Software Productivity Decoded
How Data Science helps to Achieve More
Thomas Zimmermann, Microsoft Research, USA
What makes software engineering research at Microsoft unique?

Easy access to industrial problems and data
Easy access to engineers
Near term impact
Collaborations with Microsoft researchers
Collaborations with external researchers
Product group engagement

- Windows
- Office 365
- Bing
- Visual Studio
- Xbox
What metrics are the best predictors of failures?

What is the data quality level used in empirical studies and how much does it actually matter?

I just submitted a bug report. Will it be fixed?

If I increase test coverage, will that actually increase software quality?

Are there any metrics that are indicators of failures in both Open Source and Commercial domains?

Should I be writing unit tests in my software project?

Is strong code ownership good or bad for software quality?

Does Distributed/Global software development affect quality?

How can I tell if a piece of software will have vulnerabilities?

Do cross-cutting concerns cause defects?

Does Test Driven Development (TDD) produce better code in shorter time?

What is the data quality level used in empirical studies and how much does it actually matter?

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Data Science

Productivity
Use of data, analysis, and systematic reasoning to [inform and] make decisions
Web analytics

(Slide by Ray Buse)

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Game analytics

Halo heat maps

Free to play
Usage analytics

Improving the File Explorer for Windows 8

Explorer in Windows 7

Alex Simons: Improvements in Windows Explorer.
Top 10 commands are 81.8% of Explorer command use
Command usage in Windows Explorer

- Paste: 18%
- Properties: 10%
- Copy: 8%
- Delete: 9%
- Rename: 7%
- Refresh: 6%
- Cut: 5%
- NewMenu: 4%
- CommandBar: 3%
- New: 2%

Commands in Command bar
Overlay showing Command usage % by button on the new Home tab
Trinity of software analytics

Dongmei Zhang, Shi Han, Yingnong Dang, Jian-Guang Lou, Haidong Zhang, Tao Xie:

MSR Asia Software Analytics group: http://research.microsoft.com/en-us/groups/sa/

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History of software analytics

EARLY “GLOBAL” MODELS AND SOFTWARE ANALYTICS

As soon as people started programming, it became apparent that programming was an inherently buggy process. As recalled by Maurice Wilkes, speaking of his programming experiences from the early 1950s: “It was on one of my journeys between the EDSAC room and the punching equipment that ‘hesitating at the angles of stairs’ the realization came over me with full force that a good part of the remainder of my life was going to be spent in finding errors in my own programs.”

It took several decades to gather the experience required to quantify the size/defect relationship. In 1971, Fumio Akiyama described the first known “size” law, saying the number of defects $D$ was a function of the number of LOC; specifically, $D = 4.86 + 0.018 \times i$. In 1976, Thomas McCabe argued that the number of LOC was less important than the complexity of that code. He argued that code is more likely to be defective when his “cyclomatic complexity” measure was over 10.

Not only is programming an inherently buggy process, it’s also inherently difficult. Based on data from 63 projects, Barry Boehm proposed in 1981 an estimator for development effort that was exponential on program size: effort = $a \times$ KLOCb $\times$ EffortMultipliers, where $2.4 \leq a \leq 3$ and $1.05 \leq b \leq 1.2$.

References
SOFTWARE ANALYTICS: SO WHAT?

Sustainable Embedded Software // 72
Emerging Metrics for Assessing Software // 99

THE MANY FACES OF SOFTWARE ANALYTICS
Perspectives on Data Science for Software Engineering

Edited by Tim Menzies, Laurie Williams, Thomas Zimmermann


http://tiny.cc/superdog
PEOPLE
Data Scientist: The Sexiest Job of the 21st Century

by Thomas H. Davenport and D.J. Patil

FROM THE OCTOBER 2012 ISSUE

When Jonathan Goldman arrived for work in June 2006 at LinkedIn, the business networking site, the place still felt like a start-up. The company had just under 8 million accounts, and the number was growing quickly as existing members invited their friends and colleagues to join. But users weren’t seeking out connections with the people who were already on the site at the rate executives had expected. Something was apparently missing in the social experience. As one LinkedIn manager put it, “It was like arriving at a conference reception and realizing you don’t know anyone. So you just stand in the corner sipping your drink—and you probably leave early.”

