Massachusetts Institute of Technology
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Executive Programs
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Knowledge Management

• Gaining Knowledge
  – Technology Transfer
    • Between Organizations
    • Within Organizations
  – Gatekeepers

• Disseminating Knowledge
  – Technical Communication
    • Organization Structure
    • Physical Structure of Facilities
What do we know about technology transfer?

• It is a 'people process'.
• Transferring documentation is, at best, an auxiliary process.
• People must be in direct contact and understand each other to transfer knowledge.
• The best 'package' for knowledge is the human mind.
• Moving people is the most effective way to move knowledge.
• This can imply either organizational or geographical movement.
• Organizational boundaries impose a serious barrier to the transfer of technology.
• This is due to the development of different organizational cultures.
The Context of the Study

Project Team

Organization
'Twin' Projects

Company 'A'

Company 'B'
Sources of Technology

- Internal Staff
- Literature
- Outside Experts
Literature & Documentation

- Literature
  - Outside Experts
    - 18%
  - Internal Staff
    - 4%
People as Sources of Technology

Outside Experts

Internal Staff

Literature
People as Sources of Technology

Outside Experts

Negative

XX

Positive

XX

Internal Staff

Literature
Customer Evaluation of Solutions as a Function of Idea Source

![Bar Chart]

- **Source of Idea**: Internal, External
- **Evaluation of Solution**: High, Low
- **Proportion**: 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7

The chart illustrates the proportion of customer evaluation of solutions as a function of idea source.
'Boundary Impedance' of the Organization

Outside Experts

Negative

Internal Staff

Literature
Science and Technology

• Science is Universal.

• Technology is *Local*.
Technology

• Technology is defined in terms of:
• The Business Goals
• The Marketing Strategy
• and most importantly,
• The Culture
• of the organization in which it is developed.
• Technical problems are thus defined in terms of that culture and its system of values.
The Local Nature of Technology

- This implies that:
- Anyone outside of the organization cannot fully understand the way that those within the organization define technical problems without understanding the organization's culture.
- This difficulty in understanding the problem is the principal barrier to technology transfer.
- Barriers of this sort arise any time that we try to transfer knowledge across organizational boundaries.
- It thus holds true for internal communication as well as communication with other organizations.
- It is one of the causes of poor interfunctional relations in organizations.
Performance in Transferring Designs to Manufacturing as a Function of CAD System Use for Communication

Quality of Transfer (Fewer ECs)

High

Low

Mean Communications per Day (Through CAD System)

0 0.2 0.4 0.6 0.8 1 1.2 1.4

p < 0.02
Using a Common Reference to Reduce Ambiguity in Communication
Effectiveness of Strategies for Reaching Common Understanding of Problems by Product Development and Manufacturing Engineering

Performance Score

- Mgt Intervention
- Frequent Meetings
- Show & Tell
- Tests
- Co-Location
Partial Layout of the BMW Forschung und Ingenieurung Zentrum
The Effect of Transfers

A

B

N_1
Continuing Relations

Potential Contacts
More Continuing Relations

Potential Contacts

N₁

N₂
A Typical Technical Communication Network
Netgraph of Communication Among Software Developers
(N > 600)
Netgraph of Communication Related to Age
Netgraph of Communication Related to Organizational Structure
Netgraph of Communication Related to Physical Location
### Netgraph of Communication Related to Organizational Structure

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<td>Vehicle Plan Build</td>
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Communication Mapping

• Order by location
Communication Mapping

- Order by
  - Project
  - Development
  - Process
Netgraph Showing the Low Level of Communication Among Groups in Laboratory ‘K’.
Communication Network in a Small Laboratory
High Communicators Compared with Colleagues in Readership of Refereed Journals

