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ABSTRACT

In December 1987, Motorola's MOS 5 Microprocessor Manufacturing Facility and Merex Corporation began a joint workplace literacy training project. MOS 5 had three basic objectives: to assess the level of the work materials, to assess the skill level of the work force, and to close the gap between the two. Merex designed an educational program to raise the level of employees' basic skills and address the need for training in workplace effectiveness skills. Over 300 operators and supervisors took part in classes between February 1988 and September 1989. Notable program features were as follows: analysis of skill needs, use of workplace materials, flexibility in scheduling, training in workplace effectiveness skills, mandatory participation, supervisor training, and quality assurance. Significant gains were shown on the Comprehensive Test of Basic Skills and a criterion-referenced test. The second part of "closing the gap" consisted of a major project to redesign and rewrite MOS 5's technical specifications, using principles of information processing and optimal specification design. Features of the new specifications were standardized format, defined parameters for writing style, integration of graphics, reorganization of content, and quick-reference guides. Compelling evidence showed productivity improved significantly by project end. (An executive summary at the beginning of the report highlights project components, unique features, and project results.) (YLB)

CLOSING THE SKILLS GAP

Impact of a Workplace Literacy Program

Based on a collaboration between
Motorola Inc. and Merex Corporation
April 1987 - September 1989

Introduction by N.E. Stouder

Vice President
Director of Manufacturing
Microprocessor and
Memory Technologies Group
Motorola, Inc.

Responding to worldwide competitive pressure for manufacturing excellence, Motorola's Microprocessor Wafer Manufacturing Facility MOS 5, in Mesa, Arizona, set out to significantly improve human productivity.

The first stage in this program was to gradually reduce employee census through attrition. It was anticipated that additional training would be required as individuals accepted greater scope and responsiblility in their jobs.

It was soon discovered that many employees lacked basic skills in reading and math. This was further aggravated when English was a second language.

At this point Merex was asked to assist in employee evaluation and preparation of course materials for training.

The accompanying report presents the details of this pacesetting association between Merex and Motorola. This will be looked upon in the future as a milestone event recognizing the worth and importance of individuals at all levels of a manufacturing concern.

The leadership and creative contributions of several individuals should be acknowledged. Their personal contributions have been significant. From Motorola they are: Jim Echols, Brett Richmond, Mike Mandracchia, Alan Ramias, and Dori Morgan. Equally important from Merex: Ray Karesky and Lynda Heeman.

Finally, the employees of MOS 5 must be acknowledged for their commitment to Motorola's needs and to their personal development. The field of adult education has benefited greatly from their efforts.

N.E. Stouder

One Year Plus by Brett Richmond

MOS 5 Operations Manager
Microprocessor and Memory Technologies Group
Motorola, Inc.

Since completion in 1989 of the Merex-MOS 5 "skills gap" (multi-level literacy-numeracy) closure training program, MOS 5's factory environment has undergone a significant metamorphosis. Today, the manufacturing engine has been increased to a five-inch line and has been ramping to full capacity on 1.5 micron EEprom technology with capability to transform to sub-micron volume production. The key element of this engine is the employee.

Although no formal assessment has been undertaken, there has been a significant elevation of employee self-esteem which has folded itself into solid team building and manifested strong confidence in individual performance. A team which three years ago would have questioned a complex mission is today a team with a "can do, let's go" attitude. From an operational cost standpoint, the investment in this unique training program was substantial. However, the return on this multi-year investment has been more than an order of magnitude with a unique compounding of team cohesiveness.

In order to answer a major question, namely, retentivity of the literacy-numeracy training, a post-program assessment will be undertaken over the next several months. A supposition that some regression has occurred will be examined along with exploring the overall cost effectiveness of notching the skills capability up to a higher level.

The MOS 5 manufacturing engine is climbing towards a "self-empowered, high performance" work team. The prerequisite for this type of engine is simply stated: *skills gap equals zero.*

Brett Richmond

Introduction

Rather than seeing a problem with the American worker, MOS 5 and Merex saw an opportunity for training in the many skills necessary for effectiveness in the workplace—and for making the workplace environment more responsive to that training.

