of environments as part of the transfer process itself.
- Nothing new can be created in the process of transfer. Transfer assumes a model of person-environment relation that seals a person's initial learning off from being transformed in the new problem or situation.
- Transfer involves single processes such as recognizing isomorphisms or abstracting general representations. The actual generalization of mathematical reasoning from school to work is complex and cannot be reduced to single process explanations.

Despite these problems with the transfer metaphor, the important educational issues and challenges that underlie what we have called transfer remain central and important. I and the other members of our group at Michigan State University believe that the difficulties are significant enough that the transfer metaphor should be left behind in favor of a metaphor and a set of concepts that accept both changing persons and changing social contexts as central to understanding generalization between the classroom and the workplace. A sociocultural stance affords us this possibility.

To paraphrase Mike Cole in his 1996 book, *Cultural Psychology*, our distinctiveness as humans lies in our ability to modify our world through the construction of cultural artifacts in texts, technologies, symbols, and signs, along with our corresponding ability to reconstruct the modifications in subsequent generations through our schools, families, communities, and work. We thus transform our own learning and development. It is this recursive relation between changing individuals and a changing world that is central to sociocultural work, and to our conceptualization of consequential transition.

The Concept of Consequential Transition as an Alternative to Transfer

Experiences such as learning algebra after years of studying arithmetic, becoming a machinist, founding a community organization, teaching your first-born to walk, an elementary school class writing a letter to a local newspaper, collaborating with NASA scientists on a classroom project via the Internet, making the transition from student to teacher, and learning to do manufacturing quality control in your first job out of high school are all potential examples of the sort of things we are concerned with. Clearly the forms of generalization involved go far beyond learning transfer, but cover an educational terrain that has been reduced, metaphorically, to the carrying and application of knowledge across tasks. Each of these experiences shares a set of common features as consequential transitions.

- Transitions involve the reconstruction of new knowledge, skills, and artifacts, or transformation, across time and through multiple social contexts, rather than the reproduction of something that has been acquired elsewhere. Transitions therefore involve a notion of progress for the learner and are best understood as a developmental process.
- Consequential transitions involve a change in identity: a sense of self, social position, or a becoming someone new. Therefore individuals and institutions are often highly conscious of the development that is taking place, and have particular, sometimes publicly debated, agendas for how and why it should happen. Identity is what makes these transitions consequential.

- Consequential transitions are not changes in the individual or in the social context, per se, but rather are changes in their relationship. Both person and social context contribute to a consequential transition and are recursively linked to each other.

Illustrations of the Concept of Consequential Transition: Students and Shopkeepers in Rural Nepal

The first illustration of the concept comes from a study of Nepali high school students becoming shopkeepers and adult shopkeepers attending school for the first time (Beach, 1995a, 1995b). High school students near graduation were apprenticed to adult shopkeepers for a period of several months. Similarly, adult shopkeepers who had never attended school were enrolled in an adult literacy/numeracy class for several months. Changes in arithmetic reasoning were tracked during this period of time.

The high school students engaged in a lateral transition from school to work. Many students in rural Nepal go on to become shopkeepers, and therefore the transition was unidirectional toward their future career. The shopkeepers engaged in a collateral transition between the shop and the classroom. They participated in both activities with near simultaneity. They planned to remain shopkeepers. Their transition was not preparation for participation in a new activity. Rather, it was for the improvement of their existing activity—shopkeeping. Thus changes in both the students' and shopkeepers' sense of self and social position were engaged as a part of the consequential transition.

The high school students transformed their arithmetic reasoning as a part of the transition. Students retained a written form of arithmetic notation, but the notation was changed to represent modified forms of mental and finger calculation strategies used by the shopkeepers. By transforming their arithmetic reasoning the students retained the status associated with written arithmetic while acquiring the efficiency of the shopkeepers' strategies. The transition involved a transformation of the students' knowledge of arithmetic. Unlike students, shopkeepers added some aspects of paper and pencil calculation algorithms to their existing repertoire of calculation strategies and rejected others as not useful for shopkeeping, such as the writing-out of operation signs. They expanded and reorganized their existing knowledge of arithmetical calculation but did not construct a new form for representing calculations.

