Title

Arithmetic Procedures In Everyday Situations

Journal
Proceedings of the Annual Meeting of the Cognitive Science Society, 4(0)

Author
Lave, Jean

Publication Date
1982

Peer reviewed

Arithmetic Procedures in Everyday Situations

Jean Lave
University of California, Irvine

The ubiquity and unremarkable character of routine activities such as grocery shopping qualify them as apt targets for the study of thought in its customary haunts. For the same reasons, such activities are difficult to analyze. I approach the task, however, in the conviction that the understanding of problem solving depends on an integrated conceptualization of the culturally crystallized activity-in-setting within which problems are realized. I have chosen to focus, therefore, on a social institution, the supermarket, which is highly structured in relation to a clearly defined activity-in-setting, grocery shopping.

The Adult Math Skills Project at U.C. Irvine has as its goal to explore arithemetic practices in the daily lives of their users. One branch of the project seeks to develop both theory and method for analyzing decision-making processes in grocery shopping, including the role of arithmetic in these processes. Michael Murtaugh's project, on which I draw heavily here, involved extensive interviewing, observation, and experimental work with twenty-five adult, expert grocery shoppers in Orange County, California. Detailed transcribed observations of preparation for shopping, a major shopping trip, and its aftermath provide data for the analysis sketched here (and set out in detail in our recent paper, <u>Recounting the Whole Enchilada: The Dialectical Constitution of Arithmetic Practice</u>. The Orange County residents vary in age from 21 to 80, in income from $8,000 per family to $100,000, and in schooling from 8th grade to an M.A. Twenty-two are female; all are native speakers of English whose schooling took place in U.S. public schools.

Certain aspects of activity settings have durable and public properties. For example, the supermarket is a durable entity--a physically, economically, politically and socially organized space-in-time. The supermarket, in this sense, is called an "<u>arena</u>." The supermarket as arena is outside of, <u>yet</u> encompasses, the individual, providing a higher order institutional framework within which "setting" is constituted. The setting of grocery shopping is the arena as acted in by the individual. The setting is the shopper's edited version of the arena, generated by his or her routine grocery shopping activity in the supermarket. As setting, some aisles of the supermarket do not exist as part of a shopper's field of action, while others are fine-featured areas in which the shopper routinely makes several choices and still others serve only as broad cues to a particular, routinely purchased items.

It is in this sense that it is possible to talk about the dialectical relation of setting and activity. A shopper passes the generic products with a sudden coming-into-focus of their funny, plain appearance. She stops to investigate, realizes there is a tradeoff between the comforts of known products and the possibility of lower prices. This creates a new category in her repertoire of money-saving shopping strategies, which in turn leads her to attend to it on the next trip, and on later trips perhaps, to make a regular check at this aisle before proceeding elsewhere. The setting for future shopping trips is thereby transformed into a more extensive routine route, and the activity of grocery shopping is transformed by change in the setting. On future visits a review of price-saving possibilities on a small but diverse set of products will precede consideration of the brand name projects in their usual locations.

Grocery shopping is composed of repeated processes of decision making which have the effect of reducing numerous possibilities to single items in the cart on the basis of qualitative characteristics which differentiate items. Arithmetic problem solving is both an expression of and a medium for dealing with stalled decision processes. It is, among other things, a move outside the characteristics of the product to its characterization in terms of a standard of value, money. It brings the particular decision process to an end if arithmetic calculation leads to a decision to purchase a particular item.

Given these circumstances and the predicament shoppers face, presented with an abundance of goods to choose from but no choice other than to make choices, arithmetic problem solving very often acts as a rationalization of essentially arbitrary "choices." Support for this interpretation of the role of arithmetic calculation in routine decision making (as serving to produce rational accounts for choices which are only apparent) comes from Murtaugh's research on decision processes used by shoppers in choosing grocery items. He demonstrates that arithmetic, if utilized in the course of choosing a particular grocery item, is employed near the end of the process, when the number of choices still under consideration is no greater than three and rarely greater than two. Thus, a partial analysis shows that thirteen shoppers purchased 450 grocery items. Of these items, 185 involved snag repair of some variety, and 79 of these latter items involved problem solving which utilized arithmetic. In all there were 162 episodes of calculating, approximately two calculations per item on which calculation occurred. It would be difficult to picture arithmetic procedures as major motivations driving shopping activity. Justifying choices just before and after the fact is a more appropriate description of the common role of arithmetic in shopping.

