ESD.36J System & Project Management

Dynamics of Project Performance

System Dynamics and Project Management

Class Four (10/2/03)
Topics

- Review Practice for 10/3
- Staff and schedule dynamics
- Managing the Dynamics & Summary
- Homework 4
Graph for Effect of Prior Work Quality on Quality

Time (Month)

Effect of Prior Work Quality on Quality : Class3 Step1
Effect of Prior Work Quality on Quality : Class2 Step2

Dimensionless
Dimensionless
With short time to discover rework, quality is better ...

Graph for Quality

Time (Month)

Quality : Class3 Step1
Quality : Class3 Step1 Short TDRW

Fraction

Fraction

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... because undiscovered rework is lower
Less work needs to be done and the project finishes sooner.
Lesson: *It’s the undiscovered rework!*
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Staff and Schedule Dynamics

- Schedule pressure
- Adding staff
- Slipping schedule
Schedule Pressure
Schedule Pressure

- How might management respond when a project falls behind schedule?
Schedule Pressure

How might management respond when a project falls behind schedule?

- Pressure team to work faster
- Work longer hours/overtime
Schedule Pressure

- How might management respond when a project falls behind schedule?
  - Pressure team to work faster
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- Downsides --
  - “Haste makes waste”
  - Fatigue adds to mistakes (and may reduce productivity)
Table for Effect of Schedule Pressure on PDY

Effect of Schedule Pressure on Productivity

Normal Productivity

Productivity

Anticipated Schedule Overrun

Perceived Real Completion Date

Scheduled Completion Date

Initial Scheduled Completion

Indicated Completion Date Based on Progress

Staff Level

Estimated Cost to Complete

<Work to Do>

<Project Finished>

<Time>

Average Productivity

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Expected completion date:

- When will the project finish, given current time, estimated person-years remaining, and staff?
- Estimated person-years remaining = work to do divided by productivity (person-months)
- Average Productivity = work believed to be done divided by cumulative effort expended (tasks/person-month)
Effect of Schedule Pressure …

… On Productivity

\[ p - \text{Table for Effect of Schedule Pressure} \]

\[ \begin{array}{c|c}
  \text{Anticipated Schedule Overrun (fraction)} & 2 \\
  0 & 1 \\
  -0.2 & 0 \\
\end{array} \]

… On Quality

\[ \kappa - \text{Table for Effect of Schedule Pressure} \]

\[ \begin{array}{c|c}
  \text{Anticipated Schedule Overrun (fraction)} & 1 \\
  0 & 1 \\
  0 & 0 \\
\end{array} \]

The tables are the inverse of each other
Example

- Effect of Schedule Pressure on Productivity = Sensitivity for Effect of Schedule Pressure on Productivity * Table for Effect of Schedule Pressure on Productivity + (1 - Sensitivity for Effect of Schedule Pressure on Productivity)
Output = Input Table * Sensitivity + (1 - Sensitivity)
Schedule Pressure Simulations

- If the effect of schedule pressure on quality is the exact opposite of that on productivity, schedule pressure in this simple model causes the project to finish somewhat later and cost more (Class3 Step2 vs Step1).

- However, if the quality effect is stronger than the productivity effect (Class3 Step2 PDY), then schedule pressure causes a significant delay in finishing.
Graph for Cumulative Work Done

Cumulative Work Done: Class3 Step1
Cumulative Work Done: Class3 Step2
Cumulative Work Done: Class3 Step2 PDY

Time (Month)
Lesson: Monitoring/creating the wrong pressures can be counterproductive.
Staffing
Adding Staff

Assumptions

- hiring/transfer in delays equal 4 months, transfer out 1 month
- 24 months are required to gain full experience
- inexperienced staff work at 50% productivity and quality of experienced staff
- there is no limit on staff available
Changing Schedule
(not included in Class4.mdl)
Summary of Model to Date

- Model has 3 effects on P & Q:
  - Quality on quality
  - Schedule pressure
  - Experience
- Decisions to increase or reduce staffing
- Decisions to change scheduled completion date (to be added later)
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Now that we understand what causes this behavior ... 

... what can we do about it?
How does it get started?
How does it get started?

Dynamics are initiated by (1) an infeasible initial plan, or (2) changes adding scope and obsoleting completed work ...
What makes it worse?

Diagram showing the relationships between various factors such as Time Remaining, Organisational Size Changes, Turnover, Hiring, Staffing Requested, Overtime, Equivalent Staff on Project, Hours Expended to Date, Expected Hours at Completion, Productivity, Quality, Skill & Experience, Morale, Schedule Pressure, Out-of-Sequence Work, Availability of Prerequisites, Work Quality to Date, Work to Be Done, Work Really Done, Known Rework, Undiscovered Rework, Added Work, Rework Discovery, Perceived Progress.
What makes it worse?

Corrective actions to get the project back on track...
What makes it worse?

... create vicious circles that undercut intended effects
Remember --

- PRODUCTIVITY = NORMAL PRODUCTIVITY * EFFECT OF STAFF EXPERIENCE * EFFECT OF QUALITY OF PRIOR WORK* ...

- Dimensions:
  - Productivity -- Tasks/Month/Person
  - Normal Productivity -- Tasks/Month/Person
  - Effects -- “Dimensionless”
The effects are laws of nature ...

What determines how the project moves up and down the curves?
Management Actions!

- Work Quality to Date
- Scheduled Completion Time
- Expected Completion Time
- Skill & Experience
- Schedule Pressure
- Staff
- Organisational Size Changes
- Out-of-Sequence Work
- Availability of Prerequisites
- Progress
- Added Work
- Work To Be Done
- Work Really Done
- Known Rework
- Undiscovered Rework
- Rework Discovery
- Perceived Progress
- Time Remaining
- Overtime
- Equivalent Staff on Project
- Hiring
- Turnover
- Staffing Requested
- Hours Expended to Date
- Expected Hours at Completion
- Management Actions
- Hours to Date
- Hours at Completion
- Work Quality
Major Themes to Date

- Viewpoint on causes of dynamic behavior, and an introduction to the theory and tools to understand that behavior
- Insights into the dynamics of complex projects
- *One* model of the causes of those dynamics
Are There Alternative Models?

- More P & Q effects, etc.
- Variations on the basic rework cycle
- Multi-project and organizational models
More Productivity and Quality Effects:

- Model has 3 effects on P & Q:
  - Quality on quality
  - Schedule pressure
  - Experience

- What additional affects could be included?
  - Morale
  - Overtime
  - Sequence
  - Other types of experience
  - Organizational Size Changes
  - Availability of supplier information
  - and materials
  - Skills match to needs
  - ...

...
Other simplifications?

- Task dependence/sequence is not represented explicitly -- with enough staff, could finish the project in a week
- Only one phase of work explicitly represented
- Suppliers are not represented
- Interactions with other projects are not represented

*These are treated endogenously or exogenously in more comprehensive models, and will be discussed in the remaining sessions.*
When is the project finished?

- In the current model, keep working until all work is completed correctly. In other situations, schedule may be more critical and therefore the project might:
  - reduce scope to meet schedule
  - ship with errors
Variations on the Basic Rework Cycle

- Abdel-Hamid software development model
- Ford-Sterman product development model

(see SD Bibliography on server)
Broader Dynamics

- Multi-project and organizational dynamics:
  - implementation of new tools and processes
  - competition between concurrent and future projects for resources

(We will discuss later in the term, but see Repenning and Sterman websites)
Does the basic model apply to ...

- ... Product development vs. one-of-a-kind construction projects?
- ... Hardware vs. software?
- ... Consumer products vs. military?
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Brooks’ Law