In recent years many experts have begun to question America's ability to remain competitive in the world manufacturing market. Much of this concern has focused on the American worker's ability – or inability – to produce high-quality goods in a cost-effective manner. Does the American worker have the skills necessary to perform the difficult tasks of today and then to adapt to the technology of tomorrow? The answer seems to be that more and more individuals coming out of our educational system lack the basic skills in reading and math required to perform in business and industry, especially in high technology areas.

Rather than seeing a *problem* with the American worker, MOS 5 and Merex saw an *opportunity* for training people in the many skills necessary for effectiveness in the workplace – and for making the workplace more responsive to that training. A comprehensive program addressing these needs was planned, implemented, and thoroughly evaluated. All evidence indicates that the project had the desired positive impact. We believe that it can serve as a useful model for workplace training in the future.

Executive Summary

In December 1987, Motorola's MOS 5 Microprocessor Manufacturing Facility and Merex Corporation began a joint project to address the gap between employee skills and the demands of the modern high-technology workplace. The result was a far-reaching program that has redefined the concept of workplace literacy training.

In looking at the "skills gap" often found in the modern workplace, MOS 5 management and Merex designed a multi-faceted training program to not only remediate basic skills but to enhance effectiveness in the workplace.

Most attempted solutions to the workplace literacy problem address only employees' basic skills, without relating the skills to actual workplace demands. The assumption is that "the employee is the problem," and that once "the employee is fixed", the problem will be solved.

One of the unique aspects of this project was the assumption that the problem did not reside in the employee, but in a mismatch between employee skills and the skills demanded by workplace materials and situations. Thus, the problem could be attacked by changes in workplace materials and in organizational approaches, as well as improvements in employee skills.

Project Components

The program consisted of several interrelated components:

- An educational program for line operators in both basic reading and math skills and in "workplace effectiveness skills" such as critical thinking, problem-solving, effective communication, and team-building.

- A special program for employees who spoke English as a second language, and for other employees with significant literacy deficits.
- Training of supervisors in skills that would facilitate and build upon the skills taught to operators.
- A major redesign and rewrite of the MOS 5 technical specifications, along with training of MOS 5 personnel in the new spec-writing system.

Unique Features

Apart from its unique redefinition of a "problem" as a multi-level training opportunity, this program differed from typical literacy programs in several crucial respects:

- Aspects of the training were mandatory for most MOS 5 personnel at a number of levels: line operators, engineers, supervisors, and management.
- The educational program was relevant to the workplace, using materials and vocabulary drawn from the MOS 5 work environment, and shaped by input and feedback from all participants.
- Training took place on company time, onsite, on all shifts.
- Classes were small and interactive, with instructors who specialized in workplace training skills and adult education issues.

Evaluation

It was agreed that the program would be closely evaluated in several ways, both to determine its impact on MOS 5 and

to assess its usefulness as a model for future workplace effectiveness training.

Results

All measures of the program indicate that it was successful. Employee skills improved significantly. Attitudes and behaviors in the work area changed in numerous positive ways. Employees preferred the rewritten specs and the system set up to maintain the spec-writing procedure appeared to be working smoothly. Despite the time spent off-line by personnel during training, these changes were accompanied not by a decline but by an *increase* in productivity over the course of the project.

Voluntary programs tend to attract those who need them least and ignore the needs of those employees who could benefit most and whose participation is therefore important to the organization.

Both MOS 5 and Merex saw this as an experiment in workplace training. With little in the way of workplace-literacy research to guide decision-making and evaluation, MOS 5 was willing to take on a comprehensive, far-reaching, and ground-breaking program. Guiding this decision was a willingness to provide the best for, and expect the best from, its greatest resource—its employees.

In view of its scope and success at MOS 5, it is felt that this project represents a revolutionary model for future training in basic skills and workplace effectiveness skills.

Three Objectives

MOS 5 had three basic objectives when it began its partnership with Merex: (1) To assess the level of the work materials; (2) to assess the skill level of the workforce; and (3) to close the gap.

Objective 1: Assess the level of the work materials

Merex assessed the literacy and numeracy needs of the workplace by talking to trainers, managers, engineers, supervisors, and operators and by going into the area for a first-hand look at the work environment.