Goldman, a PhD in physics from Stanford, was intrigued by the linking he did see going on and by the richness of the user profiles. It all made for messy data and unwieldy analysis, but as he began exploring people’s connections, he started to see possibilities. He began forming theories, testing hunches, and finding patterns that allowed him to predict whose networks a given profile would land in. He could imagine that new features capitalizing on the heuristics he was developing might help close the gap between the two sides of the site.
Obsessing over our customers is everybody's job. I'm looking to the engineering teams to build the experiences our customers love. [...] In order to deliver the experiences our customers need for the mobile-first and cloud-first world, we will modernize our engineering processes to be customer-obsessed, data-driven, speed-oriented and quality-focused.
Each engineering group will have **Data and Applied Science resources** that will focus on measurable outcomes for our products and predictive analysis of market trends, which will allow us to innovate more effectively.

http://news.microsoft.com/ceo/bold-ambition/index.html
The Data Scientists
Miryung Kim, Thomas Zimmermann, Robert DeLine, Andrew Begel:
The Emerging Role of Data Scientists on Software Development Teams. ICSE 2016.
## Methodology

### Interviews

16 data scientists
- 5 women and 11 men from eight different Microsoft organizations

**Snowball sampling**
- data-driven engineering meet-ups and technical community meetings
- word of mouth

**Coding with Atlas.TI**

**Clustering of participants**

### Survey

793 responses
- full-time data scientists
- employees with interest in data science

**Questions about**
- demographics
- skills
- self-perception
- working styles
- time spent
- challenges and best practices
Background of data scientists

Most CS, many interdisciplinary backgrounds

Many have higher education degrees

Survey: 41% have master’s degrees, and 22% have PhDs

Strong passion for data

I’ve always been a data kind of guy. I love playing with data. I’m very focused on how you can organize and make sense of data and being able to find patterns. I love patterns. [P14]

“Machine learning hackers“. Need to know stats

My people have to know statistics. They need to be able to answer sample size questions, design experiment questions, know standard deviations, p-value, confidence intervals, etc.
Background of data scientists

PhD training contributes to working style

*It has never been, in my four years, that somebody came and said, “Can you answer this question?” I mostly sit around thinking, “How can I be helpful?” Probably that part of your PhD is you are figuring out what is the most important questions.* [P13]

*I have a PhD in experimental physics, so pretty much, I am used to designing experiments.* [P6]

*Doing data science is kind of like doing research. It looks like a good problem and looks like a good idea. You think you may have an approach, but then maybe you end up with a dead end.* [P5]
Typical data science workflow

Activities of data scientists

Preparation
  Data engineering platform; Telemetry injection; Experimentation platform

Analysis
  Data merging and cleaning; Sampling; Data shaping including selecting and creating features; Defining sensible metrics; Building predictive models; Defining ground truths; Hypothesis testing

Dissemination
  Operationalizing predictive models; Defining actions and triggers; Translating insights and models to business values
Time spent on activities

Hours spent on certain activities (self reported, survey, N=532)
Time spent on activities

Cluster analysis on relative time spent (k-means)

