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ABSTRACT

One of the new measures developed as part of the Apple Classrooms of Tomorrow (ACOT) program is described. The ACOT project examines the impact of access to educational technology on the kindergarten through grade 12 classroom environments. The new measure is a technology-based classroom observation instrument for documenting the impact of technology on classroom instruction. The instrument uses a time-sampling procedure and is organized for recording in timed intervals using a machine-scannable form. Observers code a few key indexing variables for the activity period observed as follows: (1) subject area; (2) number of students assigned; (3) classroom observation; (4) adult roles (directing instruction, facilitating instruction, management and discipline, and not present); (5) symbol systems serving key instructional functions; (6) symbol systems that students use; (7) length of responses expected of students; (8) level of processing expected of students; (9) resources in use; and (10) students' responses to the activities. The instrument is currently used in documentation of high technology access classrooms (a database with 12 total hours observed in language arts and 6.1 hours in mathematics) and in documentation of changes in instructional practices associated with technology use over time (observations at elementary school and secondary school sites). The instrument's usefulness will ultimately depend on coordination with other data gathering techniques. Two tables present study findings, and 32 bar graphs provide examples of the "snapshot" graphical displays generated by the instrument. A 35-item list of references is included. (SLD)

A New Mirror for the Classroom:
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CSE Technical Report 336

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A New Mirror for the Classroom:
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Project Background

Since 1987, UCLA's Center for Technology Assessment has been conducting a set of evaluation, research, and development activities at selected Apple Classrooms of Tomorrow[sm] (ACOT[sm]) sites, with the goal of documenting the impact of technology access on K-12 environments (Baker, 1988; Baker & Herman, 1988, 1989; Baker, Herman, & Gearhart, 1988; Baker, Gearhart, & Herman, 1990, 1991; Baker & Niemi, 1990, 1991;

Gearhart, Herman, Baker, Novak, & Whittaker, 1990; Gearhart, Herman, & Whittaker, 1991; Gearhart, Herman, Whittaker, & Novak, 1991; Herman, 1988). When Eva Baker and Joan Herman initiated the work with ACOT in 1987, the project had been implemented in selected classrooms at five sites that were dispersed nationally and varied considerably in student characteristics and school context factors. Students and teachers in all classrooms were provided with high access to individual computer support both at home and at school, and ACOT's goal was to document how instructional innovations emerge in high access environments. Since 1987, the ACOT project has evolved to encompass more sites and has assumed a more directive role in the kinds of teacher support provided. It has shifted from a 'bottom-up' exploration of the impact of technology access to a research and development laboratory for the construction of new technology tools for instruction and new tools for the assessment of instruction and instructional impact.

The work of the UCLA Center for Technology Assessment has evolved as well. From the outset, the Center's goal for its work with ACOT has been to develop a model of technology assessment in K-12 environments by exploring the utility and applicability of existing measures and by developing new measures as needed. The shift in our work has been one of emphasis—as a result of continued confrontations with the limitations of existing measures, the development of new assessment tools has become our primary focus.

This paper is a description of one of our new measures, a technology-based classroom observation instrument for documenting the impact of technology on classroom instruction. In the report that follows, we explain the need for a new observation tool sensitive to technology impact, and then illustrate the utility of the tool with samples of two of our current approaches to data analysis.

A Technology-Based Classroom Observation Tool

Our ongoing evaluation of the ACOT project required a method for documenting instructional impact and for providing "process" explanations for student and teacher outcomes. The instrument we had in mind would provide fairly comprehensive "snapshots" of classroom activities that would reveal variations in instructional practices related to uses of diverse resources. Based on data produced from informal observations we needed a tool that could: document subject-specific instructional patterns, determine whether technology limits certain kinds of classroom organizations and supports others, describe how teachers' roles may shift when technology is in use, document how the nature of students' work differs when technology resources are in use (e.g., its challenge, length, the media used), and determine whether technology use has an impact on students' responses to instruction (e.g., their engagement with peers, or investment in their work). No existing observation instrument was available to provide us with data appropriate to our needs.

The Limits of Available Observation Instruments for Our Purposes

Available observation instruments most commonly focus on the teacher's instructional and support roles during teacher-student interactions (see reviews by Cazden, 1986; Dunkin & Biddle, 1974; Evertson & Green, 1986). Some interaction schemes are motivated by process-product analyses of common functions of classroom talk that are believed to influence student outcomes (e.g., Flanders, 1970; Good & Brophy, 1983). These schemes vary in their explication of a model of the cognitive functions of interaction in supporting students' learning and reflection. Other schemes are derived from linguistic or sociolinguistic analyses of discourse (e.g., Green & Wallat, 1981; Sinclair & Coulthard, 1975) and are used in investigations of a range of research questions, including the cultural context of teaching and learning, the functions of language in intellectual activities (e.g, Cazden, John, & Hymes, 1972), and the communicative requirements of classroom participation (e.g., Mehan, 1979). Observation methods derived from both traditions included a considerable range of procedures: on-the-spot coding procedures using either time sampling or event sampling techniques, post-observation coding of video- or audiotape, and ethnographic examinations of selected case excerpts.

While we viewed description of classroom interaction as important to our scheme, it was clear that we needed an

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instrument which could provide a more comprehensive look at classroom activities. The instruments that were closest in rationale, design, and content were those developed by Stallings (Stallings, 1975; Stallings & Giesen; 1974; Stallings & Kaskowitz, 1974), later adapted by Sirotnik (Giesen & Sirotnik, 1979; Sirotnik, 1979), and used for two highly regarded large-scale evaluations of school programs: A Study of Schooling (Goodlad, Sirotnik, & Overman, 1979) and Follow Through (Stallings, 1975; Stallings & Kaskowitz, 1974). The schemes included the physical environment inventory (PEI), daily summary (DS), classroom snapshot (CS), and five minute interaction (FMI). The schemes varied in method—once per classroom for the PEI and DS vs. time and sampling for the CS and FMI (at four times during the day, all pertinent activities [CS] or events [FMI] are coded). Data were collected for each scheme at different times of the day. The CS captured relations among *activities* (subject area as well as instructional activity, such as demonstration, discussion, work on written assignments), *directors* (teacher, aide, student, group, class, independent), and *group size*. The FMI entailed event recording of classroom interactions: persons involved (Who, Whom), interactions (What—Adult: e.g., direct questions, response, imperative, encouragement, monitor/observe; Student: e.g., directive, response, refusal, question), context (e.g., instruction, behavior, routines), and means (How—e.g., touching, with humor, with materials, negative affect).

These instruments were helpful guides to our own design
efforts. We particularly appreciated the potential flexibil-
ity of a scheme containing multiple dimensions that can be
cross-classified to produce a broad range of analyses.
However, the restriction on concurrent use of the four
schemes would limit our ability to describe as richly as
possible any given classroom activity. We wanted to know
what was happening at a *given* time to permit us to examine
relations among co-occurring aspects of classroom activities,
with particular focus on instruction associated with use of
technology resources. For example, if teachers were lectur-
ing, how was the class organized and what resources were in
use to support the lecture? When computers were in use, how
challenging were the students' tasks, how were they working
with the teacher and one another, and what proportion of them
were engaged in productive interaction? If students were
composing long texts or projects, what resources were they
using to support their work, and what symbol systems were in
use?

Our Tool

We developed a versatile, technology-based observation
tool that could serve our needs for research and evaluation.
The tool also gives education professionals an easily learned
observation method that permits rapid analysis and display of
results. In the observation scheme that resulted, instruc-
tional activities are the central organizing blocks. The

emphasis of the scheme is on capturing the nature of instruc-
tional tasks, the roles of teachers, the nature of social
relationships, the variety of resources, and the responses of
students. The instrument's breadth of coverage is coordi-
nated with qualitative techniques for collecting fine-grained
descriptions of instructional content and process.

The instrument uses a time-sampling procedure to mini-
mize rater bias, which is likely to be greater if raters
sample "events" (since events are difficult to define when so
many instructional characteristics are coded), or if raters
make summary judgments over an entire class period. The
observation form is therefore organized for recording in
timed intervals. The form is machine scannable, which
permits instant updating and rapid analysis of the resulting
database.

Observers code[3] (a) a few key *indexing variables* once for
the activity period to be observed (subject area, number of
students assigned, classroom organization), and (b) a set of
activity descriptors on a time sampling schedule throughout
the period. The following are the indexing variables:

- *Subject Area* (one set for elementary and another set for
  secondary level)
- *Number of Students Assigned* to the observed activity

The activity descriptors are then coded once during each
5-minute (elementary) or 10-minute (secondary) interval.

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[3] A coding manual is available from the authors.

During an observation period, our coders observe for 1 minute
at the start of each 5- or 10-minute interval; they then
code just what occurred within that prior minute and use any
remaining time to record field notes. The activity descrip-
tors include:

Classroom Organization: teacher-led, independent work,
    group/cooperative, group/collaborative (jointly
    produced product), pair/cooperative,
    pair/collaborative, pair/tutoring, student-led

Adult Roles :

Directing Instruction (codes that apply only to
    teacher-led classroom organizations):
    explain/provide information, question (for compre-
    hension or examination), answer students' questions,
    direct students' work (step by step), correct/grade,
    test, read to students

Facilitating Instruction (codes that apply to indepen-
    dent, cooperative, and collaborative work): moni-
    tor/rove to help students at work, facilitate
    discussion, conference, joint problem-solve

Management and Discipline: manage, discipline

Not Present (with the group currently observed)

Symbol Systems serving key instructional functions in
    the material the teachers make available to students:
    verbal, numeric, math symbols, graphic, chart, diagram,
    pictorial, model, map, puzzle/pattern, motor/action,
    music, objects

- *Symbol Systems students use in their products*: verbal, numeric, math symbols, graphic, chart, diagram, pictorial, model, map, puzzle/pattern, motor/action, music, objects
- *Length of the Responses* expected of students: repeat/copy (student replicates provided material exactly—e.g. spelling practice, cursive practice, keyboarding drill), select (multiple choice, true/false), short (no more than a sentence in length), medium (no more than a paragraph in length), long (multi-paragraph)
- *Level of Processing* expected of students: low (emphasis on rote recall), medium (requiring inference or problem solution within a well-structured problem context), high (requiring inference and construction of a response in a less structured task context)
- *Resources in Use*

  Textual, including *textbooks* (textbooks, assigned literature, workbooks/worksheets, tests), *print resources* (library books, reference books, periodicals, reference/help sheets), *materials* (paper, file cards, blackboard), *student's own work*

  Hands-on materials

  Computer, including *instructional software* (electronic worksheet, simulation/strategy), and *applications* (word processing, HyperCard, graphics, database, spreadsheet, programming, telecommunications)

> *Other technology*: laserdisc, scanner, film/video,
>   slide/filmstrip, audio, robotics, class monitor,
>   overhead, MIDI, calculator
> •*Students' Responses to the Activities*:
>   *Appropriateness* of students' behavior
>   *Students'* focus and investment
>   *Productive* student-student interaction

Results of the time-sampled observations are scanned,
analyzed, and displayed in graphic or tabular formats on a
Mac II. Currently the resultant displays are catalogued for
flexible retrieval using a menu-driven interface. A goal is
to develop a user-friendly interface for real-time, on-line
queries.

Illustrative Uses

The instrument provides us with "snapshot" descriptions
of classroom instruction which can serve multiple research
and development functions. In this paper we illustrate two
of our current uses: documentation of commonly reported
changes in high access classrooms and model-driven descrip-
tions of change.

Documentation of Reported Changes in High Access Classrooms

There is a clear need for empirical documentation of
commonly reported changes in classroom practices in high
access environments. Researchers and educators have made
informal observations that computer use is associated with:

more challenging projects, less directed teaching and more teacher facilitation, more frequent group projects, more time on task, and more peer assistance (see, for example, Collins, in press; Hawkins & Sheingold, 1986). However, there is little empirical documentation of these changes.

Observations collected in 1989-90 have provided us with enough data to make clear the importance of careful investigation. Our analyses to date indicate certain associations between technology use and classroom activities that are consistent with informal reports. But some of our results are not consistent with what now appear to be overly general and overly romantic sketches of technology's impact. Our data suggest that the teachers make motivated choices about resources and pedagogical methods based on subject area; thus their classroom activities are not technology-driven in any simple way. Our findings serve to underscore the importance of documenting technology impact (a) within specific subject areas, (b) at particular levels of schooling (e.g., elementary vs. secondary), and (c) for specific uses of technology.

We illustrate our analyses of associations between technology use and classroom instruction with 1989-90 observations collected at our elementary site in language arts and in mathematics. The database included 144 5-minute intervals (12 hours) in language arts and 73 5-minute intervals (6.1 hours) in mathematics. These data represent a less than adequate sampling of teachers' instruction, although observations were made of activities that observers and teachers

agreed were representative of each teachers' instruction. We must stress the illustrative nature of our results.

The analysis strategy was based on a nested series of queries. We defined a set of resource contexts, beginning with a simple distinction between those where the computer was in use and those where it was not, and compared instructional patterns in those two contexts. We then made further refinements as questions for analysis emerged; for example, how did instruction differ when computers were used for applications (such as word processing) versus instructional software? Most analyses of instructional patterns were based on aggregations of individual codes.[4] For example, when we examined instruction and support roles we created two summary categories: *Directing Instruction* and *Facilitating Instruction*, representing the use of any of the roles in those two categories respectively.

Illustrative results: Language Arts and mathematics at one elementary site.

The results for language arts were most consistent with informal reports of instructional patterns in high access contexts. In language arts, computers were in use a bit less than 20% of the time (Figure 1), and uses were always for applications rather than for delivery of instructional software. Consistent with informal observations of classroom

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[4] Descriptions of procedures for aggregation are available from the authors.

Computer Use by Subject - Language Arts

Percentage of intervals in which each variable was observed

Legend

■ Language Arts

On On Computers
In Instructional Software
Ap Applications
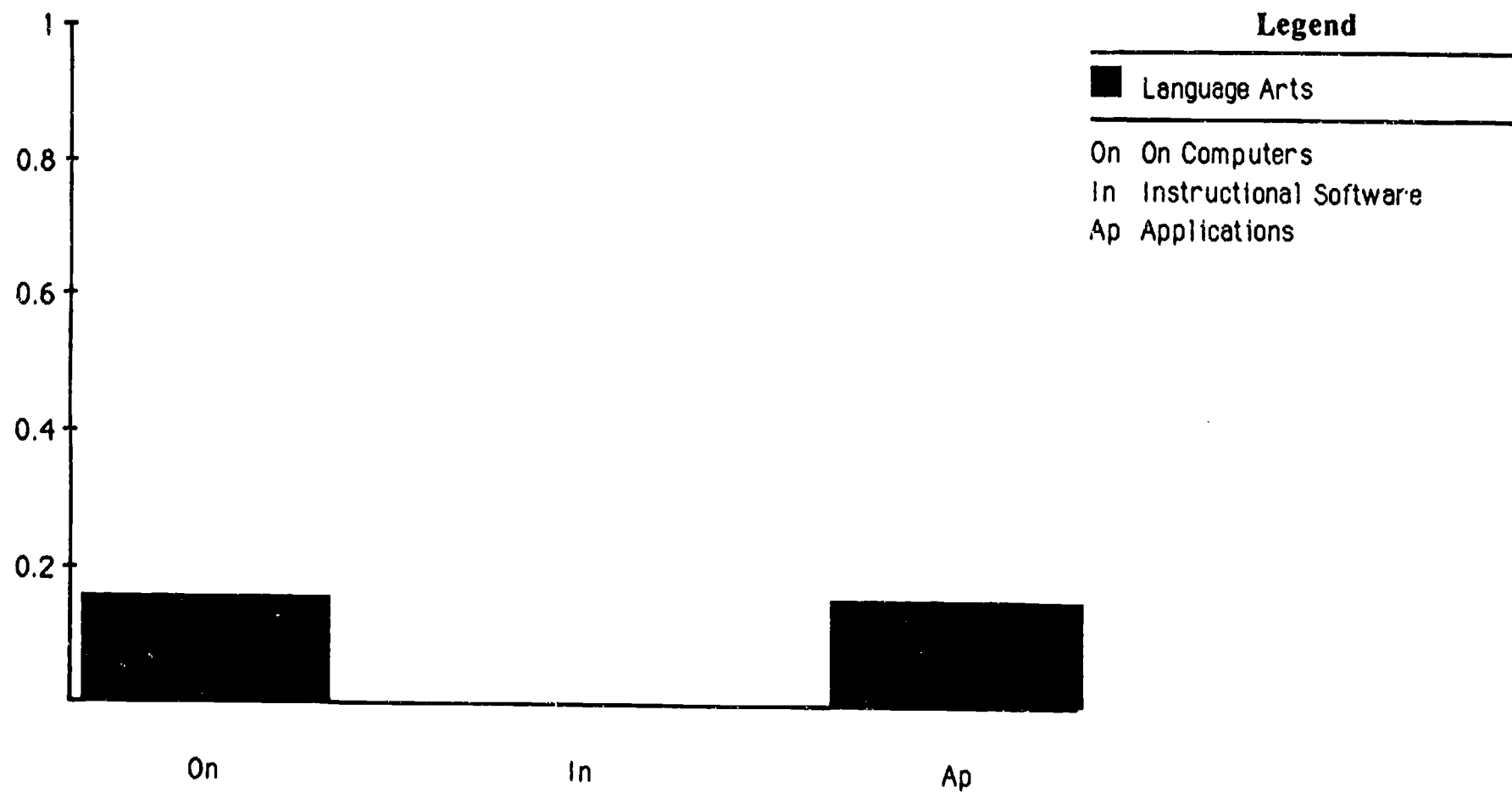
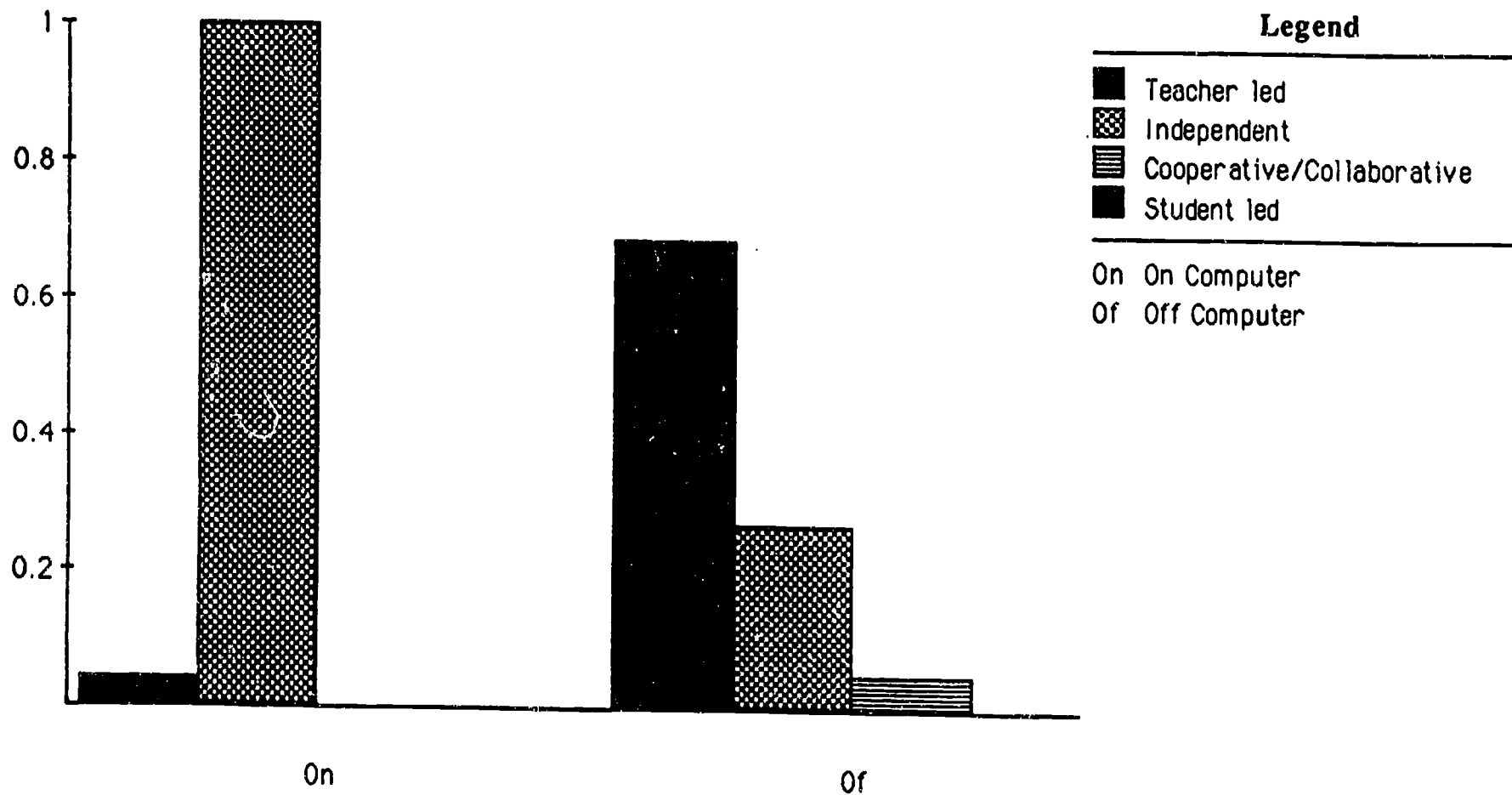### Illustrative Findings
Monday June 02, 1990 4:13.20 PM

Figure 1

17

16

organizations and teacher roles during student computer work, use of applications—primarily word processing—was associated with independent student work rather than teacher-led work (Figure 2), and with a role for teachers as facilitator of students' work rather than as director and deliverer of information (Figure 3).