The MOS 5 technical specifications ("specs") are frequently used by operators and they contain critically important information for producing an excellent product. However, since they seemed especially difficult to work with, Merex chose to focus on improving this set of documents. Detailed analysis of the specs showed that the readability level varied widely (9th to 17th grade level). In addition, there were serious problems with layout, organization, and other format aspects that affect the readability of technical documents.

Engineers, supervisors, and operators all agreed that poor specs reduced productivity in a number of ways. These included unnecessary errors, slower processing time, and lack of processing standardization that resulted in problems with accountability and quality control. There were indirect effects as well, including slower cycle time for spec writing and changes, slower cycle time for process change, and inadequacy of the specs for use as training documents.

Objective 2: Assess the skill level of the workforce

Skills of the workforce were measured in two basic areas, reading and math, using a standardized adult achievement test. It was determined that of a workforce of 340 employees, 328 could benefit from reading and/or math instruction. This included workplace effectiveness skills training for those with relatively strong basic skills.

It was also determined that training in such areas as communication skills, critical thinking, problem-solving skills, and effective teamwork could have a positive impact on employee performance.

Objective 3: Close the gap

Merex and MOS 5 agreed to close the gap between employee skills and workplace requirements from both directions.

With input from the MOS 5 training staff, Merex designed an educational program to raise the level of employees' basic skills while addressing the need for training in workplace effectiveness skills. The development, implementation, and outcomes of this training are presented in the "Merex Worksite Education Program" sections following.

The second part of "closing the gap" consisted of a major project to redesign and rewrite MOS 5's technical specifications, using principles of information processing and optimal specification design. This project is summarized in the "Merex Technical Writing Program" section.

The Merex Worksite Education Program

Features

The worksite education program went well beyond remediating skills. Over 300 operators and supervisors took part in classes between February, 1988 and September, 1989. Several features of the program deserve special note. Among the notable features of the program:

Analysis of skill needs. Merex assessed the literacy and numeracy needs of the workplace by talking to trainers, managers, engineers, supervisors, and operators and by going into the area for a first-hand look at the work environment. This research determined that employees needed to be able to locate information in a technical document quickly; scan through text for relevant details; deal with difficult technical and nontechnical terms; understand and recall information; enter information on complex forms; and interpret data presented in charts, graphs, and tables.

The need for a skill-based program that uses actual work materials cannot be overemphasized.

Coordination of education and specs programs. The design of the education training was closely coordinated with the Technical Writing Program so that skills needed to work with the new specs would be included in the training curriculum. For instance, employees were taught how to use context clues to understand difficult technical terms, because context clues were being designed into the new specs. In this way, the education program and the spec rewrite program complemented one another.

Use of workplace materials. A wide range of workplace materials were integrated into the reading program (specs, theory manuals, charts and graphs, announcements and bulletins, etc.) and the math program (real and modified log sheets), using recommendations from the MOS 5 training staff.

Flexibility in scheduling. Classes were offered onsite and on every shift. Class length and time were periodically changed in response to MOS 5 production needs, with a trend toward smaller class sizes and longer sessions. Significantly, test results showed that format changes did not affect learning.

Training in workplace effectiveness skills. Merex incorporated curriculum elements into the education program that went beyond literacy and numeracy training *per se*. These included critical and creative thinking skills, memory and concentration techniques, communication skills, attitude awareness and change, problem-solving, and team-building skills.

Scope of instruction. The Merex program was designed to meet the educational needs for a variety of individuals. 300-hour classes were offered to individuals for whom English was their second language (ESL). Reading and math improvement classes were offerred at 30, 60 and 90 hours of instruction depending on the skill levels of the individual.

Mandatory participation. MOS 5 felt that voluntary programs tend to attract those who need them least (higher-functioning employees without significant deficits) and ignore the needs of those employees who could benefit most. Therefore, Merex tested all MOS 5 employees.

Operator: "I really didn't think I would improve very much taking this course but I did. I'm proud of myself."
Supervisor: "I see good, general improvement in everyone, especially in attitude."