532 data scientists at Microsoft
## Time spent on activities

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Query existing data</th>
<th>Prepare data</th>
<th>Analyze data</th>
<th>Experiment</th>
<th>Validate insight</th>
<th>Disseminate insight</th>
<th>Engage with others</th>
<th>Operationalize insight</th>
<th>Act on insight</th>
<th>Other work related to DS</th>
<th>Other work not related to DS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entire population</td>
<td>12.0% 4.7h</td>
<td>7.2% 2.9h</td>
<td>11.7% 4.9h</td>
<td>12.5% 5.2h</td>
<td>4.8% 2.1h</td>
<td>6.9% 3.0h</td>
<td>8.5% 3.5h</td>
<td>9.2% 3.8h</td>
<td>2.4% 1.1h</td>
<td>5.5% 2.1h</td>
<td>4.1% 1.9h</td>
</tr>
<tr>
<td>532 people</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cluster 1 Polymath</td>
<td>10.4% 4.4h</td>
<td>8.5% 3.6h</td>
<td>11.5% 5.1h</td>
<td>15.1% 6.7h</td>
<td>9.1% 4.0h</td>
<td>7.7% 3.6h</td>
<td>7.4% 3.5h</td>
<td>7.9% 3.6h</td>
<td>3.2% 1.5h</td>
<td>5.2% 2.3h</td>
<td>4.0% 2.0h</td>
</tr>
<tr>
<td>156 people</td>
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<td></td>
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</tr>
<tr>
<td>Cluster 2 Data</td>
<td>6.6% 2.2h</td>
<td>2.1% 1.0h</td>
<td>6.7% 2.5h</td>
<td>7.7% 2.9h</td>
<td>2.4% 1.2h</td>
<td>7.0% 2.6h</td>
<td>12.0% 4.5h</td>
<td>23.0% 8.6h</td>
<td>3.7% 1.3h</td>
<td>9.5% 3.3h</td>
<td>13.4% 6.0h</td>
</tr>
<tr>
<td>Evangelist 71 people</td>
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</tr>
<tr>
<td>Cluster 3 Data</td>
<td>24.5% 9.4h</td>
<td>4.9% 1.9h</td>
<td>19.6% 7.8h</td>
<td>10.0% 4.0h</td>
<td>3.0% 1.3h</td>
<td>9.0% 4.1h</td>
<td>11.6% 4.5h</td>
<td>8.8% 3.5h</td>
<td>1.5% 0.7h</td>
<td>3.9% 1.3h</td>
<td>1.5% 0.7h</td>
</tr>
<tr>
<td>Preparer 122 people</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cluster 4 Data</td>
<td>5.6% 2.5h</td>
<td>1.8% 0.7h</td>
<td>27.0% 11.5h</td>
<td>25.7% 10.9h</td>
<td>6.0% 2.6h</td>
<td>8.9% 3.8h</td>
<td>7.6% 3.3h</td>
<td>7.5% 3.2h</td>
<td>2.1% 1.0h</td>
<td>3.3% 1.4h</td>
<td>2.5% 1.1h</td>
</tr>
<tr>
<td>Shaper 33 people</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

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## Time spent on activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Entire population 532 people</th>
<th>Cluster 5 Data Analyzer 24 people</th>
<th>Cluster 6 Platform Builder 27 people</th>
<th>Cluster 7 Moonlighter 50% 63 people</th>
<th>Cluster 8 Moonlighter 20% 32 people</th>
<th>Cluster 9 Insight Actor 4 people</th>
</tr>
</thead>
<tbody>
<tr>
<td>Build platforms to gather data</td>
<td>4.7h</td>
<td>3.7h</td>
<td>4.4h</td>
<td>3.1h</td>
<td>1.2h</td>
<td>0.1h</td>
</tr>
<tr>
<td>Prepare data</td>
<td>2.9h</td>
<td>0.9%</td>
<td>2.6h</td>
<td>2.2h</td>
<td>0.6%</td>
<td>2.1%</td>
</tr>
<tr>
<td>Query existing data</td>
<td>4.9h</td>
<td>5.8%</td>
<td>1.9h</td>
<td>2.4h</td>
<td>0.9%</td>
<td>0.2%</td>
</tr>
<tr>
<td>Analyze data</td>
<td>11.7%</td>
<td>5.2%</td>
<td>3.8%</td>
<td>4.3%</td>
<td>0.9%</td>
<td>1.8%</td>
</tr>
<tr>
<td>Experiment</td>
<td>12.5%</td>
<td>12.5%</td>
<td>6.1%</td>
<td>6.1%</td>
<td>2.7%</td>
<td>0.9%</td>
</tr>
<tr>
<td>Validate insight</td>
<td>4.8%</td>
<td>2.1%</td>
<td>1.9h</td>
<td>1.1h</td>
<td>1.2%</td>
<td>0.9%</td>
</tr>
<tr>
<td>Disseminate insight</td>
<td>6.9%</td>
<td>3.0%</td>
<td>4.3%</td>
<td>1.1h</td>
<td>2.0%</td>
<td>0.7%</td>
</tr>
<tr>
<td>Engage with others</td>
<td>8.5%</td>
<td>3.5%</td>
<td>2.7%</td>
<td>1.2%</td>
<td>2.0%</td>
<td>0.8%</td>
</tr>
<tr>
<td>Operationalize insight</td>
<td>9.2%</td>
<td>3.8%</td>
<td>2.2%</td>
<td>2.0%</td>
<td>1.0%</td>
<td>1.1%</td>
</tr>
<tr>
<td>Act on insight</td>
<td>2.4%</td>
<td>1.1%</td>
<td>1.8%</td>
<td>2.4h</td>
<td>2.1%</td>
<td>3.0%</td>
</tr>
<tr>
<td>Other work related to DS</td>
<td>5.5%</td>
<td>2.1%</td>
<td>4.2%</td>
<td>1.6h</td>
<td>1.4%</td>
<td>0.6%</td>
</tr>
<tr>
<td>Other work not related to DS</td>
<td>4.1%</td>
<td>1.9%</td>
<td>2.8%</td>
<td>1.3h</td>
<td>6.9%</td>
<td>3.1%</td>
</tr>
<tr>
<td>Insights</td>
<td>15.1%</td>
<td>6.7%</td>
<td>3.2%</td>
<td>1.3%</td>
<td>6.9%</td>
<td>3.1%</td>
</tr>
</tbody>
</table>