Mean Journal Readership

1. Laboratory 'A'
   - p < 0.001

2. Laboratory 'G'
   - p < 0.02

3. Laboratory 'E'
   - p < 0.01

4. Laboratory 'L'
   - p < 0.05

5. Laboratory 'M'
   - p < 0.05

6. Laboratory 'H'
   - p < 0.01

7. Laboratory 'S'
   - p < 0.01

8. Laboratory 'T'
   - p < 0.01

9. Laboratory 'U'
   - p < 0.01

10. Laboratory 'V'
    - N.S.
High Communicators Compared with Colleagues in Terms of Regular Informal Contact Outside of the Organization

- Laboratory 'A': High Communicators vs. All Other Staff, p < 0.05
- Laboratory 'G': High Communicators vs. All Other Staff, p < 0.05
- Laboratory 'E': High Communicators vs. All Other Staff, p < 0.001
- Laboratory 'L': High Communicators vs. All Other Staff, p < 0.05
- Laboratory 'M': High Communicators vs. All Other Staff, p < 0.01
- Laboratory 'H': High Communicators vs. All Other Staff, p < 0.01
- Laboratory 'F': High Communicators vs. All Other Staff, p < 0.01

Mean Number of Contacts

0 1 2 3 4 5 6
The Gatekeeper as a Link to Outside Technology

Outside Experts

Gatekeeper

Literature
Gatekeeper Characteristics

- High Technical Performance
- Not 'just communicators'
- Highest technical performers in the organization.
- Cannot be created by management.
- Low in the Organizational Hierarchy
- Concentrated at first level of technical supervision or below.
- Seldom found at higher levels of management.
- Seldom found on the technical ladder.
- Visibility
- They are easy to identify.
- Everyone knows who they are.
- Approachability
- Must be at least receptive to people.
International Gatekeepers tend to be Engineers or Scientists, who have worked in other countries and returned home.

Engineers and Scientists visiting from other countries had very high foreign contact, but insufficient domestic contact to be International Gatekeepers.
The Dual Ladder

Managerial

Technical

VP
AD
DM
DH
SH
GS
LE

 $$$
 $$
 $

 SDSS
 SSS
 SS

 $$$
 $$
 $

 Engineer A
 Engineer B
 Engineer C
Distribution of Positions in One Firm's Dual Ladder
Criteria for Technical Ladder Promotion

Managerial

Technical

VP
AD
DM
DH
SH
GS
LE

$$$
$$
$

$SS$SS$SDSS$$$

$\$$
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$\$

Engineer A
Engineer B
Engineer C
The Biggest Problem with the Dual Ladder

Managerial

Technical

VP
AD
DM
DH
SH
GS
LE

Engineer A
Engineer B
Engineer C

AD
DM
SH
GS
LE

VP
AD
DM
DH
SH
GS
LE

$$$ $$ $  
SDSS SSS SS

$$$ $$ $  
SDSS SSS SS
Choosing Each of Three Possible Career Paths

- MANAGEMENT 32%
- TECHNICAL LADDER 20%
- PROJECT ASSIGNMENT 48%
Career Preference as a Function of Age (N = 1,402)
Preferences of Technical Ladder Staff as a Function of Age (N = 351)
Career Preferences of Managers as a Function of Age (N = 374)

![Graph showing career preferences of managers as a function of age. The graph includes lines for Management, Interesting Projects, and Technical Ladder.]
The Process of Innovation
Departmental Organization
Departmental Organization

Technology

D1 → D2 → D3 → D4 → D5

Market
Time & Coordination

- Time can always be substituted for coordination!
- and the converse…
- Better coordination can reduce development time.
Project Team Organization

[Diagram showing a flow from Technology to Market through P1 to P6]
Matrix Organization

Technology

Market

D1 D2 D3 D4 D5 D6

P1 P2 P3 P4 P5 P6 P7 P8
Matrix Organization

Technology

Market

D1 D6 D2 D3 D4 D5

P1 P2 P3 P4 P5 P6 P7 P8

Battle Zone
The Basic Tradeoff and Dilemma in Product Development Organization

- **Departmental Organization**
  - Departmental structure is more closely mapped to the structure of the supporting technologies.
  - It thereby provides a better connection to those technologies and better ongoing technical support to the project effort.
  - This is, however, accomplished at the cost of much greater difficulty in coordination of the project tasks and less responsiveness to market change.