In mathematics, while computers were observed in use slightly more frequently (32%) than in language arts (Figure 4), the more striking difference was in type of use. Computers were used most often for instructional software rather than for applications. While we found relationships between computer use and classroom organization (Figure 5) and teacher role (Figure 6) that were similar to language arts, the similarity to language arts did not hold when we examined particular computer uses. When we compared use of instructional software to use of applications in mathematics, students were more likely to be working independently or cooperatively (rather than under the direction of the teacher), and teachers were more likely to be facilitating (rather than directing) students' work only when students were using instructional software (Figures 7 and 8). The small number of observations of application use limits infer-ence, but the difference in instructional software versus application use does make clear the importance of examining instructional patterns in terms of the specific functions that technology serves within instruction of particular subject areas.

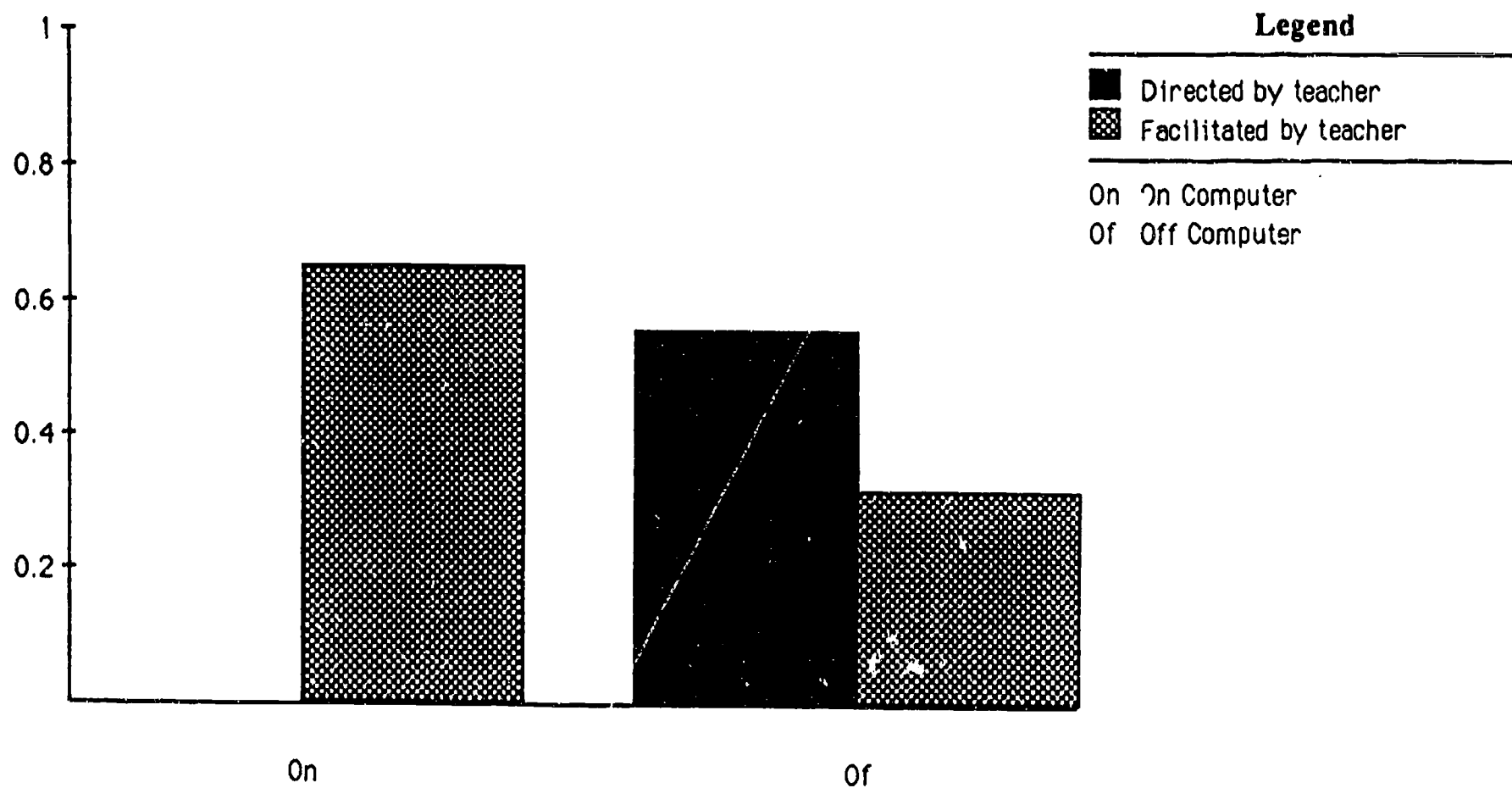# Classroom Organization Across Resource Contexts - Language Arts

Percentage of intervals within each resource context that each variable was observed

Legend

- ■ Teacher led
- ▨ Independent
- ▤ Cooperative/Collaborative
- ■ Student led

On On Computer
Of Off Computer

Illustrative Findings
Monday June 02, 1990 4:13.28 PM
Figure 2

19

20

Adult Role Across Resource Contexts -- Language Arts

Percentage of intervals within each resource context that each variable was observed
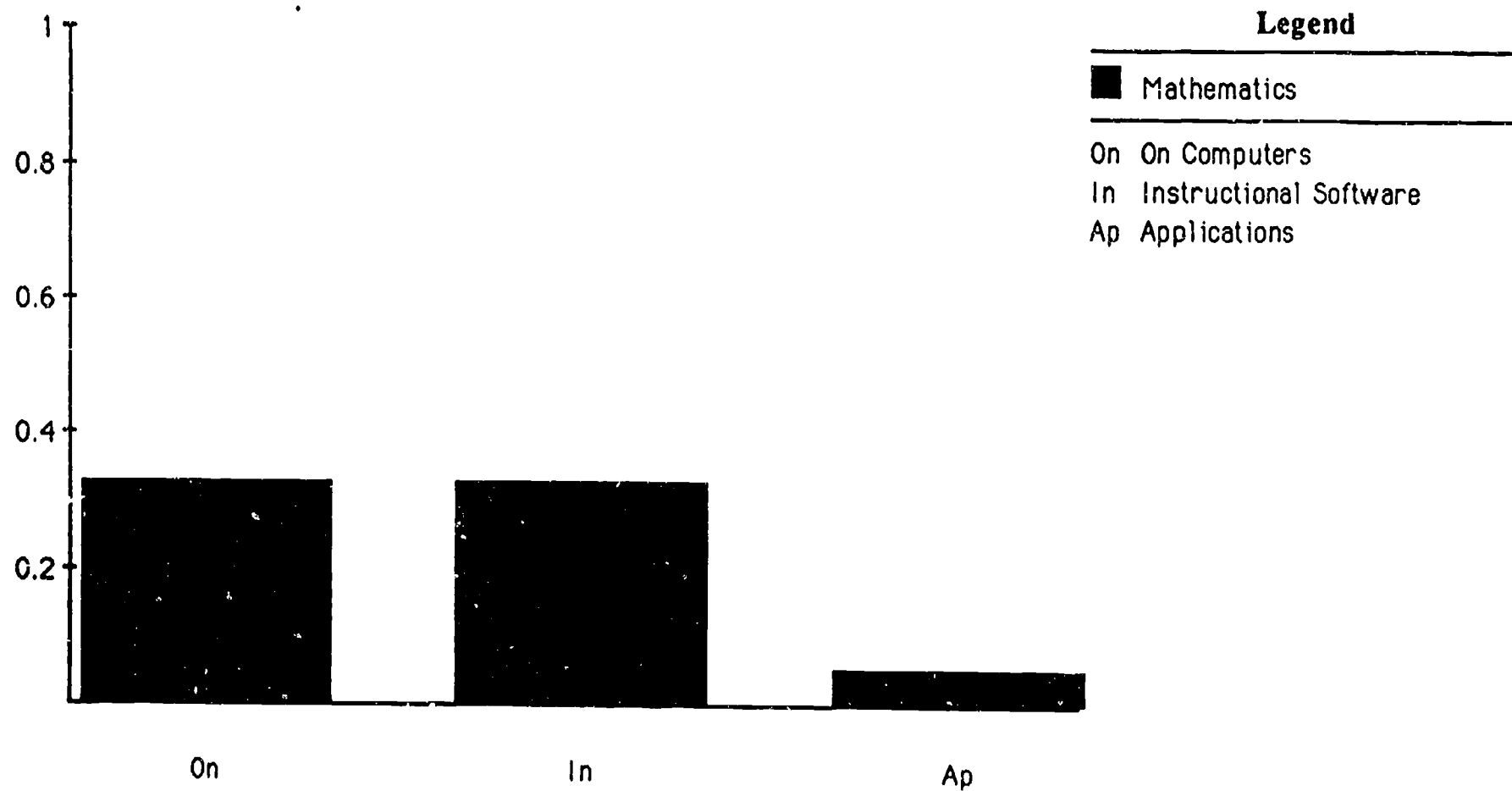

Illustrative Findings
Tuesday June 03, 1990 8:19.46 AM
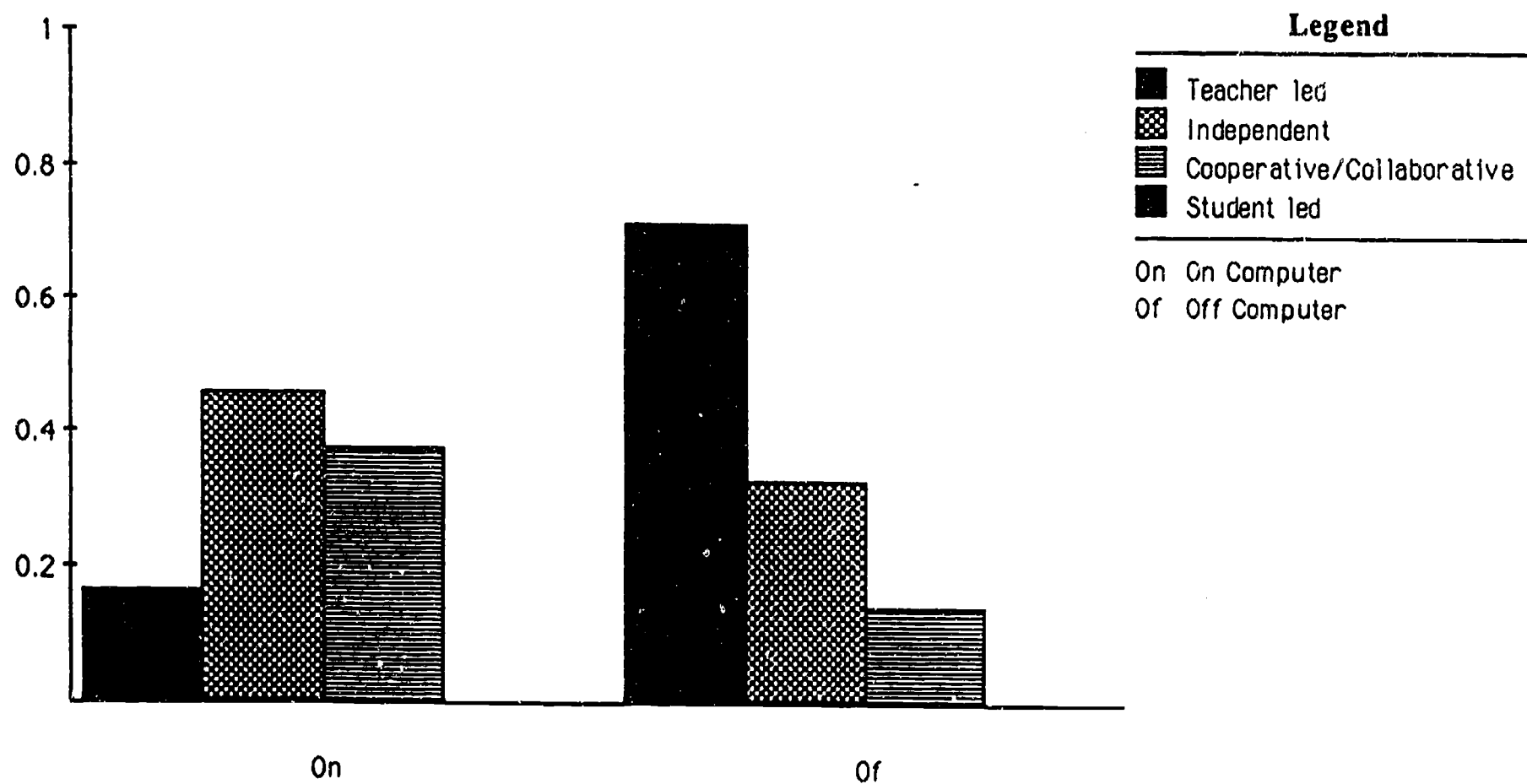Figure 3

Computer Use by Subject - Mathematics

Percentage of intervals in which each variable was observed

Legend

■ Mathematics

On On Computers
In Instructional Software
Ap Applications

Illustrative Findings
Monday June 02, 1990 4:13.24 PM
Figure 4

23

2.4

Classroom Organization Across Resource Contexts - Mathematics

Percentage of intervals within each resource context that each variable was observed