Illustrations of the Concept of Consequential Transition: The "Computerization" of Traditional Machining

The second illustration comes from a study of an industrial machine shop where machinists trained on mechanical machines were learning to use computer numerical control (CNC) machines (Hungwe, 1999; Hungwe & Beach, 1995). Mechanical machines are controlled with a series of dials, levers, and gauges that the machinist manipulates in real time to make parts. In contrast to this, program code that is written at a location distant from the machines before producing parts controls the CNC machines. The social and technological organization of the shop changed with the introduction of the computerized machines. Many of the machinists experienced an encompassing transition, a form of consequential transition occurring within the boundaries of a single social organization that is itself changing.

Machinists with decades of experience running mechanical machines mapped the CNC programming codes onto their prior knowledge of tool movement through Cartesian space and trigonometric calculations, albeit with some adjustment. However, machinists without those many years of experience with mechanical machines relied more directly on the structure of the programming code to think about tool movement and organize calculations in learning CNC machining. It can be seen from this example that it is the particular intersection of the history of the individual with the history of the social organization that determines the nature of knowledge developed during encompassing transitions.

The introduction of CNC machining supported the division of machining into machine operation and machine programming. Some machinists in the shop opted for overseeing the operation of the machines, whereas others began to program the machines. Several of the more accomplished machinists experienced a loss of craftsman identity as a part of the transition to CNC machines. They were no longer individually responsible for creating parts from start to finish. Despite having mastered the intricacies of CNC machining, these machinists returned to mechanical machines where they were fully responsible for the making of parts. Sense of self and social position, or identity, rather than knowledge and skill, drove the reversal of their earlier transition.

Illustrations of the Concept of Consequential Transition: High School Students at Work in the Fast Food Restaurant Industry

The final illustration comes from a study of high school students at work in fast food restaurants for the first time (Beach & Vyas, 1998). An exclusive focus on school subjects like math, science, and literacy gives the appearance that nothing new was gained during collateral transitions between high school and work in fast food restaurants. It fact, the situation appears to be very much one of classic transfer. Students' subject knowledge from school is applied to work in the restaurant. New understandings of math, science, and literacy are not constructed during the transition when these categories of knowledge are looked at in isolation.

A closer analysis indicates that the high school students do develop during the transition. They are learning how to learn in a production activity for the first time, in contrast to learning within a social organization that has learning as an explicit part of its agenda. Uses of language, math, and science on the job are reconstructed "on the fly," so to speak, while production is maintained. The students develop ways to learn how to avoid inefficient arithmetic calculations, call out orders that communicate without distracting, and avoid food spoilage, all without specific time and support for learning these things. Students do not see these as instances of math, literacy, or science. They are right in one sense. Math, literacy, and science each involve multiple concepts that reference each other within their respective domains, e.g., the concept of ratio is related to fractions, decimals, and division. Math-, science-, and literacy-like concepts in the fast food restaurant are referenced to aspects of production, and not to other mathematical, scientific, or communicative concepts.

Development can be found during collateral transitions when we move away from using the epistemological assumptions of one social organization—the school—to understand participation in the new organization, in this case the fast food restaurant. In doing so we are also putting aside ideological assumptions that value knowledge organized in the form of subject matter over knowledge organized is other ways, such as for production.

Some New Understandings and Questions

What might this new conceptual tool of consequential transition "buy" us in understanding and facilitating mathematics learning during transitions between school and work, and what new unresolved questions does it raise? Here are a few described in brief. A fuller explication of the concept of consequential transition can be found in a recent volume of the annual *Review of Research in Education* (Beach, 1999).

- Attempts to get mathematical reasoning to generalize by making the learning of mathematics in classrooms more like math at work, or by teaching core concepts "in the abstract," are misguided and not particularly effective.
- It is more productive to think about differences in school and work as presenting opportunities for mathematical learning and development, rather than boundaries to be overcome or transferred across. This suggests that efforts should not be directed at making school and work similar to each other, nor should seamless transitions between the two be promoted as a goal. Rather, we need to think about ways to directly support consequential transitions themselves as important pedagogical opportunities.
- Learning mathematics in classrooms engages adult learner identities in ways that are quite different from that of younger students. The sense of becoming someone new, or of not being someone, e.g., not being "educated," should be considered legitimate topics for discussion among adult learners of mathematics.
- How do we engage workplaces as environments for learning mathematics when learning and production often present competing and contradictory agendas?
- How do we maintain relations between that which the adult learner experiences as math and that which she does not experience mathematically, although we can understand both experiences as mathematical from our vantage point as teacher or researcher?

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