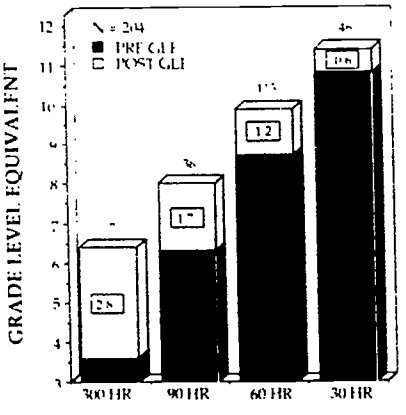
Supervisor training. Supervisors were trained in communication and team-building skills to support changes seen in Merex students. Thus, as employees began to show more willingness to ask clarifying questions or make suggestions, supervisors were able to facilitate and encourage these changes.

Quality assurance. Merex maintained close contact with MOS 5 and site training representatives at all times. In addition, Merex incorporated elements that went beyond what might be expected from most workplace skills programs – intensive teacher training and supervision, regular company meetings to fine-tune the program, and ongoing feedback from all participants (including students).

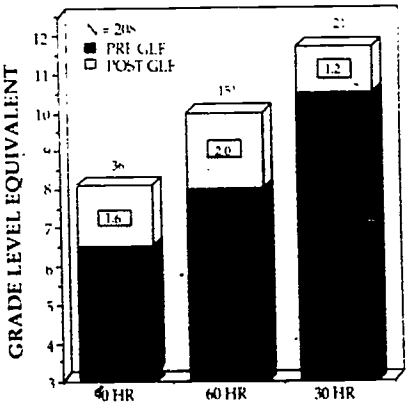
Results

The program showed strong empirical results. Merex and MOS 5 agreed that two measures of program effectiveness would be used— a second administration of the Comprehensive Test of Basic Skills (CTBS) at the end of each cycle and a criterion reference test (CRT) administered at the beginning and end of each class cycle.

CTBS Improvement: Reading



CTBS Improvement: Math

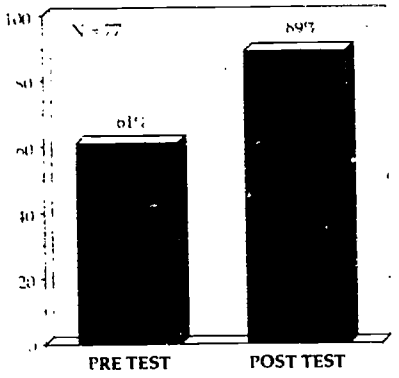


CTBS results

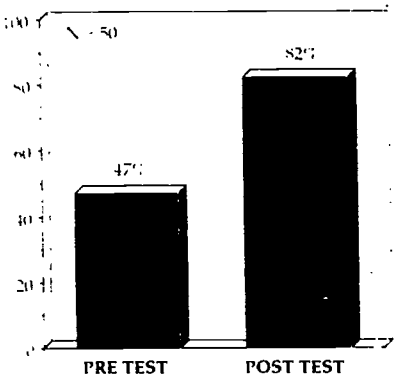
It was felt that an independent measure of program effectiveness was desirable. The CTBS was chosen as the best test available at the time (Note: This instrument has since

been replaced by an improved test – the Tests of Adult Basic Education/TABE). The CTBS is a general test of basic education which does not measure many of the skills taught in Merex classes. It also has limitations in its ability to demonstrate improvements made by adult learners in a work setting. Despite these limitations, classes showed improvements as high as 2.8 GLE in reading and 2.0 GLE in math.

CRT Improvement: Reading



CRT Improvement: Math



CRT results

Even more significant were gains shown on the criterion reference test. Developed by Merex, this test measured those skills found to be important in the workplace and incorporated workplace materials. The CRT was administered at the beginning and end of each class cycle. The average CRT score in reading classes improved from 61% to 89%; the average math score improved from 47% to 82%.

These impressive CTBS and CRT gains were achieved despite the fact that a significant portion of the Merex classroom time was devoted to the development of other important workplace skills such as communication, prob-

At the conclusion of the education project, a random sample of operators was polled to assess the impact of the program. 89% felt that they had used their new skills on the job; 83% felt that the Merex classes had improved their attitude at work.

lem solving, and teamwork. These results support MOS 5's decision to teach reading and math skills with the larger context of workplace effectiveness skills. Workplace literacy clearly involves more than just reading and math.

Anecdotal evidence of change

Feedback from MOS 5 employees who went through the Merex training was extremely positive. Employees generally rated the Merex program, instructors, and materials highly. They felt that the skills taught in the education program had immediate application at work and in other aspects of their lives. Many employees expressed increased confidence in their skills and reported plans to use those skills in further training and education.

