DOCUMENT RESUME

ED 389 580 SE 057 223

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TITLE Linking Informal Knowledge and Formal Skills: The Case of Percents.
PUB DATE Oct 95
NOTE 8p.; Paper presented at the Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education (17th, Columbus, OH, October 21-24, 1995). For entire conference proceedings, see SE 057 177.
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Adult Basic Education; *Adult Learning; *Cognitive Structures; *Computation; Interviews; Mathematics Education; *Percentage; *Prior Learning

ABSTRACT

This study examined adult students' informal knowledge of percent and its relationship to their computational skills. Sixty adults studying in urban and suburban adult education programs were interviewed to ascertain: (1) their ideas of the meanings of benchmark percents, 100%, 50%, and 25%, as they appear in advertising and media contexts; (2) their ability to use these percents in everyday mental math tasks; and (3) their visual representations of these percents. Students also completed written computational percent exercises. Students' responses were examined to determine the nature of their informal knowledge and skills, and a number of patterns were identified. The range and fragility of student responses and the diversity of knowledge gaps suggest the acquisition of isolated ideas but the absence of elaborated frameworks. (Author/MKR)

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Lynda Ginsburg and Iddo Gal

Paper presented at the Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education

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LINKING INFORMAL KNOWLEDGE AND FORMAL SKILLS: THE CASE OF PERCENTS

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This study examined adult students' informal knowledge of percent and its relationship to their computational skills. Sixty adults studying in adult education programs were interviewed to ascertain their ideas of the meanings of benchmark percents, 100%, 50%, and 25%, as they appear in advertising and media contexts; ability to use these percents in everyday mental math tasks; and visual representations of these percents. Students also completed written computational percent exercises. Students' responses were examined to determine the nature of their informal knowledge and skills and a number of patterns were identified. The range and fragility of student responses and the diversity of knowledge gaps suggest the acquisition of isolated ideas, but the absence of elaborated frameworks.

Many studies have been published in the last few decades exploring the informal knowledge of mathematics that students develop. Much of the research has examined the mathematical knowledge young children bring with them to their early schooling experiences (e.g., Carpenter, Moser, and Romberg, 1982). Other studies have focused on the mathematical knowledge older children or adults, usually with little or no prior schooling, develop in out-of-school, functional contexts (e.g., Nunes, Schliemann, and Carraher, 1993). This research demonstrated that individuals can and do acquire informal mathematical knowledge as it is needed without the benefit of school learning and that this knowledge has important similarities to and differences from school-based knowledge.

Daily functioning in numerous real-world situations (e.g., dealing with work-related tasks, shopping, and understanding messages in the media) necessitates frequent encounters with percents. Therefore, it was postulated that almost all adults, even those with limited school-based knowledge, will have formed some ideas about the meaning of the percents they encounter and developed strategies to support percent related activities. Many everyday tasks do not require extensive computations but rather interpretive skills based on an understanding of the ideas underlying the percent system, "number sense," and mental math skills relating to percents.

The goals of the study were to examine some aspects of the informal knowledge of percent displayed by adult literacy students, identify its limitations and gaps, and examine the relationship between this knowledge and computational skills.

Design of the Study

Semi-structured interviews were conducted with sixty adults studying in 7 urban and suburban adult education programs. The 57 women and 3 men ranged in age from 18 to 53 years (mean=27.5) and had completed a mean of 10.6 years of schooling. While all interviewees were studying mathematics, none had begun working with percents in their present programs.

The adults were presented with explanatory, shopping, visual, and computation tasks involving the benchmark percents 100%, 50%, and 25%. They were shown everyday percent-laden stimuli such as newspaper articles and advertising flyers to elicit their ideas about five separate but related facets of the role of 100% as the basis of the percent system. Questioning about 50% and 25% centered around the adults' interpretations of the meaning and use of the percents in shopping contexts and the mental math strategies they use in those situations and in visualization tasks. For the computation task, the students completed a series of decontextualized percent exercises.

Findings And Discussion

Knowledge about 100% as the basis of the percent system

The 5 facets of the meaning of 100% explored in the study and the percentages of students' appropriate responses are shown in Table 1. Most of the errors in the visual task involved confusion between 15% and one-fifteenth, with students dividing the circle into 15 parts and identifying one part as "15%."