Legend

- Teacher led
- Independent
- Cooperative/Collaborative
- Student led

On On Computer
Of Off Computer

Illustrative Findings
Thursday June 05, 1990 8:46.25 AM
Figure 5

25

26

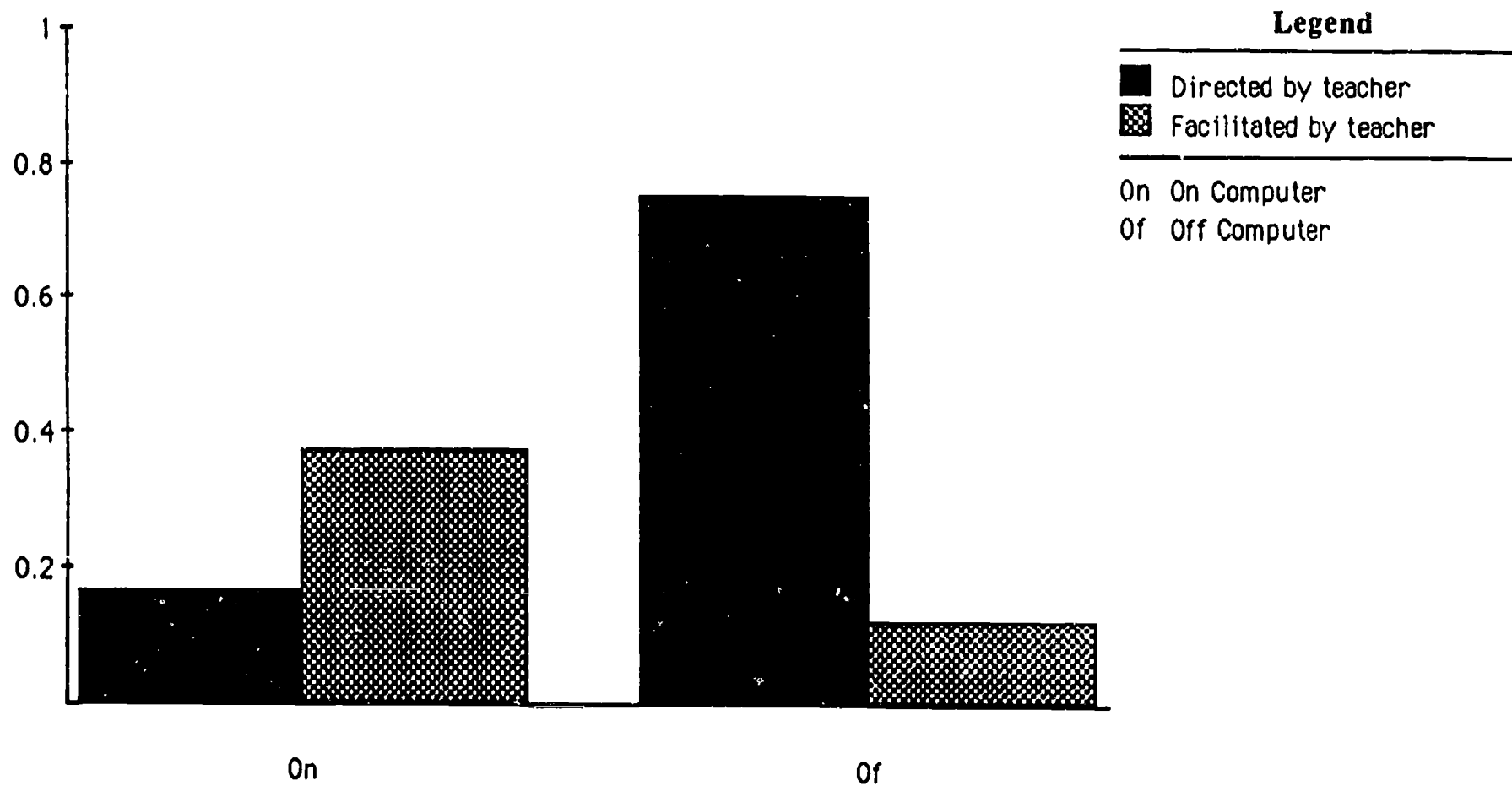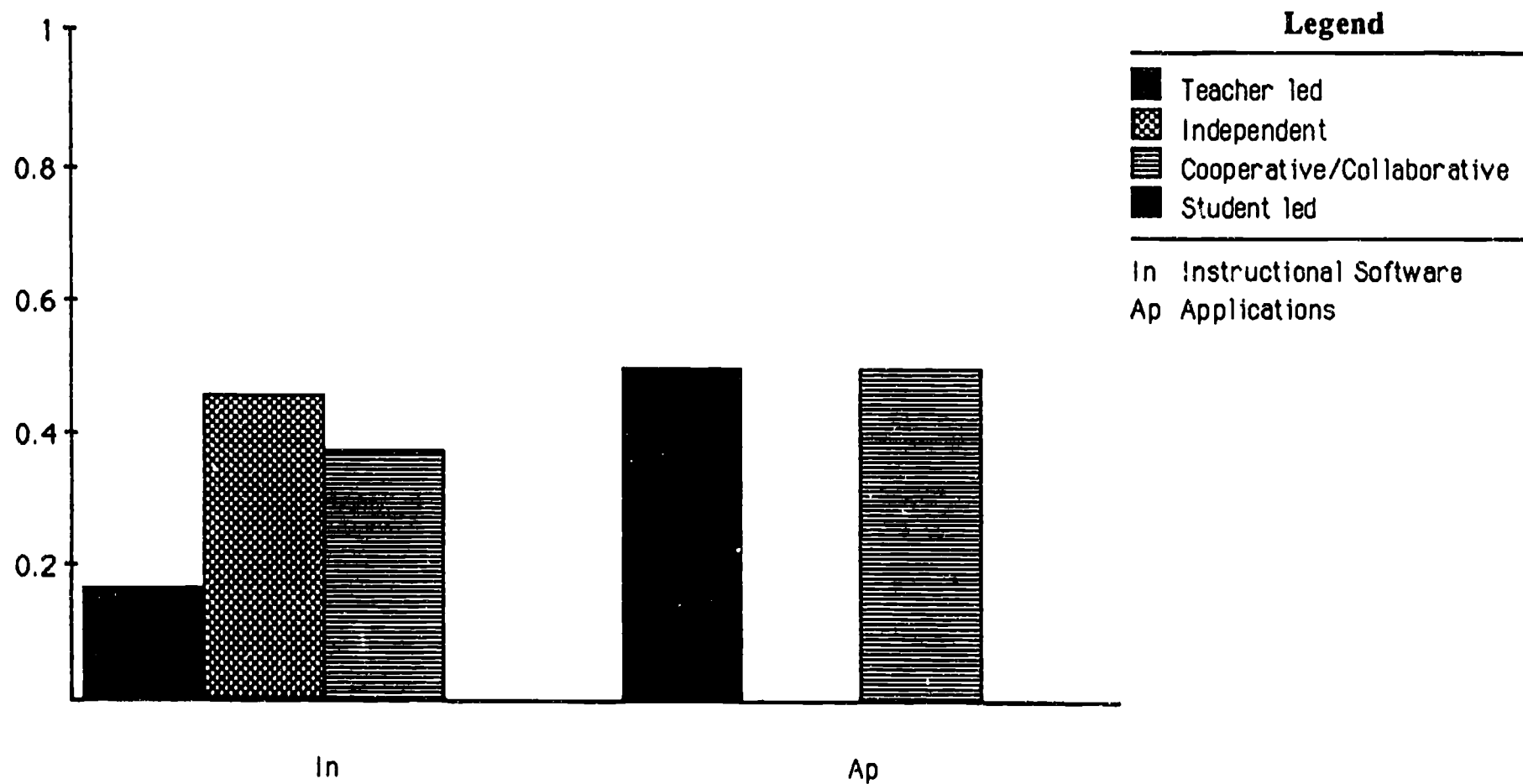# Adult Role Across Resource Contexts -- Mathematics

Percentage of intervals within each resource context that each variable was observed

Illustrative Findings
Thursday June 05, 1990 8:53.02 AM
Figure 6

27

28

Classroom Organization Across Resource Contexts - Mathematics

Percentage of intervals within each resource context that each variable was observed
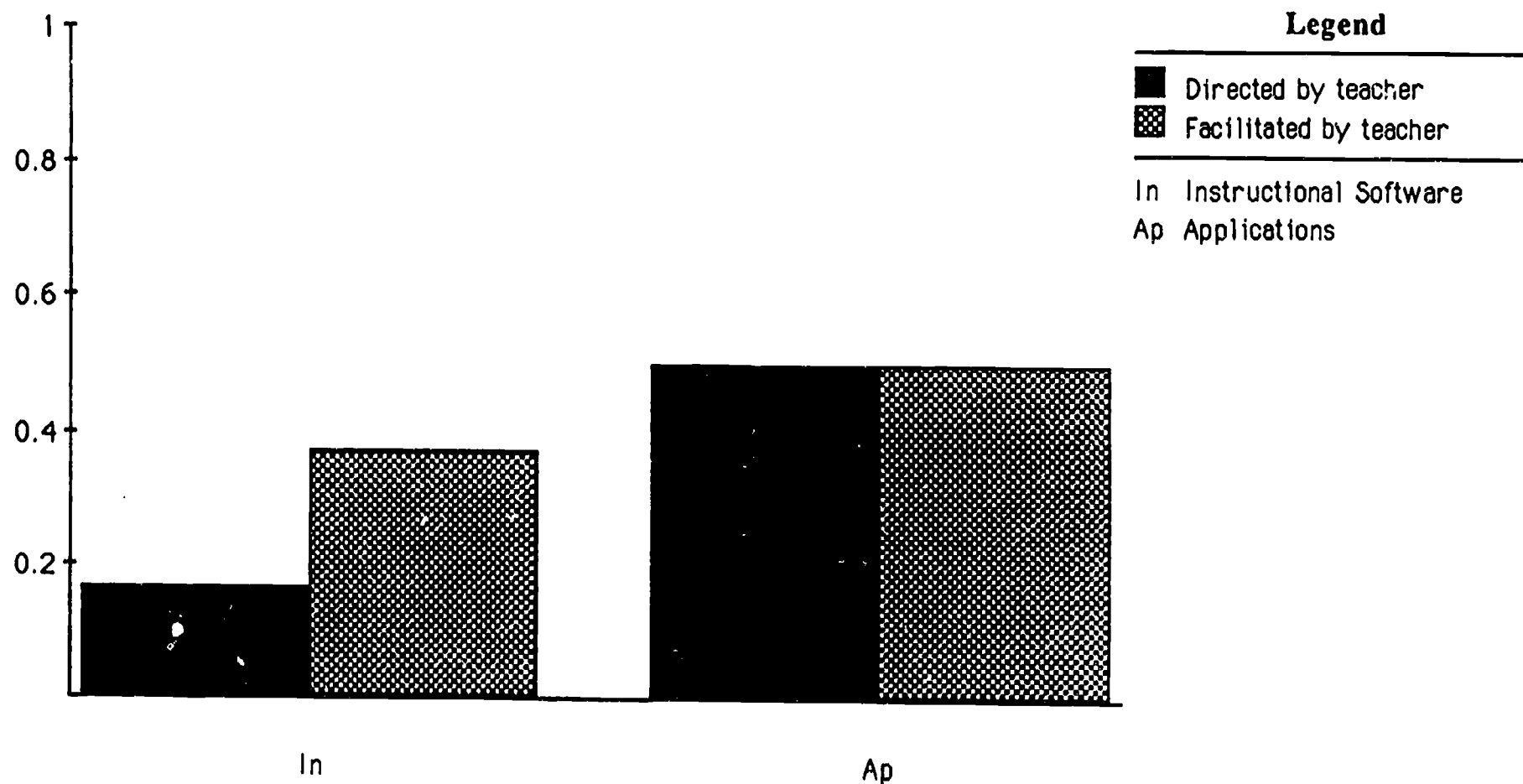

Legend

- Teacher led
- Independent
- Cooperative/Collaborative
- Student led

In Instructional Software
Ap Applications

Illustrative Findings
Thursday June 05, 1990 8:46.57 AM
Figure 7

29

30

Adult Role Across Resource Contexts -- Mathematics

Percentage of intervals within each resource context that each variable was observed

Illustrative Findings
Thursday June 05, 1990 8:53.25 AM
Figure 8

32

31

Reports that technology use supports more challenging student work were supported only by our pilot data for language arts: When computers were in use (when students were using word processing for writing), tasks were somewhat more challenging (Figure 9) and longer in length (Figure 10). In contrast, mathematics tasks were somewhat less challenging (Figure 11) and shorter in length (Figure 12) on computer; students were using instructional software to practice basic mathematics skills.

In summary, instructional patterns observed in these high access classrooms differed both by subject area and by the nature of computer use.

Model-Driven Descriptions of Instructional Change

Our instrument is designed to provide documentation of instructional practices associated with technology use and changes in instructional practices over time. The value of the descriptions we produce is markedly enhanced when descriptions are guided by a model of instructional change. If patterns change over time as predicted by a model, our results provide validation for the model; if patterns are inconsistent with a model of change, our results suggest needed revisions in the model.

In this section, our examples illustrate an approach we are taking to model-driven methods of data analysis. We have drawn from two frameworks to help us articulate our expectations for instructional impact of high technology access.

Level of Processing Across Resource Contexts - Language Arts

Percentage of intervals within each resource context that each variable was observed

Legend

■ Low
▨ Medium
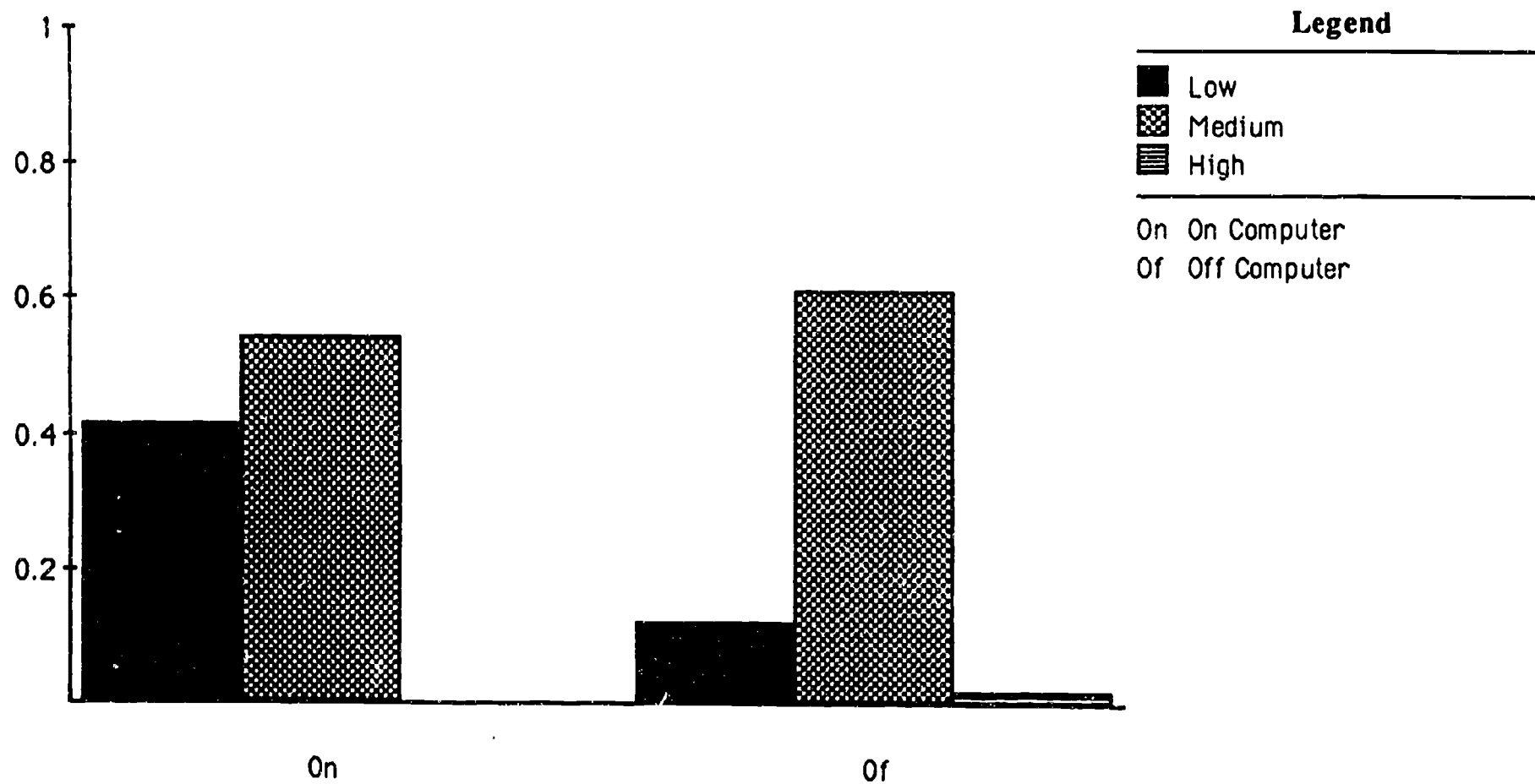☰ High

On On Computer
Of Off Computer
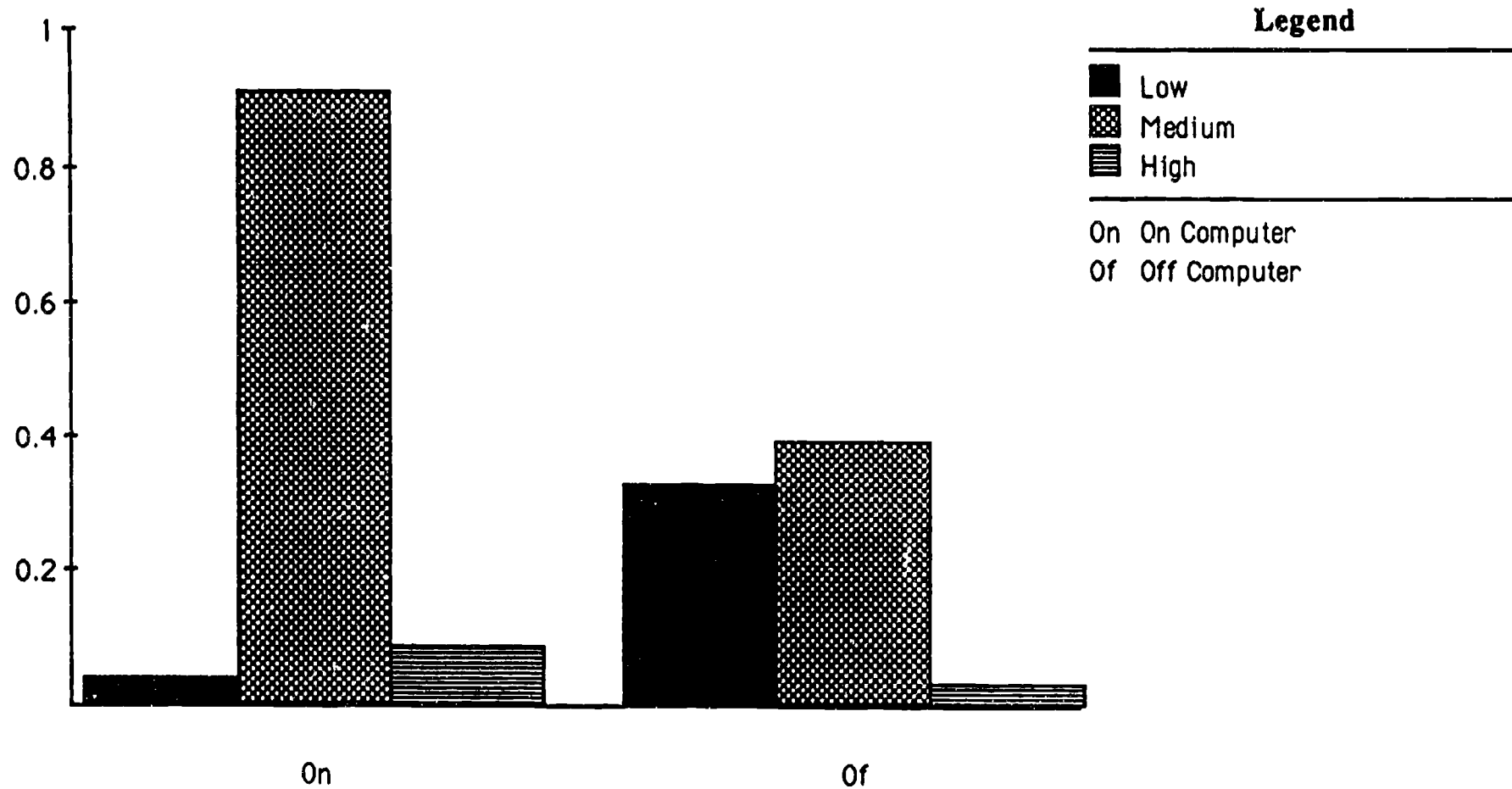
Illustrative Findings
Tuesday June 03, 1990 8:59.31 AM
Figure 9