Note: The table shows the percentage and hours spent on various activities across different clusters of individuals.
# Types of data scientists

<table>
<thead>
<tr>
<th>Generalists</th>
<th>Polymath</th>
<th>“describes data scientists who ‘do it all’ ”</th>
<th>Data Creatives</th>
<th>“data scientists [who] can often tackle the entire soup-to-nuts analytics process on their own”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specialist</td>
<td>Data Preparer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specialist</td>
<td>Data Shaper</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specialist</td>
<td>Data Analyzer / Insight Provider</td>
<td>“main task is to generate insights and to support and guide their managers in decision making”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specialist</td>
<td>Platform Builder</td>
<td>“build shared data platforms used across several product teams”</td>
<td>Data Developer</td>
<td>“people focused on the technical problem of managing data”</td>
</tr>
<tr>
<td>Specialist</td>
<td>Modelling Specialist</td>
<td>“data scientists who act as expert consultants and build predictive models”</td>
<td>Data Researcher</td>
<td>people with “deep academic training in the use of data to understand complex processes”</td>
</tr>
<tr>
<td>Manager</td>
<td>Data Evangelist / Team Leader</td>
<td>“senior data scientists who run their own data science teams act as data science ‘evangelists’ ”</td>
<td>Data Businesspeople</td>
<td>people who “are most focused on the organization and how data projects yield profit”</td>
</tr>
<tr>
<td>Moonlighter</td>
<td>50% Moonlighter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moonlighter</td>
<td>20% Moonlighter</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Andrew Begel

Andrew Begel, Thomas Zimmermann:
Analyze this! 145 questions for data scientists in software engineering. ICSE 2014
Meet Greg Wilson from Mozilla
It Will Never Work in Theory

Ten Questions for Researchers
Posted Aug 22, 2012 by Greg Wilson

I gave the opening talk at MSR Vision 2020 in Kingston on Monday (slides), and in the wake of that, an experienced developers at Mozilla sent me a list of ten questions he'd really like empirical software engineering researchers to answer. They're interesting in their own right, but I think they also reveal a lot about what practitioners want from researchers in general; comments would be very welcome.

1. Vi vs. Emacs vs. graphical editors/IDEs: which makes me more productive?
2. Should language developers spend their time on tools, syntax, library, or something else (like speed)? What makes the most difference to their users?
3. Do unit tests save more time in debugging than they take to write/run/keep updated?
Let’s ask Microsoft engineers what they would like to know!
SURVEY

203 participants, 728 questions R1..R728

Suppose you could work with a team of data scientists and data analysts who specialize in studying how software is developed. Please list up to five questions you would like them to answer.

★ CATEGORIES

Use an open card sort to group questions into categories.

12 categories C1..C12

★ DESCRIPTIVE QUESTIONS

Summarize each category with a set of descriptive questions.