- **Project Team Organization**
  - Project Team structure groups people from different disciplines together in a single team all reporting to a common manager.
  - It thereby provides better coordination of the project tasks and increased sensitivity to market dynamics.
  - This is, however, accomplished at the cost of a separation from the disciplinary knowledge underlying the project effort. When this is carried to an extreme, it will gradually erode the technology base of the organization.
Organizational Structure Space I

\[ \frac{dK}{dt} = \text{rate of change of knowledge} \]

\[ I_{ss} = \text{subsystem interdependence} \]
Organizational Structure Space II

I_{ss}

Project Team

Departments

\frac{dK}{dt}
Organizational Structure Space III

\[ I_{ss} \]

Project

Team

\[ T_1 > T_2 \]

Department

\[ \frac{dK}{dt} \]
Structuring the Organization

- **Standard Industrial Practice**
  - Ignores the rate at which technologies are developing (despite the fact that this can often be measured).
  - Usually ignores the interdependencies in project work (seasoned project managers are an exception).
  - Focuses on project duration (and usually makes the wrong decision on this parameter).
Organizational Structure Space IV

\[
\frac{dM}{dt}, \quad \frac{dK}{dt}, \quad I_{ss}, \quad T_i
\]

- Project
- Team
- Department
Organizational Structure Space V

- $\frac{dK}{dt}$
- $\frac{dM}{dt}$
- $T_i$
- Department
- Project Team
- $I_{ss}$
BMW FIZ Concurrent Engineering
Matrix Connections to Market and Technology
Matrix Connections to Market and Technology
Some Problems

Market Competition for Resources

Technology
Problems with Imbalance
The Need for Balance
The Inescapable Conflict
A More Complete Matrix Using Integrated Product Teams
Matrix Connections to Product Development and Manufacturing Engineering
Management of Transitions

• The critical points of vulnerability in the life of a project are the points of transition.
  – Transitions can involve many parameters, for example:
    • People
    • Management
    • Leadership & leadership style.
    • Primary organizational responsibility and reporting relationships.
    • Nature of the work.
    • Types of knowledge required.
    • Physical location.

• To change all of these simultaneously is to court disaster.
Management of Transitions II

Diagram showing the relationship between Project Size & Scope and Time, with Transition Points indicated.
Management of Transitions IV

• **Projects must be protected through transitions.**
  – There must be areas of continuity to offset the areas of change.
  – Team size must grow in a gradual fashion.
    • This has implications for both organizational structure and physical architecture.
    • Both must be very flexible to allow this to happen along with a gradual transition in reporting relationship.
  – There should be an extra effort to retain a sense of ‘ownership’ among team members.
    • Avoid ‘runway management’.
Management of Transitions III

![Diagram showing project size and scope over time with transition points indicated.](image-url)
social order

spatial order organizational order
Transition Performance

Location of Engineers

Separate

Co-Located

Performance

p < 0.001
PERFORMANCE AS A FUNCTION OF GROUP AGE
(PELZ & ANDREWS)
Project Performance as a Function of Team Age
(45 Chemical Industry Projects)
External Technical Communication as a Function of Team Age
(45 Chemical Industry Projects)
WORK PREFERENCES AS A FUNCTION OF MEAN TENURE
(PELZ & ANDREWS)
Perceived Influence Over Project Goals & Objectives
(Teams with Mean Tenure Greater Than Five Years)

![Bar chart showing Mean Perceived Influence for Project Team Performance.