Many employees expressed increased confidence in their skills and reported plans to use those skills in further training.

Supervisors were asked to assess the impact of the program on employees' performance. They reported that employees processed written information more effectively, that they had more positive attitudes, especially toward work, and that their math skills and critical thinking/logical processing skills had improved.

One exciting demonstration of a positive attitude change occurred near the end of the project. Twenty-five MOS 5 employees participated voluntarily in a GED preparation course. Employees came on their own time for 16 hours of instruction (provided free by Merex) and a Saturday test (paid by MOS 5). Eighteen passed the test. Notably, many of these employees had never attempted to complete their schooling until their exposure to the Merex program. The motivation and the increased confidence gained from achievements like this cannot help but have a positive impact on MOS 5 in the future.

The Merex Technical Writing Program

The Technical Writing Program began in August, 1988 and ended in January, 1990, and generated over 3000 pages. The program consisted of several overlapping phases:

- Analysis of the existing specs and the spec-writing system.
- Consultation with management, engineers, supervisors, and operators.
- Setup of hardware and software systems.
- Production and review of sample rewrites.
- Rewrite of all existing MOS 5 technical specifications.
- Training of MOS 5 personnel (engineers and document control personnel) in the new system.

Under this system, the specs and the spec-writing procedure were completely redesigned by Merex, with input from MOS 5 engineers, operators, supervisors, and document control personnel.

Too often, input from the user is ignored in the design or revision of technical specs. Apart from the practical value of this input, it is important that employees know that their concerns and ideas are being considered.

Features

Standardized format. A "user-friendly" format was adopted using clear section headings, grey bars, and other elements designed to help operators survey the document and locate information quickly .

Writing style. Using information processing guidelines, Merex defined specific parameters for writing style such as sentence length, controlled vocabulary, and consistent use of context clues.

Placement of graphics. Graphics were integrated into the document where they were first referenced, rather than clustered at the end.

Organization of content. Information contained in the specs was reorganized so that the reader would be referred as little as possible to other sections or other specs. Procedures were rearranged in logical, sequential order. In addition, Merex defined future guidelines for organizing information.

Quick-reference guides. To help users locate information quickly, the system incorporated such features as a table of contents, a list of documents referenced in the spec, and a more effective numbering system.

Maintenance improvements. The new spec system was designed to ensure that future specs, as well as revisions to existing specs, would conform to the new standards. Merex built into the software a set of writing guidelines, graphics standards, and spec formats. Document control personnel were thoroughly trained in their use.

Impact of the Project on MOS 5

Ultimately, the success of a program like this has to be measured in terms of its impact on the company. MOS 5 engaged Merex in this project because it wanted a better-prepared and higher-functioning workforce interacting with better workplace materials, which in turn would increase productivity.

There is, in fact, compelling evidence that productivity in MOS 5 had improved significantly by the end of the project. Figures for the third quarter of 1989 (the end of the Merex program), when compared with the third quarter of 1987 (before the program), show:

- 33% reduction in absenteeism
- 4.2% reduction in scrap
- 18% reduction in cycle time
- 18% improvement in productivity based on outs
- 42% improvement in productivity based on turns

These figures were posted despite a 31% reduction in the workforce, a change toward a more difficult product (from HMOS to HCMOS), and considerable loss of operator time because of attendance in Merex classes. Clearly, a substantial training effort was accomplished without the expected negative impact on productivity figures.

The Merex program was only one of many variables influencing the improved productivity figures, and its precise role in these improvements can never be measured. There is however a general belief at all levels of MOS 5 that the impact of the program was positive, and that the goals of the program were fully realized.

Issues and Recommendations

The MOS 5 – Merex experience suggests a number of issues that might arise in production areas considering similar projects. To ensure the success of future training programs the following elements should be considered.

Worksite Education Program

Scheduling. Flexibility in scheduling classes is an important factor since changing production needs may necessitate changes in class schedules. Also, the advantages of offering classes onsite and on all shifts should be considered.

Employee resistance. When any skills/literacy program is instituted, there may be employees who are anxious about their skills and feel threatened by the program. Interestingly, organizations may also experience some resistance to change. It is important to take these issues into account and to deal with them in a sensitive manner.