The question that caused the most difficulty required students to justify their use of 100% and clarify its meaning. Of those whose responses were considered appropriate, some at first seemed to be unsure or tentative about their ideas, but then appeared to be crystallizing and thinking through their ideas during the response process, suggesting that their ideas about 100% as the basis for percent may be fragile and still evolving.

Interviewer: Why did you use 100%?

Dorothy: It all depends on how you're breaking it down. You can use any number for a whole: fifty fiftieths, four fourths.

Interviewer: And when you are dealing with percent?

Dorothy: It would have to be over 100, 200% could be a whole, 250% couldn't be a whole because that breaks the rhythm.

Interviewer: So which numbers can be a whole?

Dorothy: Zeros: 100, 200, 300.

Interviewer: As high as you want?

Dorothy: All depends on what type of money you're dealing with. Got 10 million dollars (pause). No keep it at 100%, forget the 200%, etc. 100% is a whole.

In their justifications, 48% of the adult students seemed to be unsure that 100% represents a whole and is the reference point for other percents. Some students were unable to separate percent ideas from the contexts in which they were en-

Table 1

Percentages of Appropriate Responses for Each Facet of 100% as the Basis of the Percent System

	Grade level				
Facet	6th and below n=15	7th-8th n=24	9th and above n=15	Unclass. n=6	Total n=60
Percents lie on a 0-100 scale.	87%	96%	93%	100%	93%
Percentages of the of a "whole" sum to 100%	80%	79%	100%	67%	83%
Visual representation of % as proportional part of whole.	67%	71%	67%	100%	72%
100% mean "whole" of "all."	80%	83%	87%	83%	83%
Justify use of 100% as the reference point for percents.	40%	38%	80%	67%	52%

countered while others ignored the proportional nature of percent and treated percents as absolute numbers.

Interviewer: Would you always use 100% [to evaluate 90% in "This new test detects cancer correctly in 90% of the cases"]?

Theresa: Yes. In a way, you don't know. It all depends on how many cases they used. 90% is good out of 100% of the people. If you have 250, 90% is not good. It's not half of 250 people. 125 would be half.

The number of appropriate responses by students for all 5 tasks involving 100% are shown in Table 2. A majority of the students, including a sizable group from the most advanced cohort, appeared to grasp some facets of the meaning of 100% but were unable to grasp others, demonstrating gaps, limitations, or inconsistencies in knowledge. There were no patterns of errors; knowledge gaps varied across students within all grade level groups.

Response patterns across tasks involving 50%

When asked about the meaning of 50% as it appeared in department store sales flyers, all students responded that 50% means one-half . However, when asked to explain their statement that 50% is the same as one half, 40% of the students did not relate 50% to 100% but rather explained the meaning of 50% as an artifact of our monetary system: "because 50 cents is one half of a dollar" or "$50 is one half of $100."

Table 2
Percentage of Students Within Grade Levels by Number of Appropriate Responses to Questions About 100% as the Basis of the Percent System*

	Grade level				
Number of Appropriate responses	6th and below n=15	7th-8th n=24	9th and above n=15	Unclass. n=6	Total n=60
0	7%	0%	0%	0%	2%
1	0%	4%	0%	0%	2%
2	20%	4%	7%	0%	8%
3	13%	29%	13%	17%	20%
4	27%	46%	27%	50%	37%
5	33%	17%	53%	33%	32%

Percentages are calculated within each grade level. Columns may not sum to 100% due to rounding.

One third of the students were able to solve all tasks involving 50%. Thirty students (50%) were able to solve tasks in shopping and visualization contexts, yet failed to solve at least one of the two mathematically equivalent written computational problems. Perhaps the test-like environment requiring written responses created an expectation that problems had to be solved using school-based computational algorithms and prevented students with limited knowledge of percent algorithms from assuming that they could create mental (or visual) models of test items to support meaning. The remaining students (17%) displayed various patterns of responses to questions involving 50%. Included in this group were two students who were able to solve one written computational task (50% x 10=?) but were unable to solve either an arithmetically equivalent shopping task or the visual task.