35

34

Level of Processing Across Resource Contexts - Mathematics
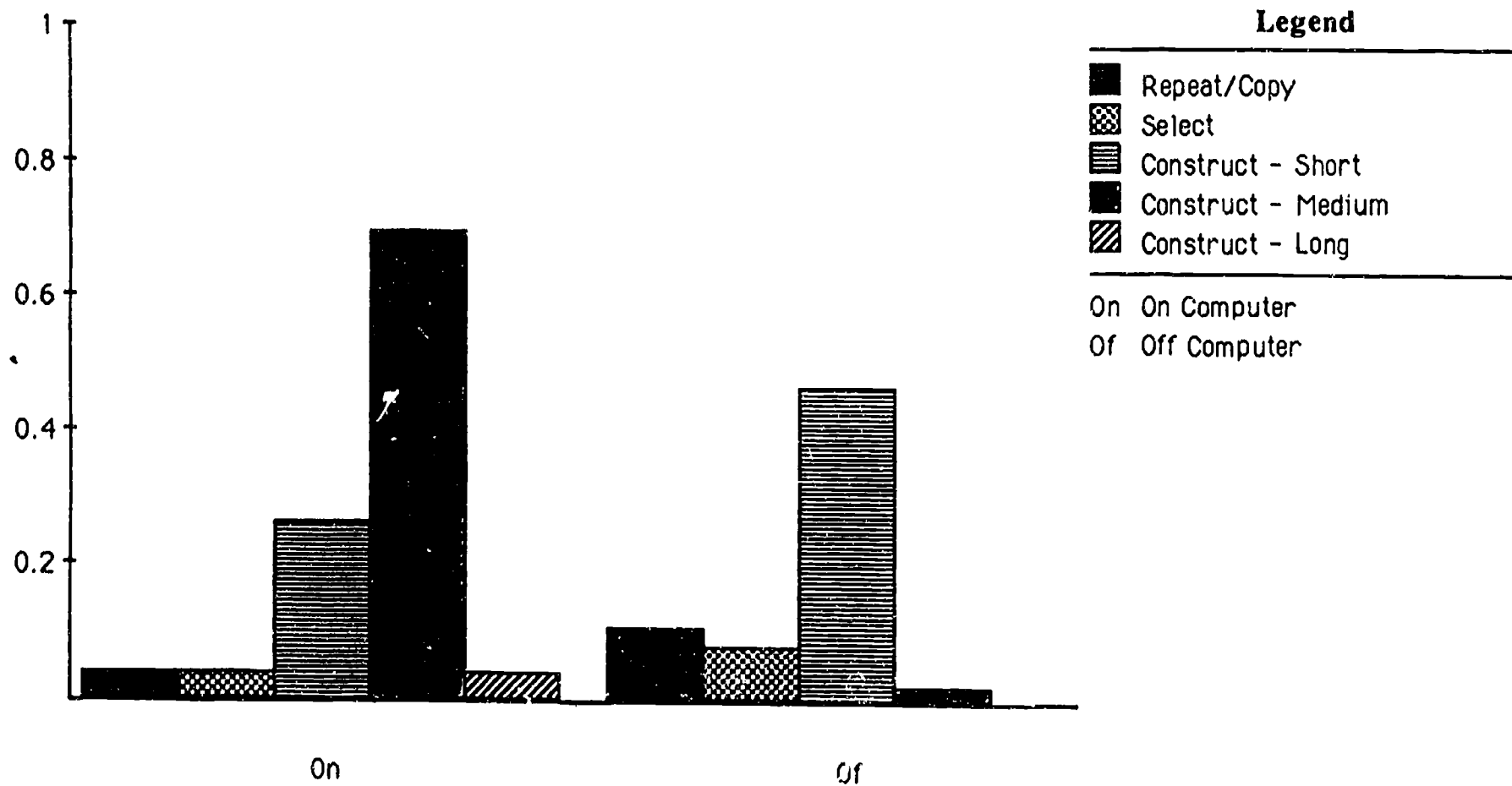
Percentage of intervals within each resource context that each variable was observed

Illustrative Findings
Thursday June 05, 1990 9:05.52 AM
Figure 10

Product Item Length Across Resource Contexts - Language Arts

Percentage of intervals within each resource context that each variable was observed

Legend

- Repeat/Copy
- Select
- Construct – Short
- Construct – Medium
- Construct – Long

On   On Computer
Of   Off Computer

Illustrative Findings
Tuesday June 03, 1990 9:04.27 AM
Figure 11

Product Item Length Across Resource Contexts - Mathematics

Percentage of intervals within each resource context that each variable was observed

Legend

- ■ Repeat/Copy
- ▨ Select
- ▤ Construct – Short
- ■ Construct – Medium
- ▨ Construct – Long

On On Computer
Of Off Computer
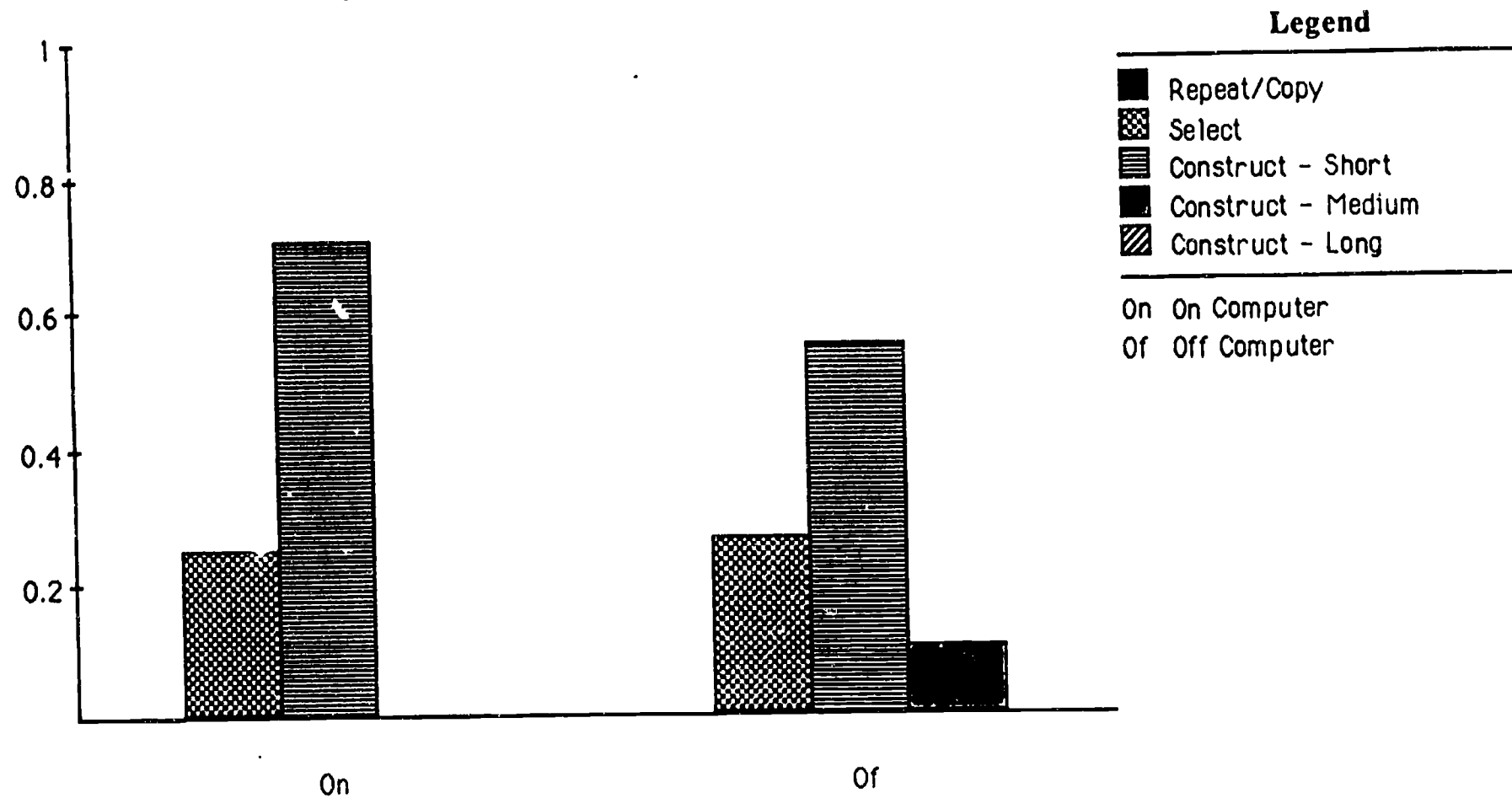
Illustrative Findings
Thursday June 05, 1990 9:06.58 AM
Figure 12

4()

41

Toward a model of instructional change: Two key frame-
works. David Dwyer, Cathy Ringstaff, and Judy Sandholz
(Dwyer, Ringstaff, & Sandholz, 1990) have proposed a model of
ACOT teacher change based on analyses of ACOT teachers' regu-
larly dictated audiotape records of their ACOT experience.
Dwyer and his colleagues propose a five-phase process of
instructional change:

- **Entry**: the technology is implemented and a team of
  teachers selected
- **Adoption**: basic instructional patterns are main-
  tained, with technology support for drill, practice,
  and word processing
- **Adaptation**: teachers find that their instructional
  program is completed more rapidly and efficiently,
  freeing time for exploration of new curricula and
  pedagogy
- **Appropriation**: computer expertise enables experimen-
  tation
- **Invention**: teachers invent and implement fundamen-
  tally new forms of learning and teaching

These phases of instructional change can be interpreted
as phases in which "technology push" leads to a succession of
newly emerging instructional goals (cf. Baker, 1988). The
phase descriptions do not point consistently to particular
causes or contexts of change, however. For example,
"efficiency" is cited in the transition from adoption to
adaptation, but it is not clear how teachers recognize it or

choose then to depart from traditional practices. Nor is a
particular model of "new forms of learning and teaching"
proposed.

To provide that model—and thus a model for the final
"invention" phase in Dwyer et al.'s (1990) framework—we have
adapted the analysis of "inquiry environments" proposed by
Marlene Scardamalia and Carl Bereiter (Scardamalia &
Bereiter, in press; Scardamalia, Bereiter, McLean, Swallow,
& Woodruff, 1989). In their analysis of visionary, technol-
ogy-supported instructional environments, technology is a
valued resource that can support (a) "learning goals" rather
than "task goals" and, (b) depth and breadth of knowledge
construction among students and teachers rather than simply
information delivery and retention. Adapting the constructs
contained in our observation instrument (Table 1), we charac-
terized activities in these classrooms as follows. Projects
are organized across disciplines which share corresponding or
interconnected core concepts. Resources permit active
construction of understandings via multiple and flexible
representations of content. Students' work requires consid-
erable initiative and construction of understandings;
students' compositions are often lengthy. Learners use a
variety of resources among themselves and the help of
supportive adults. Students are often working cooperatively
and teachers are often facilitating rather than delivering or
directing instruction.

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Table 1. Observation categories applied to final Invention phase in Dwyer et al.'s model (1990)

OBSERVATION	INVENTION learning as Inquiry knowledge-building community
Subject areas	Integrated Interdisciplinary
Resources	Multimedia Interactive Multi-representational
Task characteristics	Technology-supported activities requiring considerable student planning, inference, integration, application, and construction
Classroom organization	Common use of technology-supported cooperation and collaboration
Instruction and support roles	Common uses of a range of facilitating roles, including conferencing and joint problem-solving Use of supportive telecommunications

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How might our instrument provide descriptions of instruction that could validate—or suggest revisions—in Dwyer et al.'s phases of instructional change? Table 2 is an outline of instructional characteristics that can be documented with our instrument and that fit three illustrative phases of Dwyer's model, including a Scardamalia & Bereiter-like interpretation of Dwyer's "invention" phase.

Illustrative results. Comparisons between language arts instruction at our elementary site and English instruction at our secondary site illustrate how inferences can be made regarding the "fit" of our observations to various stages. The database consisted of 145 5-minute intervals at the elementary level (12 hours) and 45 10-minute intervals at the secondary level (7.5 hours). Again we must stress that the results represent illustrations of approaches to analysis, not results that we necessarily expect to remain with more extensive data collection. The patterns we found suggested an association between school level and degree of instructional innovation. Compared with the secondary teachers, the elementary level teachers in our samples appeared to be considerably further from the visionary model of inventive, instructional inquiry environments sketched above.

Subject area. At the elementary school level, only one core subject—science—was ever double-coded with language arts. Field notes indicate that students were engaged in science writing (Figure 13). In contrast, at the secondary

Table 2. Observation categories applied to three proposed phases of instructional change
(Dwyer et al., 1990)

OBSERVATION	Proposed phases of instructional change		
	ADOPTION traditional instruction instructional software word processing	APPROPRIATION computer exper- tise enables exper- imentation with curriculum and pedagogy	INVENTION learning as inquiry knowledge- building community
Subject areas	Isolated	Experiments in technology-supported integration	Integrated Interdisciplinary

Resources	Traditional/texts
	Instructional software
	Word processing
		Declining reliance on
		  texts and
		  instructional software
		Word processing
		Experiments in
		  multiple media and
		  representations
			Multimedia
			Interactive
			Multi-representational

Task
characteristics
	Structured =
	Basic skills,inference
	in well structured con-
	texts, brief answers
		Structured
		Experiments with
		  some technology-
		  supported activities
		  requiring higher-level
		  reasoning and
		  student construction
			Technology-supported
			activities requiring
			considerable student
			planning, inference,
			integration, application,
			and construction

Classroom
organization
	Teacher-led
	Independent
		Teacher-led
		Independent
		Experiments
		  in cooperation and
		  collaboration (some
		  technology-
		  supported)
			Common use of
			  technology-
			  supported
			  cooperation and
			  collaboration

Instruction and
support roles
	Directing
	Facilitating
		Directing
		Facilitating, with
		  experiments in
		  specific techniques
		  such as conferencing
			Common uses of a
			range of facilitating
			roles, including
			conferencing and joint
			problem-solving
			Use of supportive
			telecommunications

46

Double-coding With Language Arts Within Each Subject Area - Elementary Level

Percentage of periods in which Language Arts was double-coded with each subject

Legend

■ Percentage

Ma Mathematics
Sc Science
So Social Studies
Mu Music
Ar Art
Pr Problem Solving
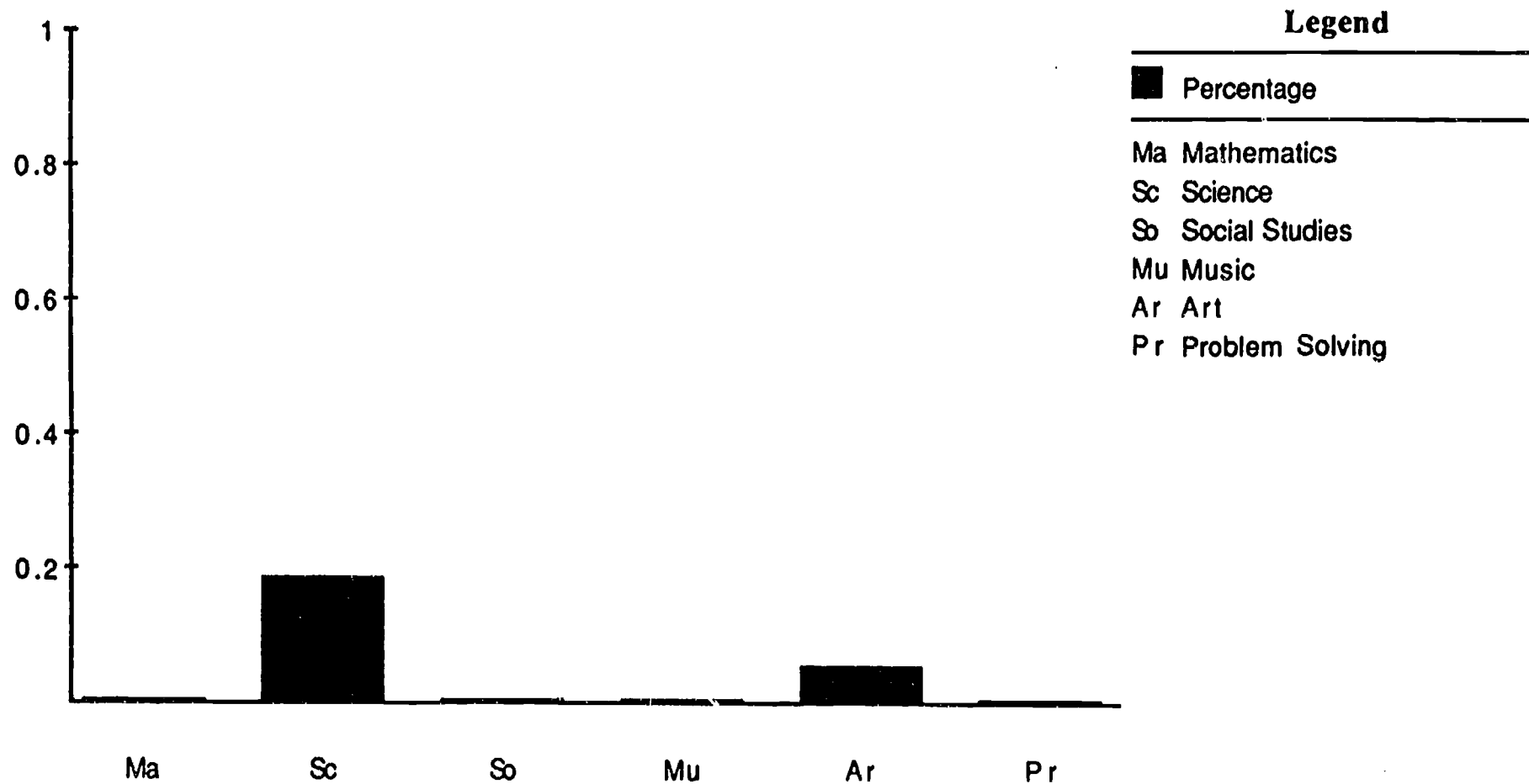
Illustrative Findings
Wednesday September 05, 1990 11:02.12 AM
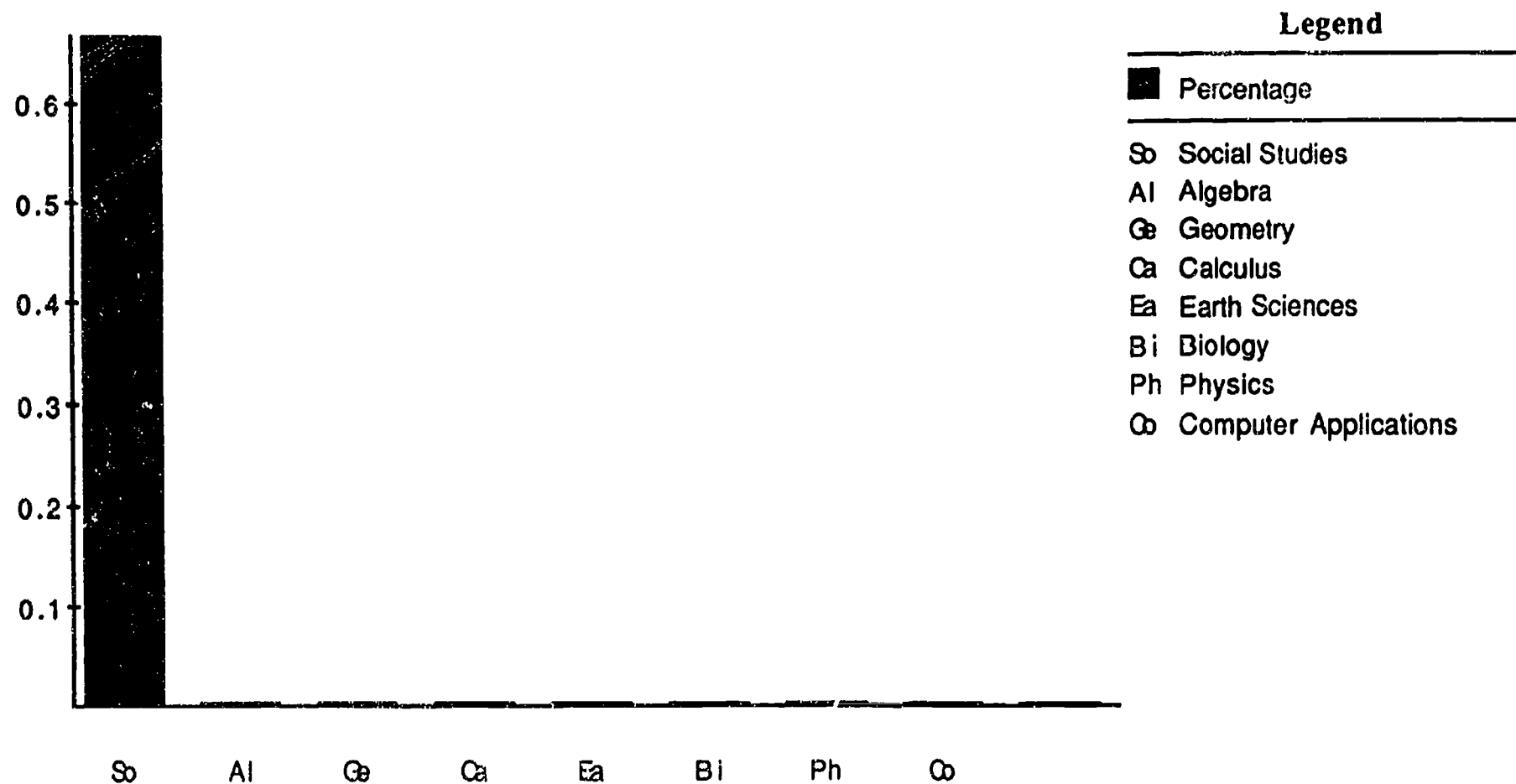Figure 13

47

48

site, English was judged as integrated with another subject—social studies—70% of the time (Figure 14).