So far I have said that a "problem" in routine activities is an interruption or snag in individually constituted routine and that arithmetic is often used in a rationalizing capacity to overcome snags. A third critical characteristic of problem solving follows from the character of activity-setting relations as a whole (as analyzed in the full version of the paper): The relation between activity and setting is a dialectical one; (arithmetic) problem solving is part of that activity-in-setting and thus must conform to the same dynamic. It follows from this position that the activity-in-setting of grocery shopping is crucial in shaping problem-solving activities. The data support this view.

In the course of our research, shoppers took an extensive paper-and- pencil arithmetic test, covering integer, decimal, and fraction arithmetic, using addition, subtraction, multiplication and division operations. The sample of shoppers was constructed so as to vary in amount of schooling and in time since schooling was completed. Problem-solving success averaged 59% on the arithmetic test, compared with a startling 100%--error-free--arithmetic in the supermarket, and this in spite of the fact that a number of problems on the test were constructed to have exactly the same arithmetic properties as problems grocery shoppers successfully solved in the supermarket.

Subtest scores on the math test are highly correlated with each other, but none correlates significantly with frequency of arithmetic problem solving in the supermarket. Number of years of schooling is highly correlated with performance on the math test but is not significantly correlated with frequency of calculation in the supermarket. Years since schooling was completed is significantly correlated with math test performance but not with grocery shopping arithmetic.

However it may be noted that my position is not one of extreme situational specificity. Although there is not time to discuss it here, I take the view that any activity-in-setting is interelated with interpenetrates, other activities-in-settings. These relations are the basis of the generality, in the sense of spread, or multiple use of, knowledge across situations, including arithmetic.

But the main point here is to illustrate the dialectical form of arithmetic problem solving in the routine activity-setting of grocery shopping. A successful account of problem-solving procedures will explain two puzzles uncovered in preliminary attempts to analyze grocery shopping arithmetic. The first is the error-free arithmetic performance in the supermarket by shoppers who made frequent errors in parallel problems in formal testing situations. The other is the frequent occurrence of more than one attempt to calculate during a single decision segment of shopping.

First it is useful to make explicit what is dialectical about the process of problem-solving. The routine nature of grocery shopping activity and the location of arithmetic at the <u>end</u> of decision-making processes about grocery items within the activity of grocery shopping suggests that there must be rich content and shape to a problem solution at the time arithmetic becomes an obvious next step. Problem-solving under these circumstances is an iterative process involving moves between what the shopper knows and the setting holds that might help, on the one hand, and what the solution looks like, on the other, since many of the solution's parameters are already in place as the result of the prior process of deciding, up to a point, what to purchase. The dialectical process is one of gap-closing between strongly specified solution characteristics and the inputs and procedural possibilities for solving the problem.

Thus, a change in either solution shape or resources of information leads to a reconstitution of the other: The solution shape is generated as the product of the decision process up to the snag. Problem identification changes the salience of setting characteristics. This in turn suggests, more powerfully than before, procedures for generating a specific solution; information and procedural knowledge accessed by mind and/or eye make possible a move towards the solution or suggest a change in the solution shape that will draw it closer to the information at hand.

These basic points are illustrated by a shopping episode in which the shopper, J. (a 43 year old woman with 4 children), discusses the price of noodles--noodles last week and this, big packages and little ones, different brands, and so on, as she replaces the family supply.

She begins by taking a package of noodles off the shelf and putting it in her cart. It is the kind she customarily buys, Perfection elbow noodles, 32 ounces, $1.12. As she does so she comments that it is cheaper than American Beauty noodles. It is clear from her action of placing the package in the cart that a decision has been made, and the decision prefigures and shapes the course of calculations to come. The arithmetic problem J. will work on during the rest of the segment is to decide which is the better buy, which gives more for the money: The one she purchased, or one of three sizes of American Beauty Noodles: 24 ounces for $1.02, 48 ounces for $1.79, or 64 ounces for $1.98. After a digression about goulash, J. and the anthropologist, (M.), get back to noodles.

> J.: There's large elbow /noodles/. This is really the too--large economy bag. I don't know if I, probably take me six months to use this one.... I don't know, I just never bought that huge size like that. I never checked the price though on it. But being American Beauty it probably costs more even in the large size.

J. here has reiterated somewhat more firmly than before her opinion that American Beauty is more expensive than other brands. The resolution of the numerical comparison is taking on clearer outlines. The next interchange starts a process of simplification of the arithmetic comparison. She transforms large number of ounces into a small number of pounds.

> M.: That's what, that's 6. . . J.: It's 4 pounds and what did I buy, 2?