145 questions Q1..Q145
SURVEY

607 participants, 16765 ratings

Split questionnaire design, where each participant received a subset of the questions Q1..Q145 (on average 27.6) and was asked:

*In your opinion, how important is it to have a software data analytics team answer this question?*

[Essential | Worthwhile | Unimportant | Unwise | I don’t understand]

★ TOP/BOTTOM RANKED QUESTIONS

★ DIFFERENCES IN DEMOGRAPHICS

  Discipline: Development, Testing, Program Management
  Region: Asia, Europe, North America, Other
  Number of Full-Time Employees
  Current Role: Manager, Individual Contributor
  Years as Manager
  Has Management Experience: yes, no.
  Years at Microsoft
# Microsoft’s Top 10 Questions

<table>
<thead>
<tr>
<th>Question</th>
<th>Essential</th>
<th>Essential + Worthwhile</th>
</tr>
</thead>
<tbody>
<tr>
<td>How do users typically use my application?</td>
<td>80.0%</td>
<td>99.2%</td>
</tr>
<tr>
<td>What parts of a software product are most used and/or loved by customers?</td>
<td>72.0%</td>
<td>98.5%</td>
</tr>
<tr>
<td>How effective are the quality gates we run at checkin?</td>
<td>62.4%</td>
<td>96.6%</td>
</tr>
<tr>
<td>How can we improve collaboration and sharing between teams?</td>
<td>54.5%</td>
<td>96.4%</td>
</tr>
<tr>
<td>What are the best key performance indicators (KPIs) for monitoring services?</td>
<td>53.2%</td>
<td>93.6%</td>
</tr>
<tr>
<td>What is the impact of a code change or requirements change to the project and its tests?</td>
<td>52.1%</td>
<td>94.0%</td>
</tr>
<tr>
<td>What is the impact of tools on productivity?</td>
<td>50.5%</td>
<td>97.2%</td>
</tr>
<tr>
<td>How do I avoid reinventing the wheel by sharing and/or searching for code?</td>
<td>50.0%</td>
<td>90.9%</td>
</tr>
<tr>
<td>What are the common patterns of execution in my application?</td>
<td>48.7%</td>
<td>96.6%</td>
</tr>
<tr>
<td>How well does test coverage correspond to actual code usage by our customers?</td>
<td>48.7%</td>
<td>92.0%</td>
</tr>
</tbody>
</table>
## Microsoft’s 10 Most Unwise Questions

<table>
<thead>
<tr>
<th>Question</th>
<th>Unwise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which <strong>individual measures correlate with employee productivity</strong> (e.g. employee age, tenure, engineering skills, education, promotion velocity, IQ)?</td>
<td>25.5%</td>
</tr>
<tr>
<td>Which <strong>coding measures correlate with employee productivity</strong> (e.g. lines of code, time it takes to build software, particular tool set, pair programming, number of hours of coding per day, programming language)?</td>
<td>22.0%</td>
</tr>
<tr>
<td>What metrics can use used to <strong>compare employees</strong>?</td>
<td>21.3%</td>
</tr>
<tr>
<td>How can we <strong>measure the productivity of a Microsoft employee</strong>?</td>
<td>20.9%</td>
</tr>
<tr>
<td>Is the number of bugs a good <strong>measure of developer effectiveness</strong>?</td>
<td>17.2%</td>
</tr>
<tr>
<td>Can I generate 100% test coverage?</td>
<td>14.4%</td>
</tr>
<tr>
<td>Who should be in charge of creating and maintaining a consistent company-wide software process and tool chain?</td>
<td>12.3%</td>
</tr>
<tr>
<td>What are the benefits of a consistent, company-wide software process and tool chain?</td>
<td>10.4%</td>
</tr>
<tr>
<td>When are code comments worth the effort to write them?</td>
<td>9.6%</td>
</tr>
<tr>
<td>How much time and money does it cost to add customer input into your design?</td>
<td>8.3%</td>
</tr>
</tbody>
</table>
Success Strategies
Take your time to define ground truth

You have communication going back and forth where you will find what you’re actually looking for, what is anomalous and what is not anomalous in the set of data that they looked at.
Operationalization of models is important

They accepted [the model] and they understood all the results and they were very excited about it. Then, there’s a phase that comes in where the actual model has to go into production. ... You really need to have somebody who is confident enough to take this from a dev side of things.
Translate findings into business values

In terms of convincing, if you just present all these numbers like precision and recall factors... that is important from the knowledge sharing model transfer perspective. But if you are out there to sell your model or ideas, this will not work because the people who will be in the decision-making seat will not be the ones doing the model transfer. So, for those people, what we did is cost benefit analysis where we showed how our model was adding the new revenue on top of what they already had.
Choose the right questions for the right team

(a) Is it a **priority** for the organization

(b) is it **actionable**, if I get an answer to this, is this something someone can do something with? and,

(c), are you as the feature team — if you're coming to me or if I'm going to you, telling you this is a good opportunity — are you committing resources to deliver a change?