Resources in use.   At the elementary level, the resources in use tended to be textual and not technological. Computers were in use slightly less than 20% of the time (Figure 15). Computer uses, however, were exclusively applications rather than instructional software; constructive writing tools—word processing—were the applications in use (Figure 16).   There were no observations of software providing other forms of representation (e.g., graphics) or multi-representational technologies such as laserdisc, video or audio (Figure 17).   Since children were in fact engaged in art and music activities associated with their language arts curriculum, our findings revealed that the teachers were not yet exploiting the potential of technology to support these same activities.

At the secondary site, the resources in use were also more often textual than technological. Computers were in use here about 35% of the time (Figure 18), again exclusively for applications rather than for presentation of instructional software.   There was some variety in type of applications—word processing, HyperCard, and graphics (Figure 19).   In addition, occasional use of interfacing multi-representational technologies was noted—audio and scanners (Figure 20). Thus at the secondary site we did observe some technology-based tools for multi-representational activities.

Double-coding With English Within Each Subject Area - Secondary Level

Percentage of periods in which English was double-coded with each subject
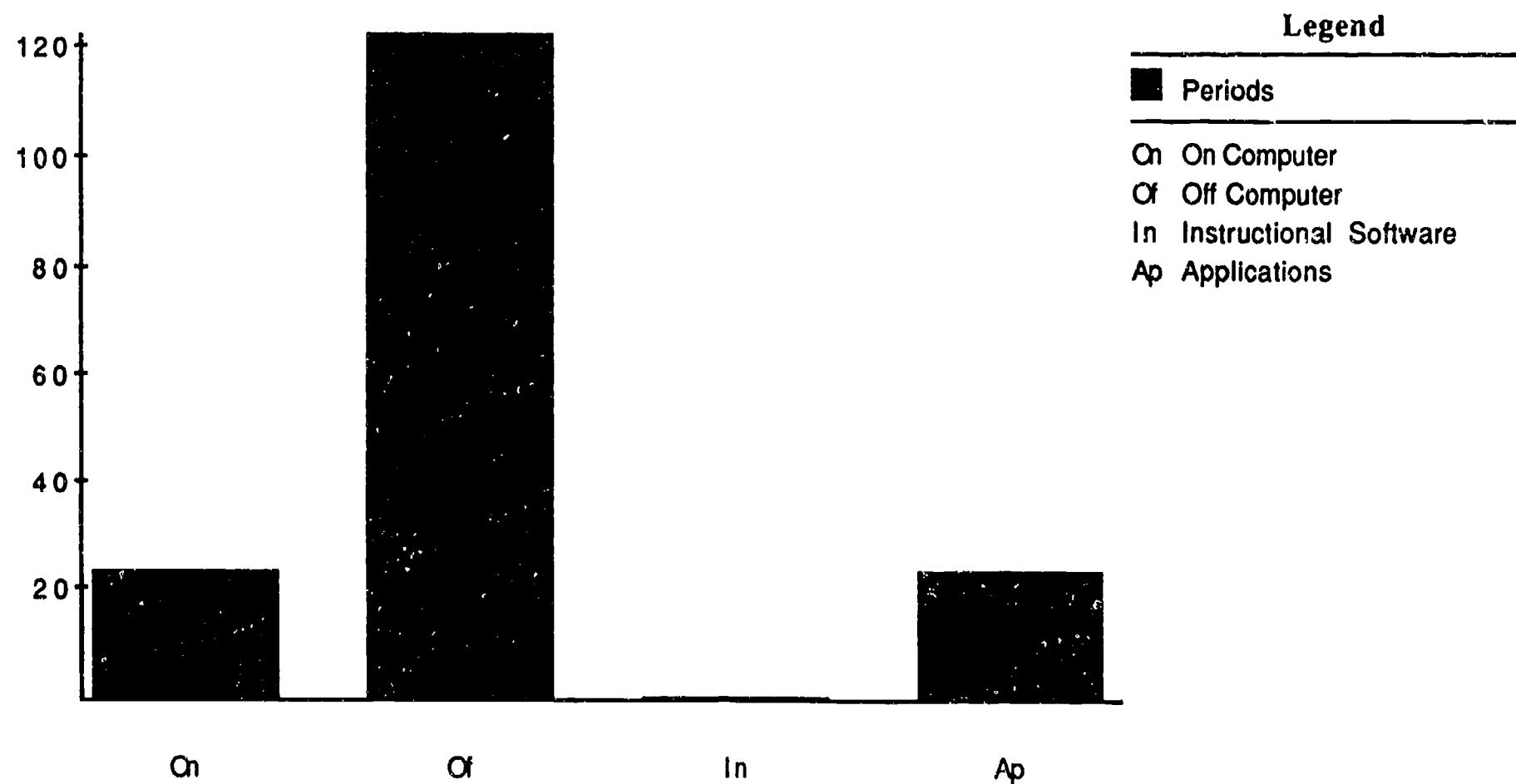

Legend

■	Percentage

So	Social Studies
Al	Algebra
Ge	Geometry
Ca	Calculus
Ea	Earth Sciences
Bi	Biology
Ph	Physics
Co	Computer Applications

Illustrative Findings
Tuesday September 04, 1990 1:48.44 PM
Figure 14

50

51

Number of Intervals Observed Within Each Resource Context - Elementary Level

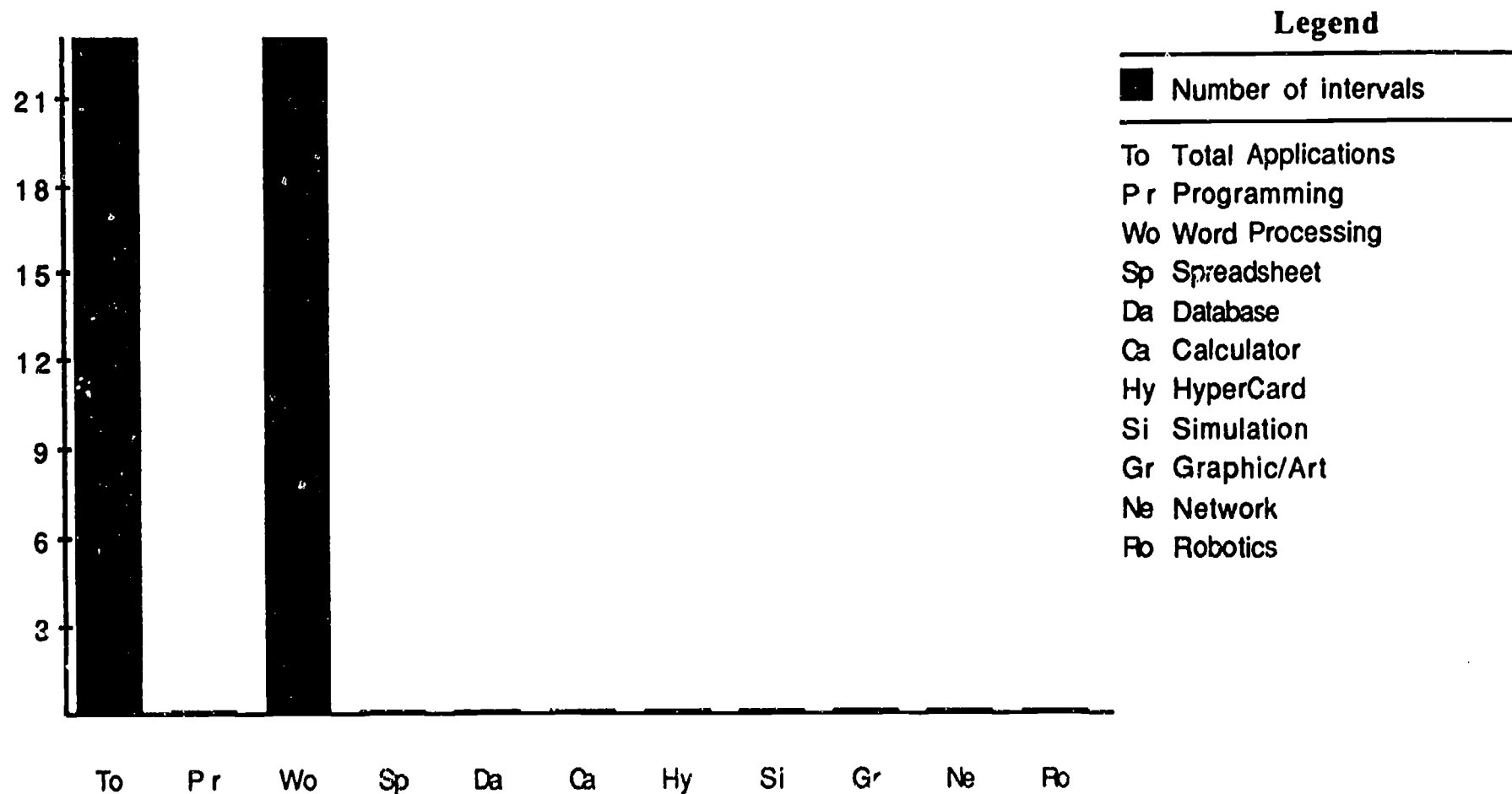Count of intervals in each context

Illustrative Findings
Tuesday September 04, 1990 1:24.27 PM
Figure 15

52

53

Number of Intervals in which Computer Applications were Observed - Elementary Level

Total number of intervals observed and number of intervals in which each application was observed


Legend

■ Number of intervals

To Total Applications
Pr Programming
Wo Word Processing
Sp Spreadsheet
Da Database
Ca Calculator
Hy HyperCard
Si Simulation
Gr Graphic/Art
Ne Network
Ro Robotics

Illustrative Findings
Wednesday September 05, 1990 11:17.55 AM
Figure 16

54

55

Percentage of Intervals in which HyperMedia were Observed - Elementary Level

Percentages of total intervals in which computer applications were observed with other technologies
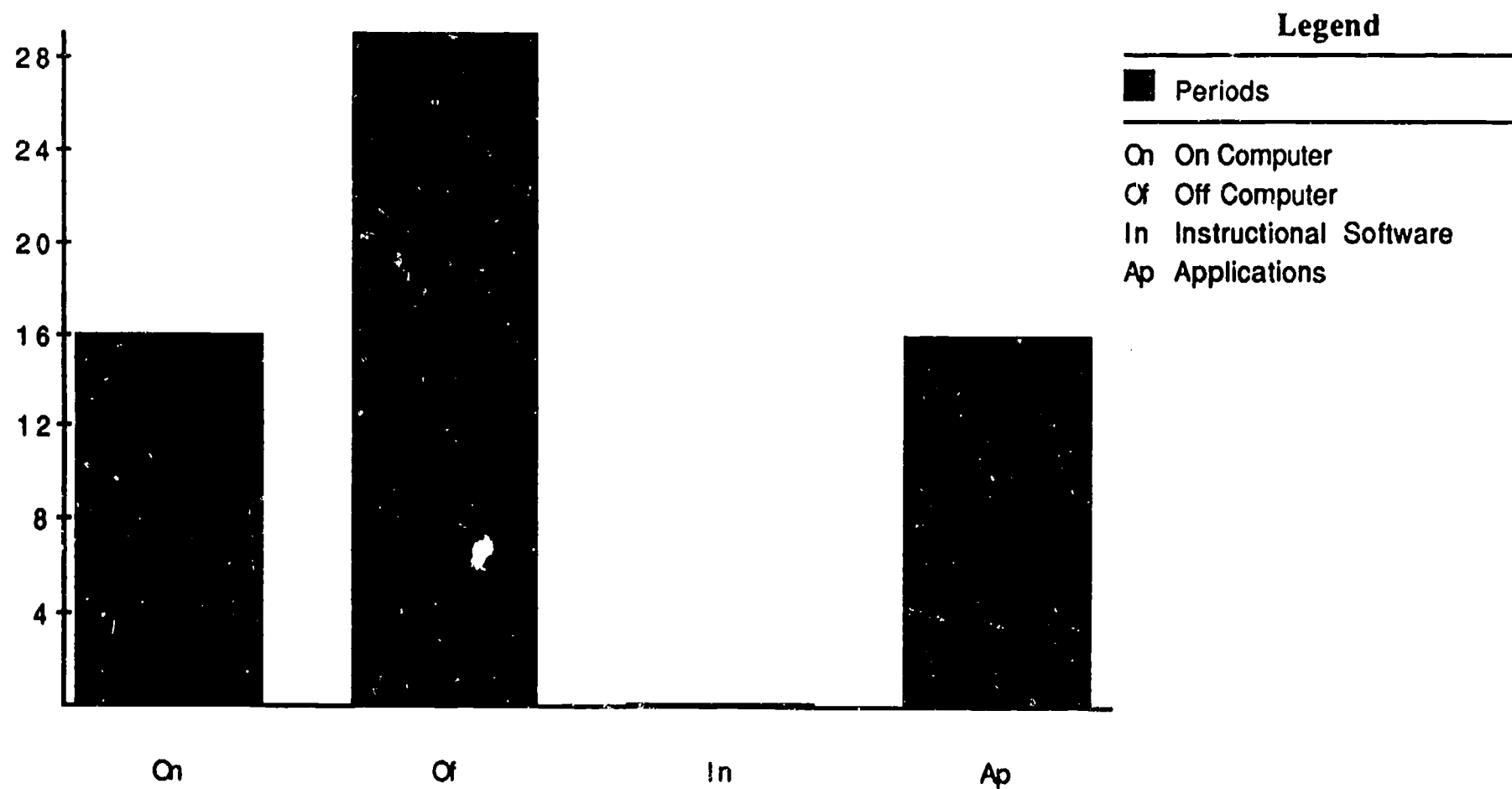

Legend	
■	Percent
La	LaserDisc
Vi	Video
Au	Audio
Sc	Scanner
Mi	Midi Interface
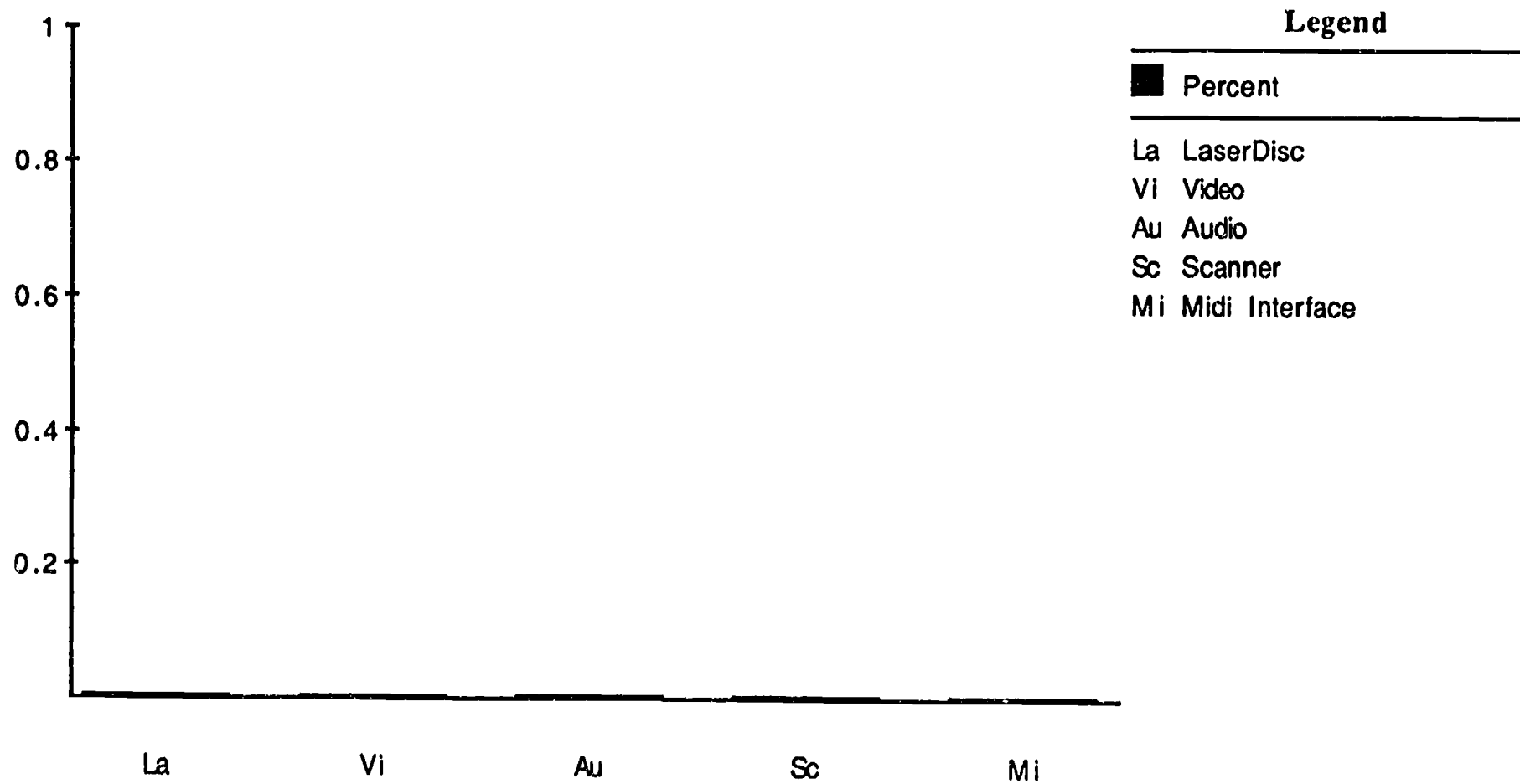
Illustrative Findings
Tuesday September 04, 1990 1:20.48 PM
Figure 17