Response patterns across tasks involving 25%

Reliance on the monetary system was also found in students' explanations of the meaning of 25%. The responses of 77% of the students referred to fractions (one-fourth or one-quarter), money (25 cents off a dollar), or a combination of fractions and money. ("One quarter" was a difficult response to classify since the students could not always decide if they meant a fractional part, the name of a coin, or both.) The remaining 23% of the students were unable to explain the meaning of 25% (in the context of "25% off sale") although they did know that 50% was one half.

Of the 60 interviewees, 12 students (20%) responded appropriately to all tasks involving 25% and seven (12%) were unable to respond correctly to any task. The remaining students exhibited a variety of patterns of responses with the two most common patterns being success with only the visual task (23% of all students), and success with only the written computational task (15% of all students).

General trends across tasks involving 100%, 50%, and 25% and implications

Using a criterion of a maximum of one incorrect response to the tasks within a category (i.e., 4 correct out of the 5 tasks involving 100%, 4 out of 5 tasks involving 50%, or 3 out of 4 tasks involving 25%), success rates in the categories of "100%" and "50% " were quite similar. Of the 60 students, 41 (68%) were successful with "100% tasks" and 43 students (72%) were successful with "50% tasks." When individual performance across these two categories of tasks was considered, 55% of all students were successful in both categories and 15% were unsuccessful in both categories. The remaining students (30%) were successful in only one of the categories, with about half successful in each category.

The finding that 30% of the students were successful in one category but not the other suggests that the ideas targeted by the two categories of questions may not inform each other. A demonstrated knowledge of one set of ideas or skills does not necessarily lead to knowledge of the other; each body of information or skills is attainable in isolation for these students. Apparently, some students have some knowledge of the different facets of 100%, yet this knowledge does not help them sufficiently to make sense of situations in which 50% appears. Other students realize that 50% is equivalent to one half and are able to apply that knowledge in a useful way, yet do not have an elaborated conceptualization of a system based on 100% within which 50% has meaning. Perhaps the knowledge of the meaning and application of 50% is not mathematically based but was developed through personal experiences and encountering percent words in everyday usage in which the term "50%" is treated as a word synonymous with "half" rather than as part of a mathematical system.

The tasks using 25% were more difficult for students in all grade level groups than were the 50% tasks. Yet, 24 students (40%) were successful with at least three of the four 25% tasks, including 2 students from the group with the lowest scores on the standardized tests. The successful students were found to be those who also demonstrated proficiency on the "knowledge of 100%" questions (only 1 of the 24 students responded appropriately to *less* than four of the five questions) *and* on the tasks using 50% (only 2 of the 24 students were not successful here and all of their missed questions were written computations). These data suggest that those who were competent in comprehending and using 25% also demonstrated *both* a knowledge of the role of 100% within the percent system and the ability to use at least one other percent (50%) in a meaningful way.

On the other hand, demonstrated knowledge of the facets of 100% did not necessarily imply an ability to activate that knowledge across a variety of tasks using 25% (for 18 students), nor did an ability to work with 50% necessarily transfer to an ability to work with 25% (for 21 students). Knowledge of 100% and the ability to use 50% appropriately, to the extent these constructs were measured, was apparently not always sufficient for students to be in a position to generalize their knowledge to apply to 25%.

As expected, the highest grade-level group was the most successful with the various percent tasks. However, even within this group, there was evidence of gaps in understanding as well as some limitations on how and when knowledge was applied. Less expected was the ability of many in the lowest grade-level group to respond successfully to many of the questions. Apparently, many of the adult students who are classified as needing much remedial mathematics education (based on existing testing practices), do have some knowledge of the percent system and/ or some familiarity with 50%; this knowledge, however, often seems to be limited to isolated informal ideas that do not inform activities involving 25%.

Many of the adult students in this study have acquired bodies of informal knowledge of percent and are able to apply that knowledge in some contexts but not others. Often this knowledge includes misinformation or gaps, but this does not seem apparent to the individual. Much of the students' knowledge of percent consists of isolated pieces of information tied to those contexts in which it was developed, either everyday contexts or school contexts, but is not integrated into an elaborated mathematical structure.

References

Carpenter, T. P., Moser, J. M., & Romberg, T. A. (1982). *Addition and subtraction: A cognitive perspective.* Hillsdale, NJ: Erlbaum.

Nunes, T., Schliemann, A. D., & Carraher, D. W. (1993). *Street mathematics and school mathematics.* New York: Cambridge University Press.