If those things are not true, then it's not worth us talking anymore.
Work closely with consumers from day one

You begin to find out, you begin to ask questions, you being to see things. And so you need that interaction with the people that own the code, if you will, or the feature, to be able to learn together as you go and refine your questions and refine your answers to get to the ultimate insights that you need.
Explain the findings in simple terms

A super smart data scientist, their understanding and presentation of their findings is usually way over the head of the managers...so my guidance to [data scientists], is *dumb everything down to seventh-grade level*, right? And whether you're writing or you're presenting charts, you know, keep it simple.
Productivity
What is productivity?

Productivity

From Wikipedia, the free encyclopedia

This article is about the economic and business concept. For other uses, see Productivity (disambiguation).

Productivity describes various measures of the efficiency of production. A productivity measure is expressed as the ratio of output to inputs used in a production process, i.e. output per unit of input. Productivity is a crucial factor in production performance of firms and nations. Increasing national productivity can raise living standards because more real income improves people's ability to purchase goods and services, enjoy leisure, improve housing and education and contribute to social and environmental programs. Productivity growth also helps businesses to be more profitable.

There are many different definitions of productivity and the choice among them depends on the purpose of the productivity measurement and/or data availability.
What is productivity?

Productivity = \frac{\text{Output}}{\text{Input}}
Examples of productivity measures

From academic papers

- number of modification requests and added lines of code per year
- number of tasks per month
- number of function points per month
- number of source lines of code per hour
- number of lines of code per person month of coding effort
- amount of work completed per reported hour of effort for each technology
- ratio of produced logical code lines and spent effort
- average number of logical source statements output per month over the product development cycle
- total equivalent lines of code per person-month
- resolution time defined as the time, in days, it took to resolve a particular modification request
- number of editing events to number of selection and navigation events needed to find where to edit code
What influences productivity?

Technical factors

Product: complexity, quality, constraints
Process: maturity, completeness of design
Development environment: tools, modern development practices, programming language, documentation

What influences productivity?

Social factors
Corporate culture: fairness, respect, credibility
Team culture: team cohesion, turnover

Capabilities and experiences:
programmer capability, experience with application domain, platform, language, and tool,

Work environment: fragmentation, separation

Project: average team size

Different levels of productivity

Individual

Team

Organization
Individual Productivity
Personal Software Process

PSP
A Self-Improvement Process for Software Engineers

Watts S. Humphrey
Fitness Tracking
André N. Meyer, Laura Barton, Gail C. Murphy, Thomas Zimmermann, Thomas Fritz. The Work Life of Developers: Activities, Switches and Perceived Productivity. IEEE TSE

André N. Meyer, Thomas Fritz, Gail C. Murphy, Thomas Zimmermann: Software developers' perceptions of productivity. SIGSOFT FSE 2014
Survey: Method & Participants

28 questions on background, perceptions, assessing, measuring and improving productivity

Recruitment through emails and posts in online forums

379 participants
194 within Microsoft, 185 public survey
9.2 years of professional experience on average
Survey: Method & Participants

Productivity

Please complete the following sentence in up to three ways:

I have a productive workday when...

1
2
3

Are you satisfied with your productivity of your prior workday?

- very unsatisfied
- unsatisfied
- undecided
- satisfied
- very satisfied

Are you satisfied with your productivity last week?

- very unsatisfied
- unsatisfied
- undecided
- satisfied
- very satisfied
I have a productive workday when

I complete the goals I set for myself that day.

I get through my list of tasks for the day.

I write more than 10 lines of code.

I wrote at least 1 line of code.

I am focused on one work item and have all the inputs I need to close on that work item.

I am in a good mood and slept well :)

I am not randomized too much by meetings and interruptions from others

I have a productive workday when I have autonomy on what I do and don't have to wait for response from other side of earth.