56

57

Number of Intervals Observed Within Each Resource Context - Secondary Level

Count of intervals in each context

Legend

- ■ Periods

On On Computer
Of Off Computer
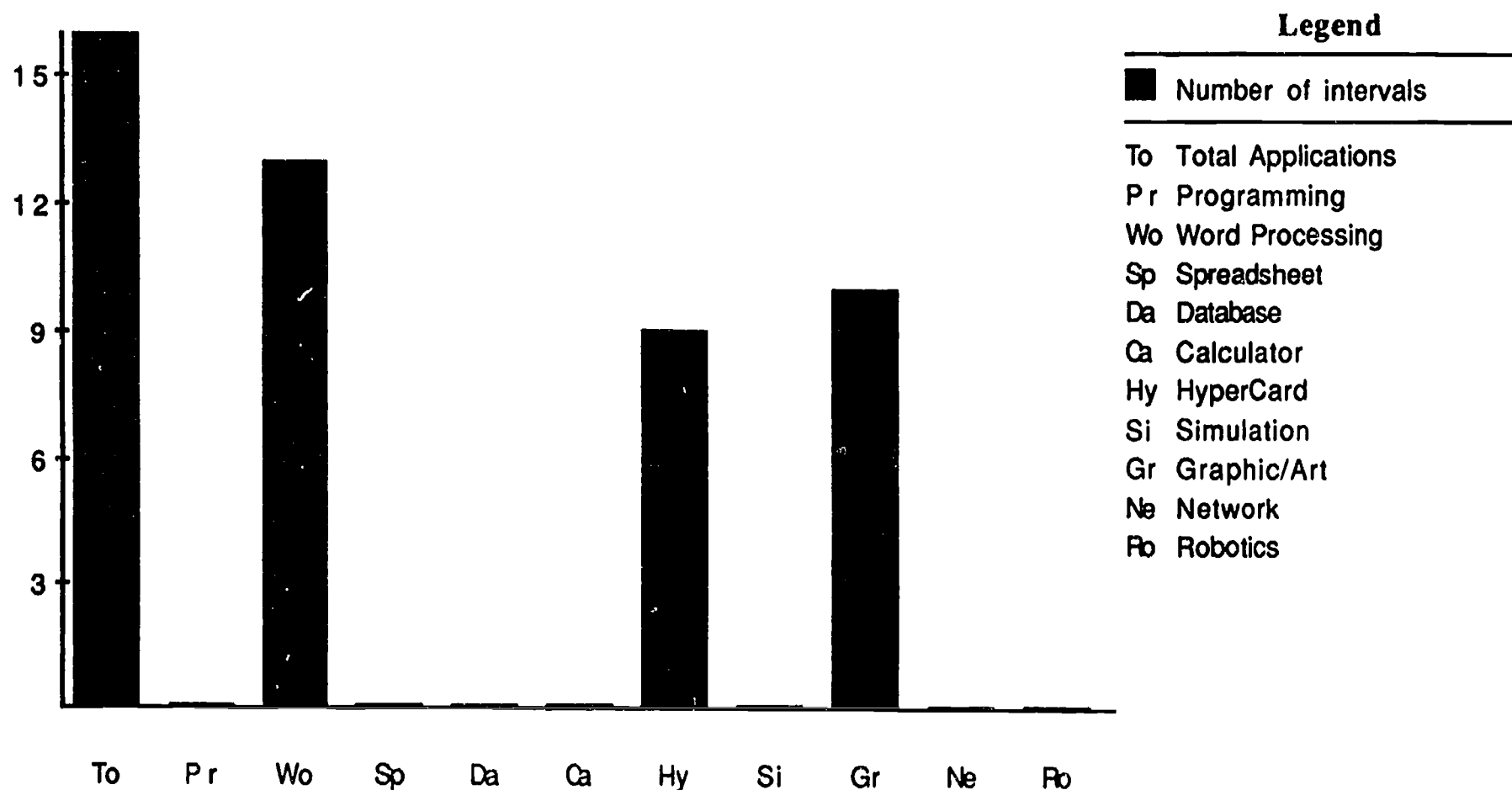In Instructional Software
Ap Applications

Illustrative Findings
Tuesday September 04, 1990 1:20.53 PM
Figure 18

58

Number of Intervals in which Computer Applications were Observed - Secondary Level

Total number of intervals observed and number of intervals in which each application was observed


Legend

■ Number of intervals

To Total Applications
Pr Programming
Wo Word Processing
Sp Spreadsheet
Da Database
Ca Calculator
Hy HyperCard
Si Simulation
Gr Graphic/Art
Ne Network
Ro Robotics

Illustrative Findings
Wednesday September 05, 1990 11:18.01 AM
Figure 19

60

61

Percentage of Intervals in which HyperMedia were Observed - Secondary Level

Percentages of total intervals in which computer applications were observed with other technologies

Legend

■ Percent

La LaserDisc
Vi Video
Au Audio
Sc Scanner
MI Midi Interface
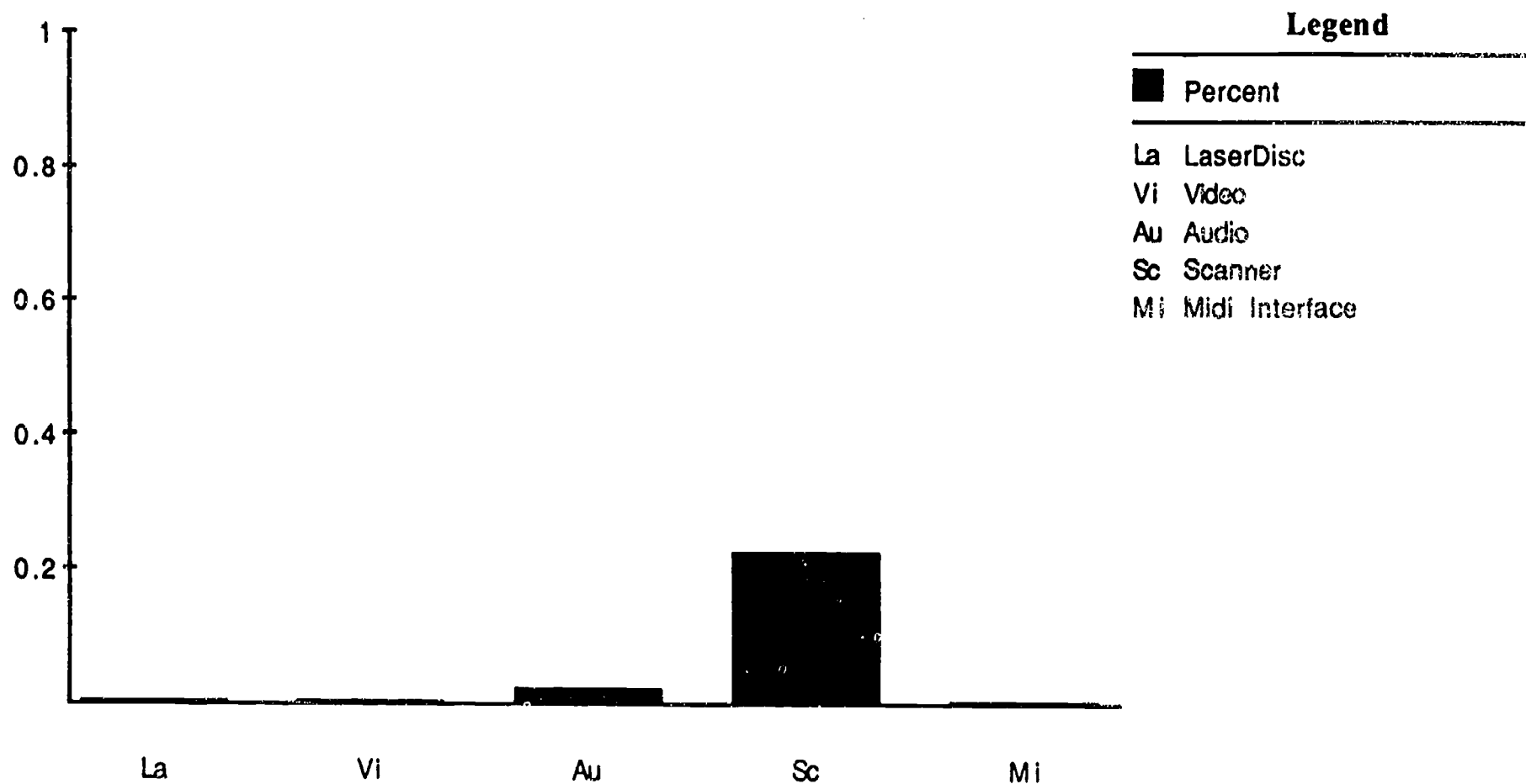
Illustrative Findings
Tuesday September 04, 1990 1:11.53 PM
Figure 20

62

63

Nature of students' work. At the elementary level, the language arts tasks were rated predominantly as either medium or low in level of processing—thus, well structured activities with teacher-defined criteria for completion (Figure 21). While teachers were utilizing word processing as support for students' writing, activities in which students participated substantively (in planning and coordinating the work) were rarely observed. Similarly, tasks were generally either short or medium in length and while task length tended to be longer with computer support, it was rarely judged as long in any resource context (Figure 22).

At the secondary level, while well-structured activities with teacher defined criteria for completion were most common, ill-structured activities (high) were not uncommon (Figure 23). The very low frequency of any code "off-computers" reflects the finding that students in the secondary classrooms were rarely producing any assigned product without computer support.[5] Similar to the results for *Level,* tasks were rated at all possible lengths, including "long" (Figure 24). (These indices total more than 100% because multiple-coding within activity is permitted.)

Classroom organization. At the elementary level in language arts, classrooms were generally organized for independent work, and teachers utilized computers heavily as support for independent work (Figure 25). Cooperative work

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[5] When students are engaged in listening, reading, watching, or taking notes, we do not code their participation for 'Length' or 'Level of challenge'.

Level of Processing Across Resource Contexts - Elementary Level

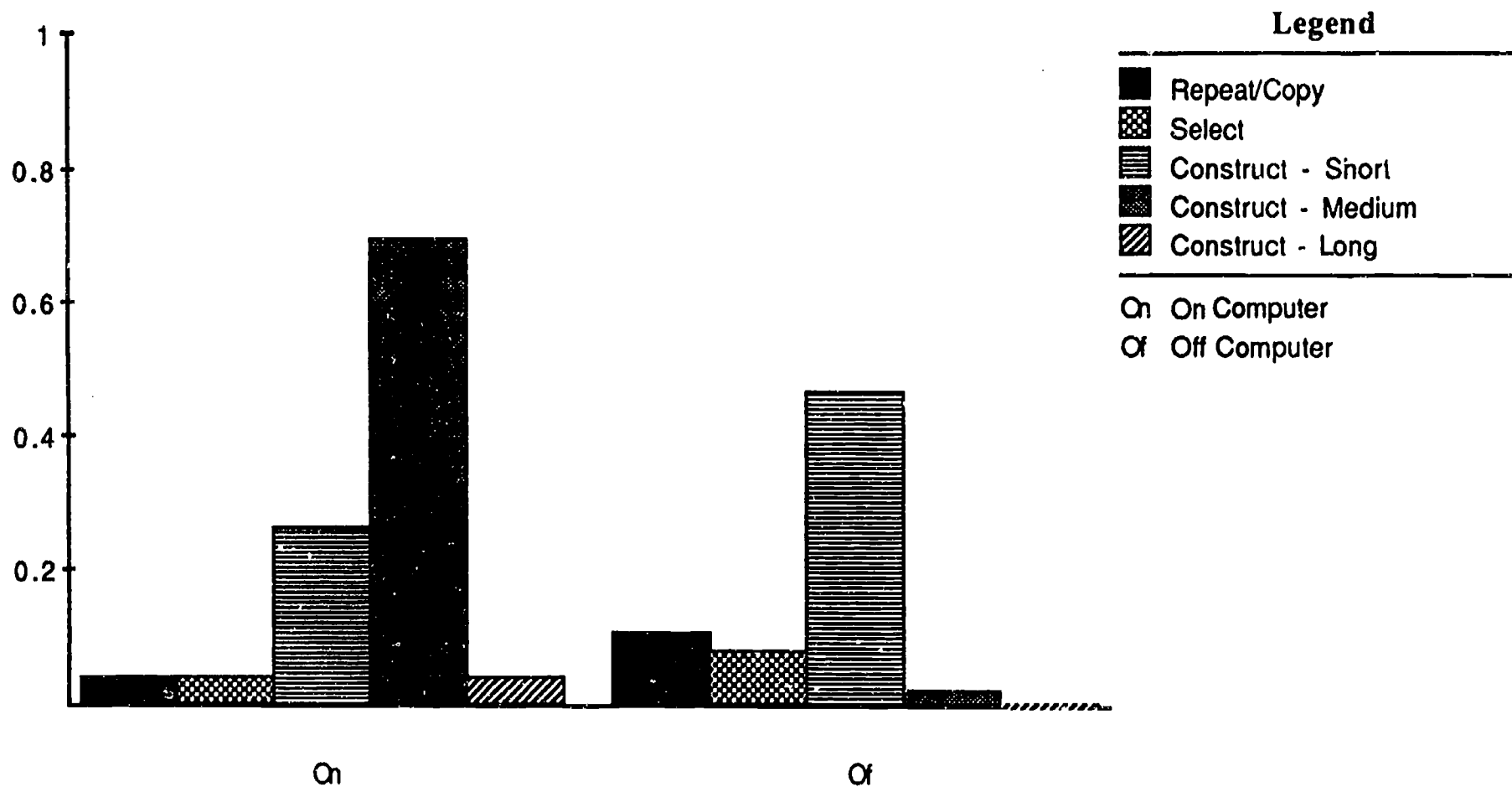Percentage of intervals within each resource context that each variable was observed

Illustrative Findings
Tuesday September 04, 1990 4:22.26 PM
Figure 21

66

Product Item Length Across Resource Contexts - Elementary Level

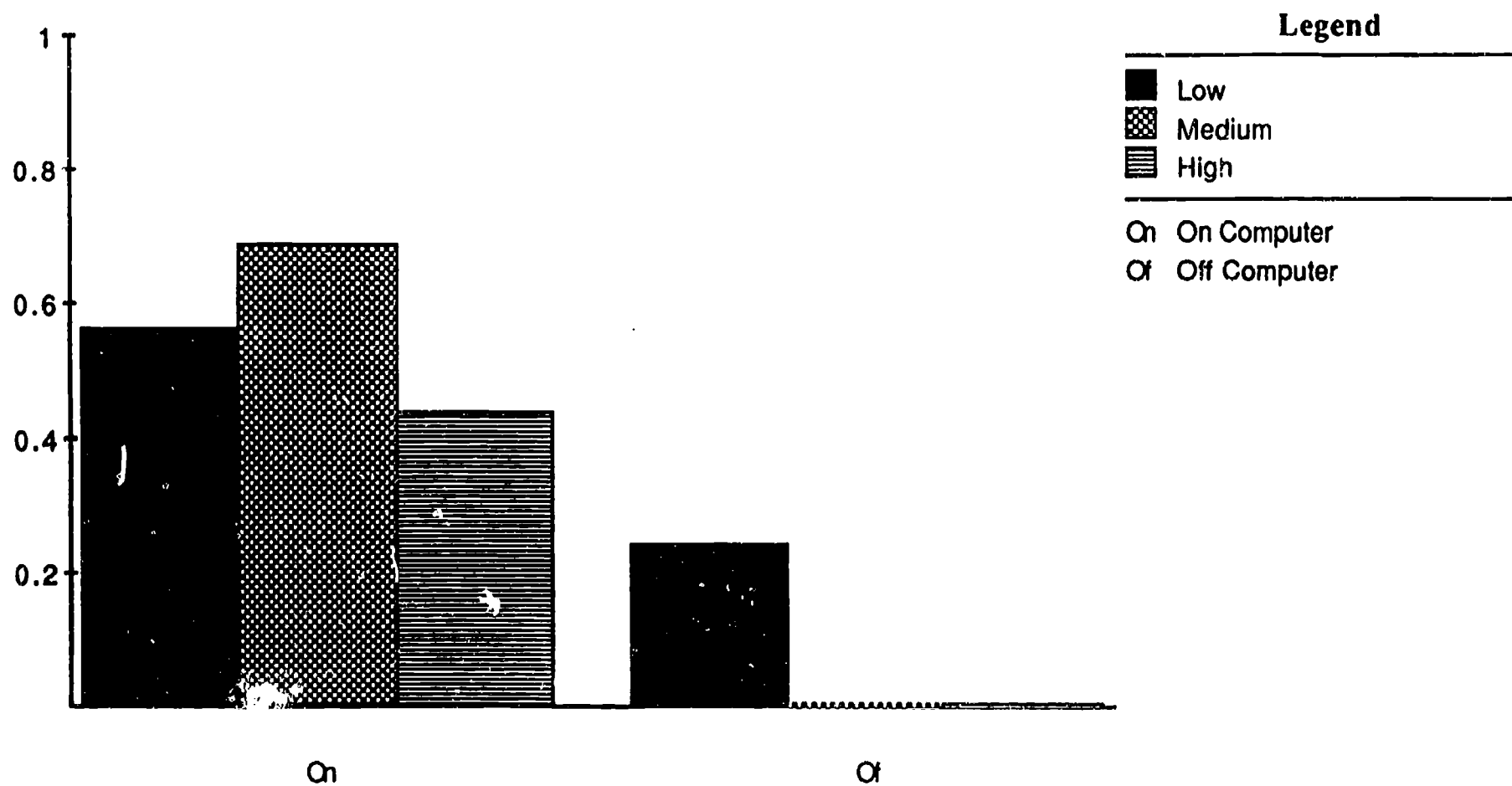Percentage of intervals within each resource context that each variable was observed

Legend

- Repeat/Copy
- Select
- Construct - Short
- Construct - Medium
- Construct - Long