That this is phrased as a question suggests that she is making a comparable change from ounces to pounds for the 32 ounce package in her cart as she has just made for the 64 ounce package on the shelf. The problem now looks like this:

Perfection noodles,	2 pounds	$1.12
American Beauty noodles	4 pounds	$1.98

She eventually simplifies the problem to

> 2 pounds for $1, 4 pounds for $2.

She concludes that they are equivalent buys, at 50 cents a pound. But she does not stop there. Her point is to demonstrate a difference in price per pound, so she starts yet another round of calculation with more specific prices, going back to $1.12 in order to produce a precise enough calculation to demonstrate the difference. Simplification does not become an end in itself, then. In these calculations it is just one possible step whose relation with the solution shape may lead either to an end to calculating, a return to more complex forms of calculation, or to a change in the solution shape.

All this goes by so fast that only repeated analysis of transcripts make clear that calculation has taken place at all. Meanwhile, in the course of the discussion there is yet another price comparison. J. looks at two packages of American Beauty spaghetti noodles, and sees what appears to be a justification for not buying a large bag:

J.: But this one, you don't save a thing. Here's 3 pounds for a dollar 79, and there's 1 pound for 59.

Having a solution, "you don't save a thing," confirmed, "Here's 3 pounds for a dollar 79 and 1 for 59," the process of looking at the bags while reading off the information required to justify the conclusion, leads to reassessment of the information: For the "1 pound package" in fact does not weigh a pound. Immediately she adds a second round of calculations:

J.: No, I'm sorry, that's 12 ounces. No, it's a savings.

Two rounds of calculation have just occurred. The first produced the conclusion that in both cases the noodles were essentially 60 cents per pound. Recognizing the weight error, only a "less than" inference would be required to move to the conclusion that the big bag is in fact a saving. And in the second round this is just what she does.

However, the "only" is deceptive, as is the conciseness of the transcript, if they convey the impression that the arithmetic is simple in paper-and-pencil, place-holding algorithmic terms. The problem in these terms would be to discover if one point seven nine divided by three is equal to point fine nine. An active process of simplification is required to transform this set of operations into the form that J. achieves. This kind of simplifying transformation, which preserves relations and simplifies numerical representations, is characteristic of grocery shopping arithmetic.

The pattern of moves made in the course of J.'s calculations is something like this: She starts with a probable solution, but inspection of evidence and comparison with the expected conclusion cause her to reject it. Given corrected information, she recalculates and obtains a new result. This whole process is what is meant by "gap-closing:" the weaving back and forth between the expected shape of the solution and the information and calculation devices at hand, in the course of which each is repeatedly transformed by the other.

One characteristic of the preceding account has been the need to assign multiple functions to individual moves in gap-closing arithmetic procedures. It seems to be the nature of dialectically constituted processes to pose severe problems of description. Perhaps one must give up the goal of assigning arithmetic problems to unique locations--in the head or on the shelf--or labelling one element in a problem-solving process as a calculation procedure, another as a checking procedure; or even distinguishing the problem from its answer. In such circumstances statement of the problem, solution to the problem, procedure for solving the problem, and checking activity, may be analytically indistinguishable.

In discussing these implications of a dialectical model of problem solving I have, among other things, been developing an explanation of the multiple-calculation, error-free arithmetic practiced in grocery shopping. Error-free arithmetic is not error-free because people do not make mistakes. Indeed, multiple calculations to repair initial difficulties, are the rule rather than the exception. Typical gap-closing procedures occur in "rounds." Dialectical processes of problem solving account for the multiple calculation phenomenon.

Why is the end product of calculating so extraordinarily accurate? The analysis cannot be presented in complete form here. But a major reason is that dialectical processes of problem-solving make possible powerful monitoring by the problem solver, due to the juxtaposition of problem, problem-solving procedure, solution and checking activity.

I have tried to cover a great deal of ground in a very short time. The talk can hardly do more than indicate the nature of the issues taken up in the paper itself. But in closing it might be useful to stress the major point of the exercise: the dialectical constitution of problem-solving in any particular activity setting grows out of the encompassing dialectical relation between the activity and setting within which it takes place. The nature of the dialectical relation between grocery shopping and the supermarket generate the routiness of the activity in setting in relation to which problems are constituted as snags or interruptions. Likewise, the dialectical relation between shopping and market setting generates the overdetermined nature of choice and the rationalizing character of problem solving; and the activity-in-setting directly gives the dialectical character to problem solving for it is part of that activity-in-setting.

Arithmetic problem solving is not "the same" everywhere and at all times. But this in no way negates the possibility of developing general theory about the constitution and reconstitution of activity in setting.