Program relevancy. The need for a skill-based program that uses actual work materials cannot be overemphasized. Systematic training in the skills required to work with those materials must be incorporated into current and future training programs.

Program content. Besides basic skills, training in "workplace effectiveness" skills is essential. These include communication, problem-solving, critical thinking, and team-building skills. Also needed is a process component to address attitudinal issues and resistance to change. It is important to note that the impressive empirical gains shown in this program were achieved while the workplace effectiveness skills were being taught. This indicates that quality of in-

struction is not compromised by these "value-added" components, but in fact is enhanced by them.

Program evaluation. Ongoing evaluation of the quality of the program and its impact on employees and on the company is vital. This process should be multifaceted and not limited to test results.

Input from all parties. Too often, input from the writer or user is ignored in the design and revision of technical specs. Apart from the practical importance of this input, it is essential that employees feel that their concerns and ideas are valued.

Standardization. Writers and users of specs can function more efficiently with standardized guidelines for text, graphics, and layout. A coherent, practical, and user-friendly set of standards is a high priority.

Provisions for future specs. A system must be written for writing future specs that will meet the new standards is a must. Standards and constraints should be built into the system, as should repeatable text-processing capabilities.

Efficient maintenance. A technical writing system has to allow for future maintenance of existing specs, including such contingencies as tracking and cross-referencing revisions.

Conclusion

The successful collaboration between MOS 5 and Merex clearly reflected Motorola's commitment to prepare employees for the workplace of the future. From the start, MOS 5 viewed this project as more than just a literacy project. They recognized it as a vehicle for strengthening the sense of teamwork and commitment required to achieve organizational goals and sector imperatives.

By going beyond traditional approaches to workplace literacy, MOS 5 and Merex provided learning opportunities that conveyed the value of continued employee development. Employees learned much more than just basic skills. They developed the attitudes and skills of responsible learners – learners who are more flexible and open to the changing demands of the work environment.

Motorola and MOS 5 are committed to their employees and believe they are among the best in the world. Part of this commitment is to provide the training necessary to do a quality job now and to continue to improve to meet the needs of tomorrow. The MOS 5-Merex Workplace Education Project is an example of this.

Acknowledgements

We would like to thank Jim Echols, Mike Mandracchia, Alan Ramias and Dori Morgan from MOS 5. Dori kept great notes and asked all the right questions.

Thanks also to all the people at Merex Corporation – especially Ernie Crane who gave us lesson plans, real materials and this report. Special thanks to all the dedicated Merex teachers who really made it happen in the classroom.

Perhaps the most important acknowledgement goes to the employees/students at MOS 5. Your interest, energy, hard-work and feedback really made this happen, then, now and in the future. We thank you for being who you are and contributing to this process.

Ray Karesky

Ray Karesky
President

Lynda B. Heeman

Lynda B. Heeman
Vice-President

Profiles

MOS 5 Profile

A division of Motorola, MOS 5 Microprocessor Manufacturing is a semiconductor wafer fabrication facility whose mission is:

- To build microprocessor products which are fabricated on HMOS and HCMOS processes down to 1.2 micron feature size.
- To satisfy its customers' needs for the highest quality, for on-time delivery, and for minimum cost.

In mid-1987, MOS 5 recognized that one of the critical requirements in achieving this mission was excellence in its workforce. Changing technology and increasing competition in the world marketplace made it imperative that MOS 5 employees respond to new information and new procedures quickly and accurately. This would enable them to be flexible in their job responsibilities and make it possible for management to respond quickly to both technical and market changes.

Merex Profile

Merex Corporation provides education and technical writing services to business and industry from its offices in Tempe, Arizona.

Because effective learning involves both skills and attitudes, the Merex Worksite Education Program goes beyond traditional reading and math programs. Its information processing approach emphasizes attitude, communication, self-confidence, flexibility, and critical and creative thinking, particularly as they affect job performance. This comprehensive approach to learning addresses both the skill needs of the employees and the technical needs of the company.

This approach is also applied in the Merex Technical Writing System, where the need of the company for accuracy in technical documents is coupled with a system for clearly written, visually interesting, easy-to-follow format for document users.

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