On On Computer
Of Off Computer

Illustrative Findings
Tuesday September 04, 1990 4:23.32 PM
Figure 22

Level of Processing Across Resource Contexts - Secondary Level

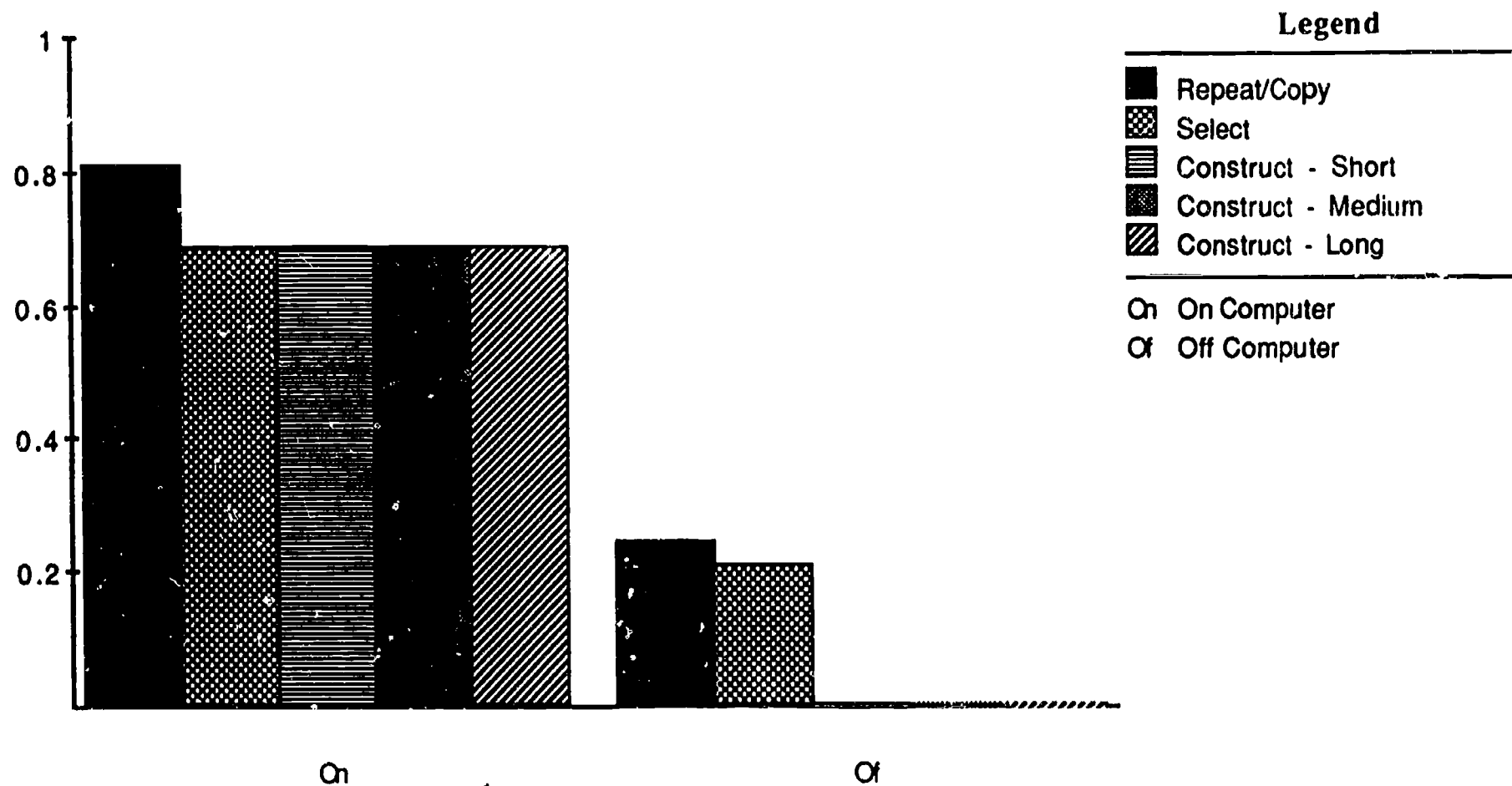Percentage of intervals within each resource context that each variable was observed

Legend

■	Low
▨	Medium
▤	High

On   On Computer
Of   Off Computer

Illustrative Findings
Tuesday September 04, 1990 4:28.05 PM
Figure 23

70

69

44

Product Item Length Across Resource Contexts - Secondary Level

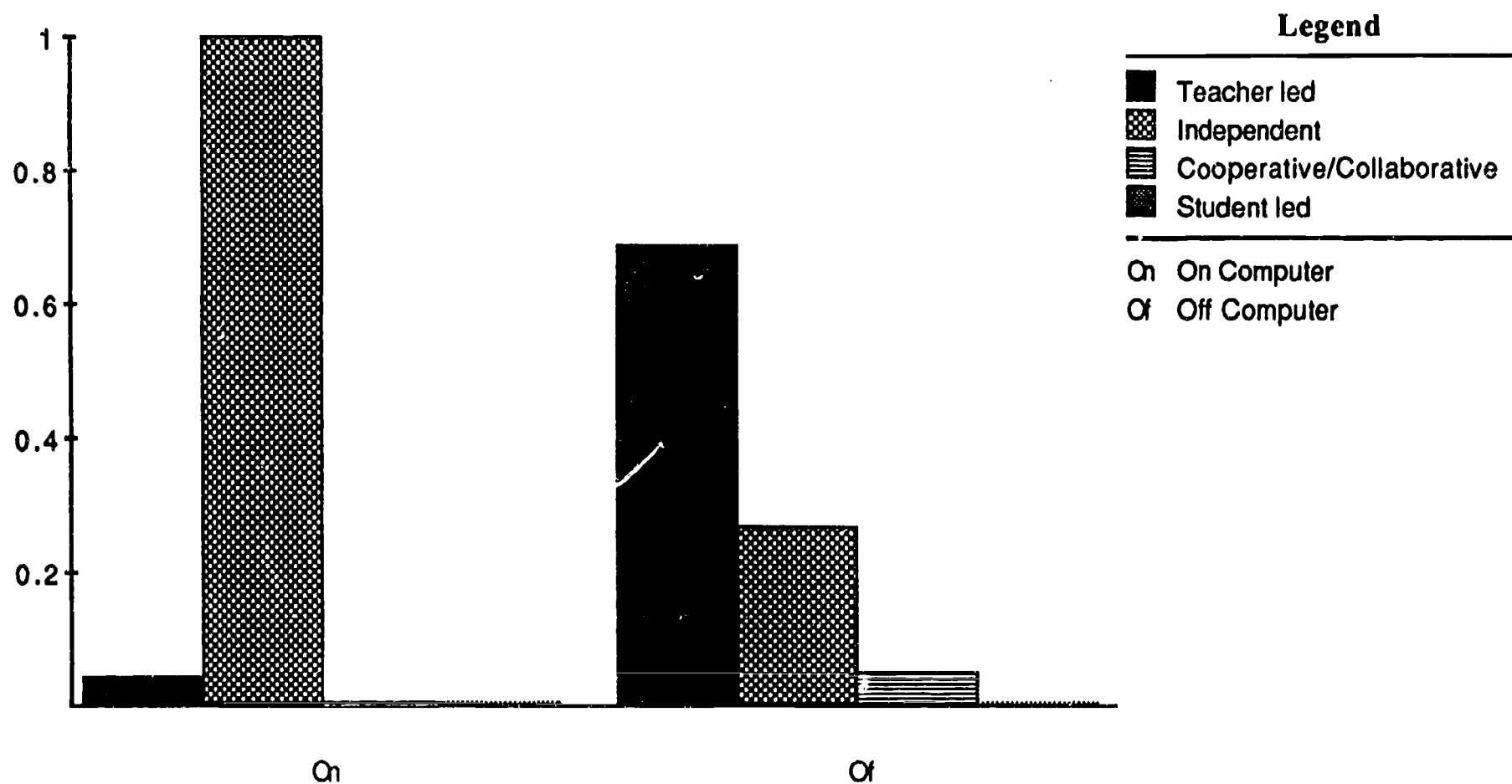Percentage of intervals within each resource context that each variable was observed

Legend

- ■ Repeat/Copy
- ▨ Select
- ▤ Construct - Short
- ▨ Construct - Medium
- ▨ Construct - Long

On On Computer
Of Off Computer

Illustrative Findings
Tuesday September 04, 1990 4:28.56 PM
Figure 24

72

71

Classroom Organization Across Resource Contexts - Elementary Level

Percentage of intervals within each resource context that each variable was observed

Legend

- ■ Teacher led
- ▨ Independent
- ▤ Cooperative/Collaborative
- ▩ Student led

Cn On Computer
Of Off Computer

Illustrative Findings
Wednesday September 05, 1990 11:29.03 AM
Figure 25

74

73

was very rare, and although truly collaborative projects were observed (jointly-produced products), these activities were not technology-supported (Figure 26). At the secondary level in English, classrooms were generally organized for indepen- dent work with computer use, and teacher-led instruction off- computer (Figure 27). Although cooperative activities were not uncommon on-computer, none of these was a collaborative activity (Figure 28).

Instruction and support roles. At both the elementary and the secondary levels, teachers were predominantly facili- tating instruction when students were on-computer and direct- ing instruction when off-computer (Figures 29 and 30). Students were engaged in productive peer interaction more often with computer support (Figures 31 and 32).

Interpretation: A role for subject matter expertise in teaching. Why might secondary teachers be more able to create opportunities for technology-supported, constructive student work? To provide a possible explanation for the results, and therefore a possible explanation for instruc- tional change as described by a model like Dwyer et al.'s phase model, we return again to work of Scardamalia and Bereiter.

Scardamalia and Bereiter (in press) argue that students engaged in constructive inquiry must be provided with resources representing multiple kinds of expertise. The kinds of expertise articulated—subject matter, curriculum, and pedagogical—can be distributed among teachers, students

75

Classroom Organization Across Resource Contexts - Elementary Level

Percentage of intervals within each resource context that each variable was observed
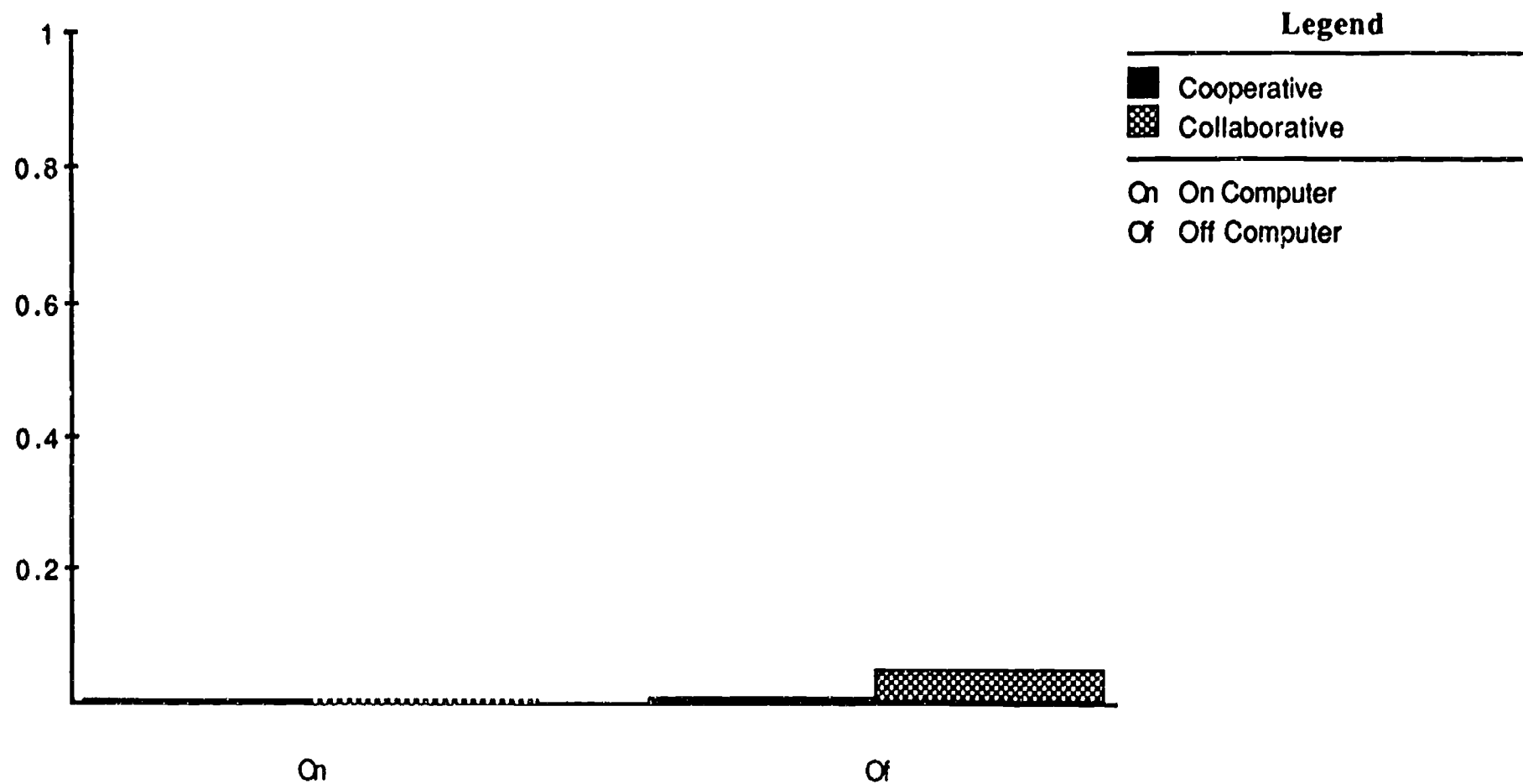
Illustrative Findings
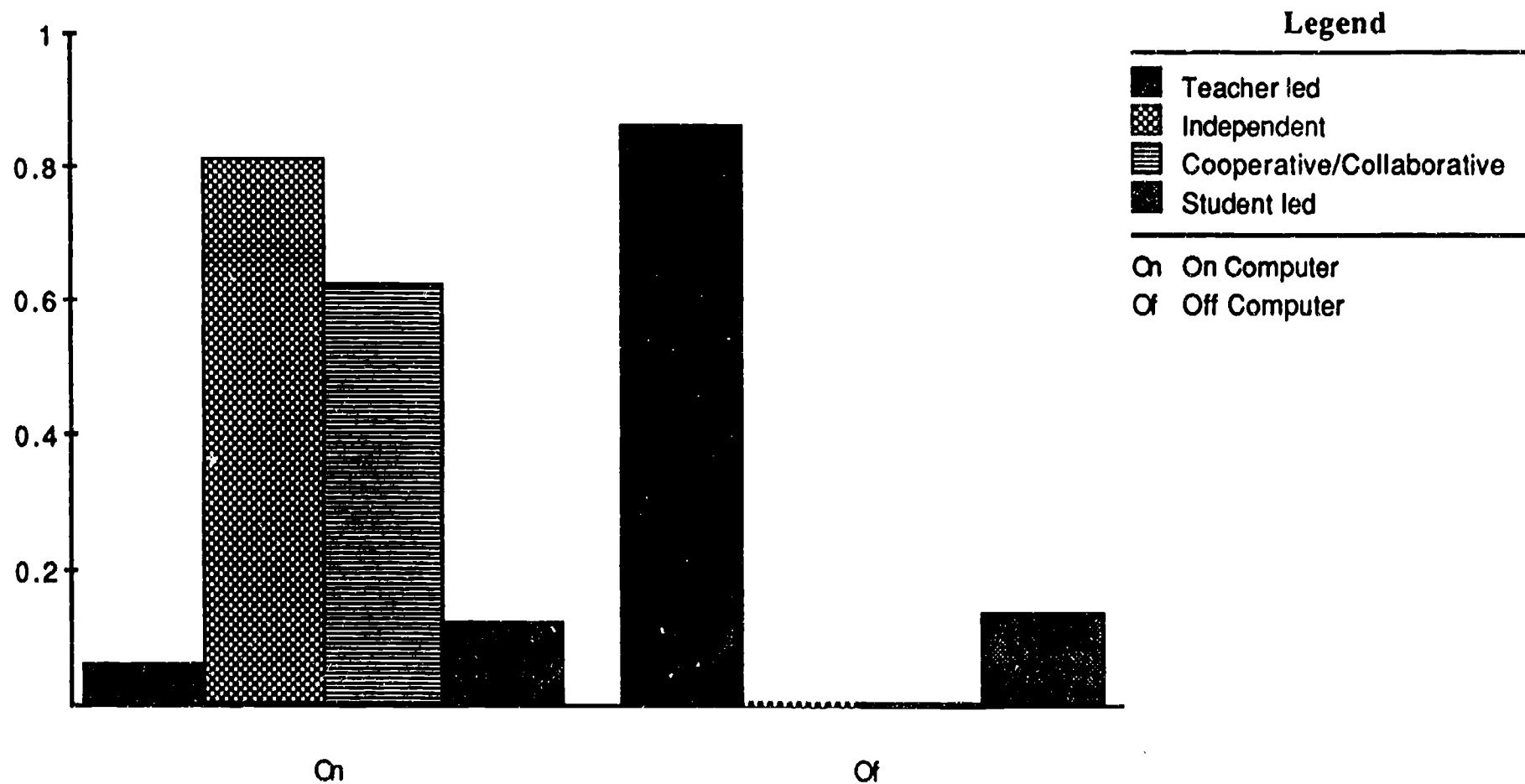Wednesday September 05, 1990 11:31.56 AM
Figure 26

76

77

Classroom Organization Across Resource Contexts - Secondary Level

Percentage of intervals within each resource context that each variable was observed