- **Low** Project Team Performance:
  - Engineers: High influence
  - Project Manager: Low influence

- **High** Project Team Performance:
  - Engineers: Moderate influence
  - Project Manager: High influence

Legend:
- Engineers
- Project Manager
PERFORMANCE AS A FUNCTION OF GROUP AGE
(PELZ & ANDREWS)
Project Performance as a Function of Team Age
(45 Chemical Industry Projects)
Project Performance as a Function of Team Age
(45 Chemical Industry Projects)
Project Performance and External Communication as a Function of Team Age
(45 Chemical Industry Projects)
Project Performance and External Communication as a Function of Team Age
(45 Chemical Industry Projects)
WORK PREFERENCES AS A FUNCTION OF MEAN TENURE
(PELZ & ANDREWS)

![Graph showing work preferences as a function of mean tenure. The x-axis represents the mean tenure of group members in years, ranging from 0 to 12. The y-axis represents the degree of preference, ranging from 30 to 65. Two lines are shown: one for broad exploration of new areas in green, and one for deep exploration of narrow areas in orange. The graph indicates that as mean tenure increases, the preference for broad exploration decreases, while the preference for deep exploration increases.]
Perceived Influence Over Project Goals & Objectives
(Teams with Mean Tenure Greater Than Five Years)
We Shape Our Buildings

"On the night of May 10, 1941, with one of the last bombs of the last serious raid, our House of Commons was destroyed by the violence of the enemy, and we have now to consider whether we should build it up again, and how, and when. **We shape our buildings, and afterwards our buildings shape us.** Having dwelt and served for more than forty years in the late Chamber, and having derived very great pleasure and advantage therefrom, I, naturally, should like to see it restored in all essentials to its old form, convenience and dignity."

- WSC, 28 October 1943 to the House of Commons (meeting in the House of Lords).

Notes: The old House of Commons was rebuilt in 1950 in its old form, remaining insufficient to seat all its members. Churchill was against "giving each member a desk to sit at and a lid to bang" because, he explained, the House would be mostly empty most of the time; whereas, at critical votes and moments, it would fill beyond capacity, with members spilling out into the aisles, in his view a suitable "sense of crowd and urgency."
Proportion of Communication Partners as a Function of Distance
Probability of Technical Communication as a Function of Distance Between Work Stations

![Graph showing the probability of weekly communication as a function of separation distance in meters. The probability decreases rapidly as the separation distance increases.]
Intradepartmental and Interdepartmental Communication and Physical Separation

Smoothed Probability of Communication vs. Separation Distance (Meters)

- INTRA-DEPARTMENTAL
- INTER-DEPARTMENTAL
The Effect of Organization I

\[ P(C) \]

\[ D = f(1/N) \]

\[ \text{DISTANCE} \]
The Effect of Organization II

 DISTANCE

 P = f(Iss)

 D = f(1/N)
Some Obvious Points

\[ P(C) \]

- \( S_2 < S_1 \)
- \( p_2 < p_1 \)
- \( S_3 < S_1 \)
- \( p_3 > p_1 \)

Distance
Departmental Size

![Graph showing the relationship between size of department and probability of communication. The graph plots probability of communication on the y-axis and size of department on the x-axis. There are two data sets represented: Smoothed P(C) and Raw Data. The graph includes a trend line labeled "Power (Raw Data)." ]
Face-to-Face and Telephone Communication
‘Bandwidth’ Limitation

Low Complexity Information

- Within a Floor
- Within a Building
- Within a Site
- Between Sites

Proportion of Contacts

High Complexity Information

- Within a Floor
- Within a Building
- Within a Site
- Between Sites

Proportion of Contacts

Face-to-Face  Telephone
Steelcase Ground Floor
Steelcase Third Floor
Effect of New Steelcase Building on Breadth of Communication

- **Mean Number of Communication Partners per Person**
- **Time (Weeks)**

![Graph showing the effect of moving to a new building on the breadth of communication. The graph displays a decrease in the mean number of communication partners per person after moving, followed by an increase and then a decrease. There is a notable increase around week 8, labeled as "Move to New Building."