Legend

- Teacher led
- Independent
- Cooperative/Collaborative
- Student led

On On Computer
Of Off Computer

Illustrative Findings
Wednesday September 05, 1990 11:40.43 AM
Figure 27

78

79

Classroom Organization Across Resource Contexts - Secondary Level

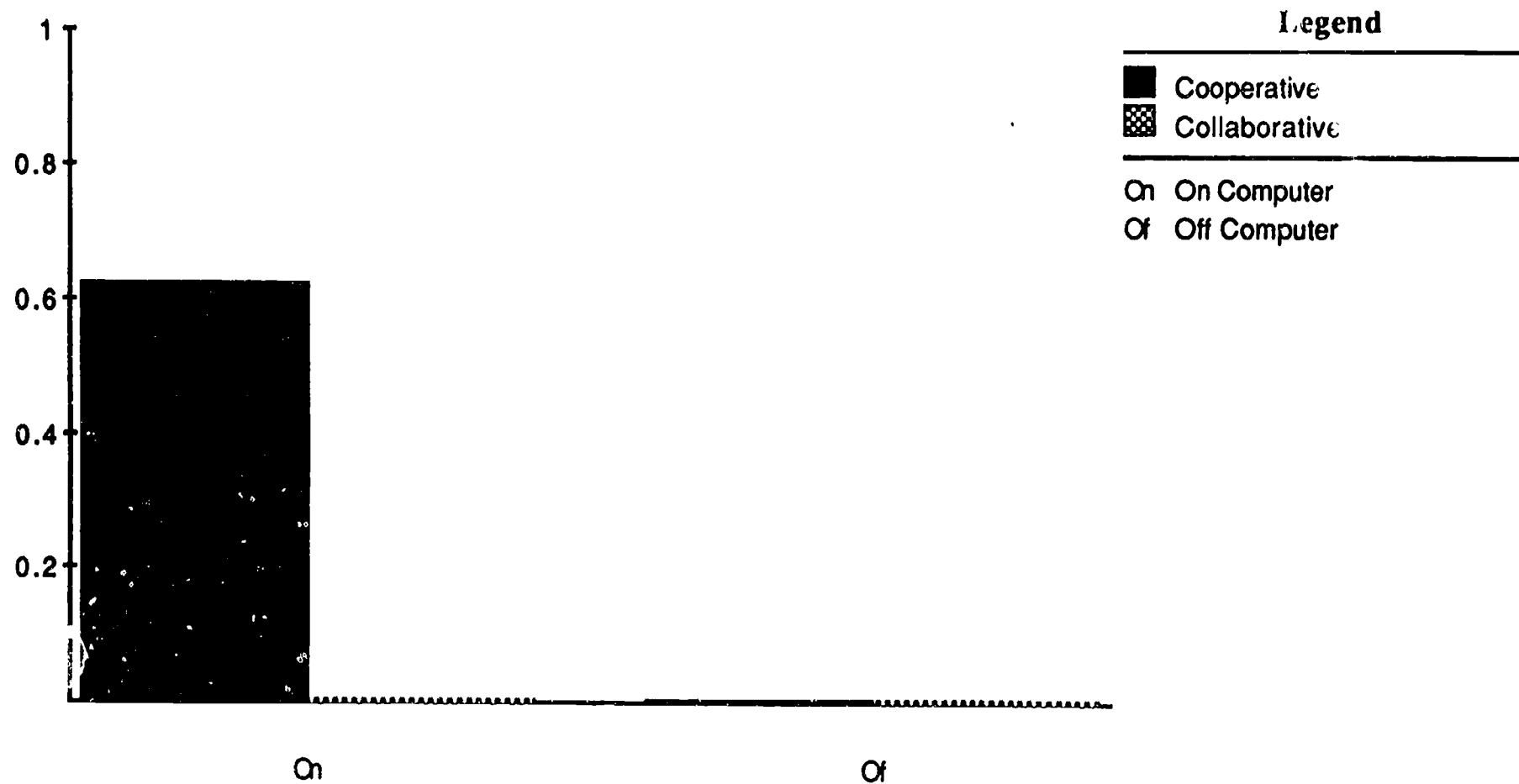Percentage of intervals within each resource context that each variable was observed
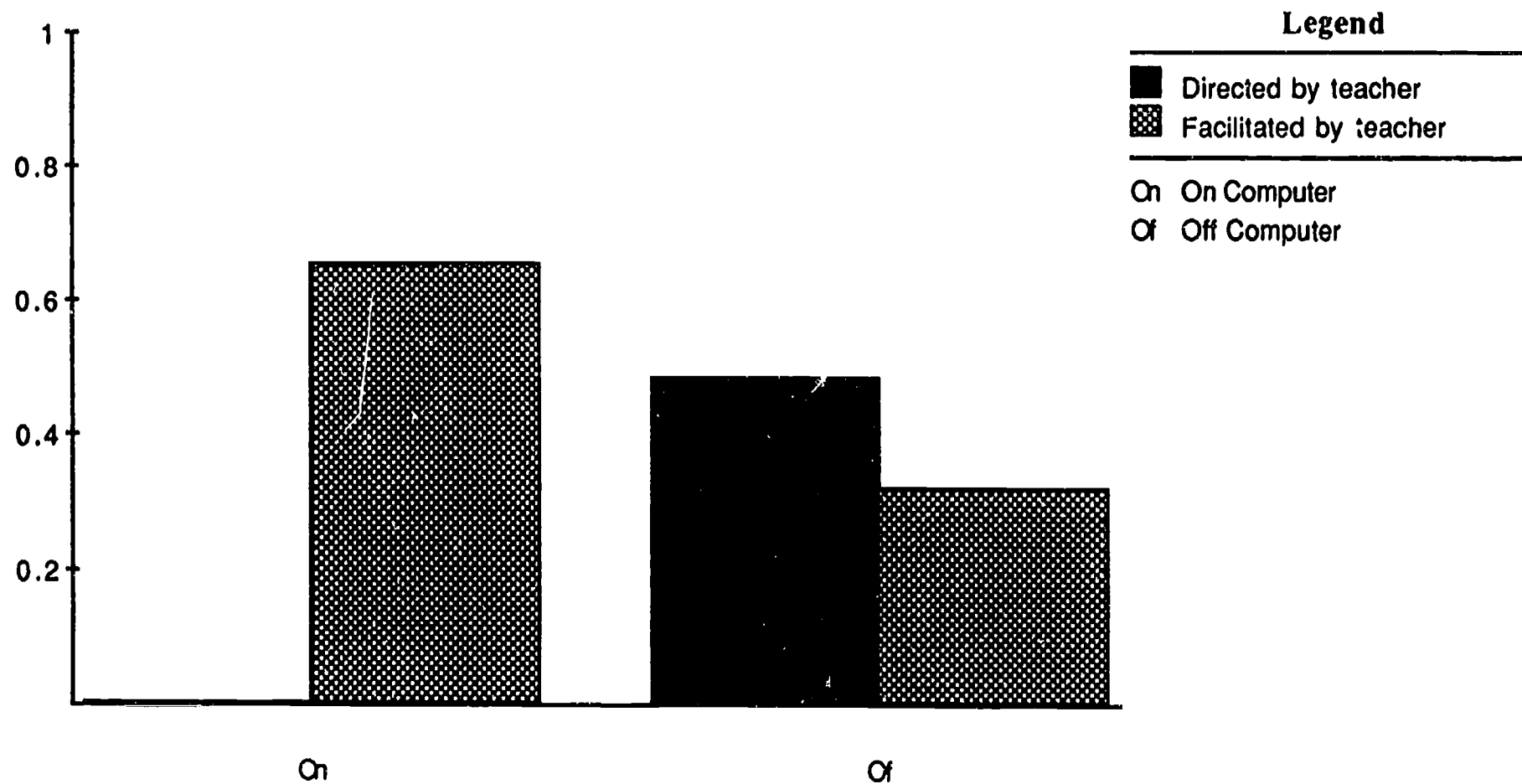

Illustrative Findings
Wednesday September 05, 1990 11:41.08 AM
Figure 28

80

81

Adult Role Across Resource Contexts - Elementary Level

Percentage of intervals within each resource context that each variable was observed

Legend

- ■ Directed by teacher
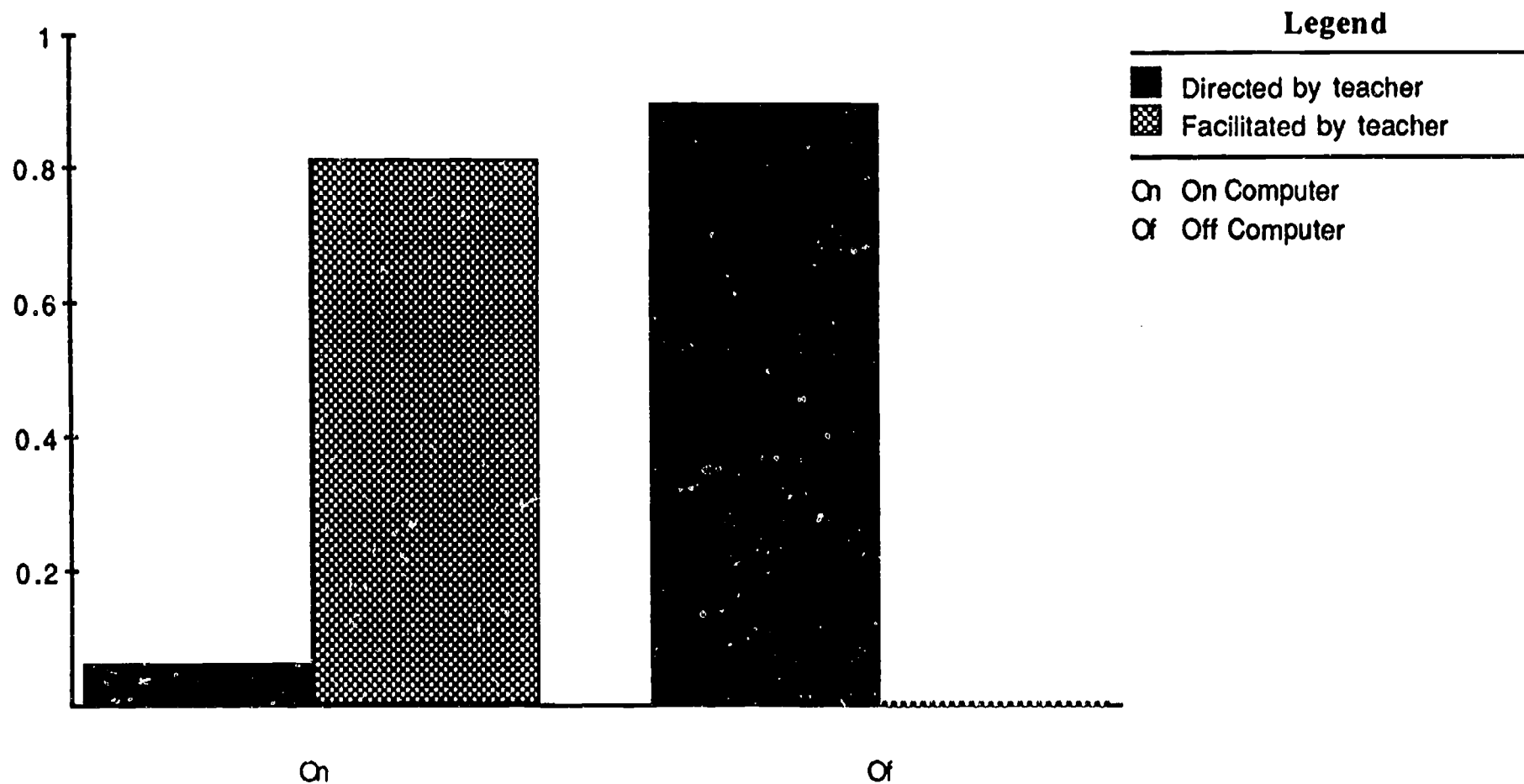- ▨ Facilitated by teacher

On On Computer
Of Off Computer

Illustrative Findings
Wednesday September 05, 1990 11:34.08 AM
Figure 29

Adult Role Across Resource Contexts - Secondary Level

Percentage of intervals within each resource context that each variable was observed

Legend

■ Directed by teacher
▨ Facilitated by teacher

Cn On Computer
Of Off Computer

Illustrative Findings
Wednesday September 05, 1990 11:41.30 AM
Figure 3C

Task-related Student Interaction Across Resource Contexts - Elementary Level

Percent of students exhibiting task-related interaction within each resource context
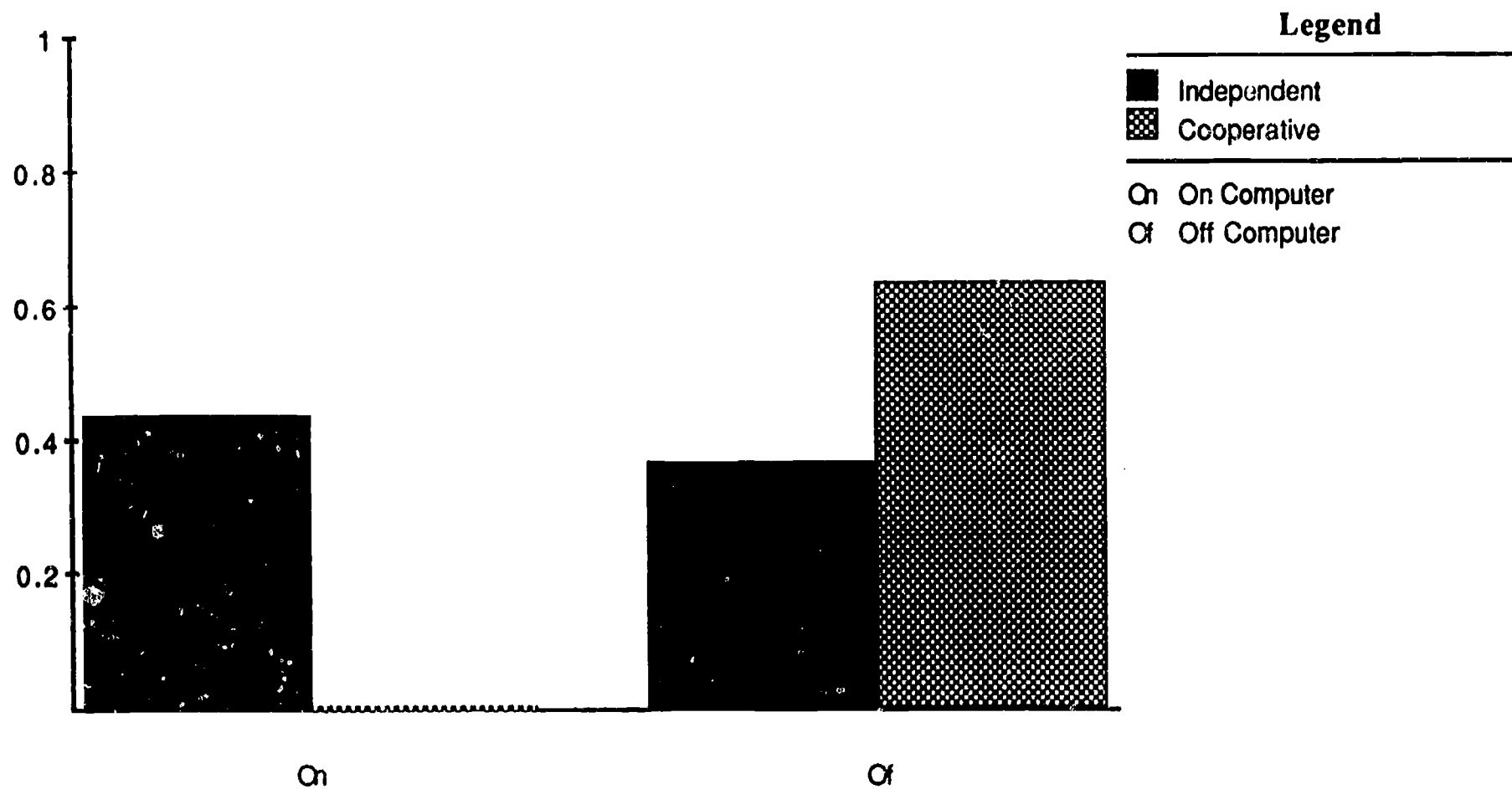
Illustrative Findings
Wednesday September 05, 1990 11:38.59 AM
Figure 31

87

86

Task-related Student Interaction Across Resource Contexts - Secondary Level

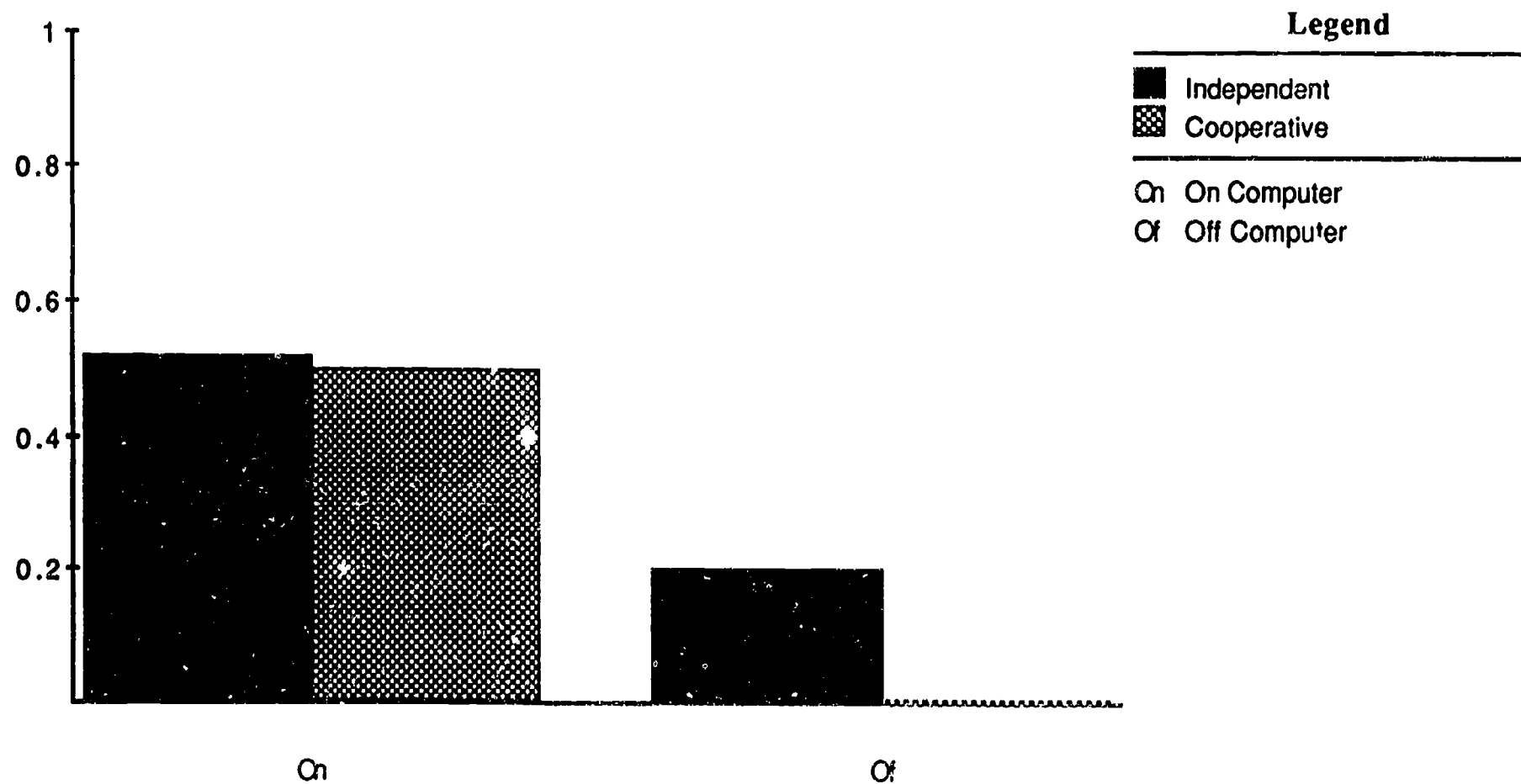Percent of students exhibiting task-related interaction within each resource context

Illustrative Findings
Wednesday September 05, 1990 11:41.57 AM
Figure 32

89

88

themselves, and instructional materials. Thus teachers are not seen as solely responsible for providing expertise, but as contributors to the design of instructional environments; their expertise certainly helps them to know what is needed to support a given project. Moreover, teachers' own engagement in building personal scholarship—subject matter expertise—provides a model to students of knowledge-building activities.

Scardamalia and Bereiter do not address directly how kinds of expertise can support constructive uses of technology. It is reasonable to assume, however, based on their arguments, that understandings of a subject's concepts and methods enable teachers to envision how technology might support inquiry within that discipline. If so, then the differences we found in technology use between the elementary and secondary level teachers are not surprising given typical differences in subject area training and specialization for teachers at each level. Elementary teachers are curricular and pedagogical generalists within a tradition where curriculum has been defined as a set of discrete facts and concepts not typically based on disciplinary expertise. The secondary teachers are likely to have somewhat greater subject matter knowledge by virtue of the training required of them for certification. Secondary teachers also focus their curriculum development efforts within one subject area. It is likely, then, that subject matter expertise, together with an instructional focus within one subject area, supported ACOT

secondary teachers' appropriation of technology's capabilities to support knowledge building and inquiry.

Both sets of teachers, however, have yet to exploit the full potential of technology for fostering deep understanding of subject matter content. There was evidence of some instructional innovation at the secondary level, but the patterns tended to suggest local experimentation (adaptation/appropriation) rather than comprehensive revision (invention). Further work is needed to understand how subject matter expertise, among a range of other factors, plays a role in teachers' construction of new conceptions of instructional environments.

Conclusions and Future Directions

Our goal is to develop tools that enable us to document the impact of technology on classroom instruction and on student, teacher, and parent outcomes. In this paper, we described one new tool—our new classroom observation instrument—and w: demonstrated its value for documenting instruction. We provided two illustrations of its potential uses: documenting commonly-reported observations of instruction in high access classrooms, and validating models of the role of technology use on instructional change.

The usefulness of our instrument will ultimately depend on both coordination with other kinds of qualitative data gathering and validation of the instrument through planned contrasts, either with classrooms utilizing technology in

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