I have at most one meeting.

I have no code reviews to complete.

Get what I have planned done

When the weather is dry and I can work at a silent and well ventilated place.

I get enough rest and can take nap when I feel tired.
I have a productive workday when

<table>
<thead>
<tr>
<th>Statement</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Complete tasks or goals</td>
<td>53.2%</td>
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<tr>
<td>Have no/few interruptions and distractions</td>
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<td>Have no meetings</td>
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<td>Have clear goals</td>
<td>19.9%</td>
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<tr>
<td>Plan my workday</td>
<td>17.2%</td>
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Developers feel productive when they make progress on tasks with few context switches.
### Productive/unproductive activities

#### Productive activities

- Coding: 72%
- Meetings: 17%
- Planning: 7%

#### Unproductive activities

- Meetings: 58%
- Emails: 19%
- Unplanned work: 18%

Based on a survey of 379 professional developers from many different companies.
Measures to assess productivity

Which measures are helpful to assess your productivity?

**Number of**

- API methods I learned
- **Code elements** I changed
  - Code elements I changed for the first time
- **Code reviews** I’ve contributed to
  - Code reviews I’ve signed off
- **Commits** I made
- **Emails** I wrote
- **Lines of code** I changed per day
- **Meetings** I attended
- **Test cases** I wrote
  - Test cases I wrote that subsequently failed
- **Work items** I closed
  - Work items I created
  - Work items I created that were fixed

**Time spent**

- **Writing** code
- **Reviewing** code
- **Meetings**
- **Browsing** for work
  - Browsing for personal matters
  - Per code project or package
  - Per work item
  - Sign off on code reviews (average)
  - Respond to email (average)
Measures to assess productivity

Which measures are helpful to assess your productivity?
Measures to assess productivity

Which measures are helpful to assess your productivity?

“The number of commits I made.”
Mean: 2.84, Standard Deviation: ±1.38

“The time I spent in meetings.”
Mean: 3.31, Standard Deviation: ±1.34
Measures to assess productivity

Which measures are helpful to assess your productivity?

“The number of work items (tasks, bugs) I closed.”
Mean: 3.88, Standard Deviation: 1.22
Observing developers

- **R1**: 96 activity switches, 28 task switches, 4 distinct tasks
- **R2**: 102 activity switches, 61 task switches, 6 distinct tasks
- **R3**: 108 activity switches, 16 task switches, 5 distinct tasks
- **R4**: 148 activity switches, 27 task switches, 4 distinct tasks
- **S1**: 88 activity switches, 17 task switches, 5 distinct tasks
- **S2**: 59 activity switches, 20 task switches, 5 distinct tasks
- **S3**: 85 activity switches, 13 task switches, 4 distinct tasks
- **S4**: 230 activity switches, 79 task switches, 4 distinct tasks
- **T1**: 166 activity switches, 79 task switches, 4 distinct tasks
- **T2**: 51 activity switches, 10 task switches, 3 distinct tasks

**Legend**:
- Dev:VC
- Dev:Debug
- Dev:Code
- Dev:Review
- Dev:TestApp
- Dev:Other
- BrowsingRel
- BrowsingUnrel
- MeetInformal
- MeetPlanned
- Email
- Planning
- ReadWriteDoc
- Other

**Time [minutes]**
Observing developers

148 activity switches, 27 task switches
Observing developers

Participants felt fairly productive, yet switched frequently between tasks (13.5 times/hour) and between activities (47 times/hour).

Cost of a context switch varies
Retrospection

The tool collects data about:
Activity – Application usage – Meeting information – Email statistics – Perceived Productivity
Additional findings
Based on data collected from 20 users of the retrospection tool

Developers only spend about half their time active on their computer.

For every work hour, developers have an average of 2.5 short breaks, totaling 10.5 minutes of unplanned time away from their computer.

Developers spend about a fourth of their time on coding related activities and another fourth of their time on collaborative activities.

The range and time spent on activities varies greatly depending on the individual and company.

Developers’ work is highly fragmented, spending very short amounts of time (0.3 to 2 minutes) in one activity before switching to another one.
When are people productive?

Please fill out the following survey:

Hint: The term session refers to the time period since the beginning of your workday or the time you last answered this survey today.

Compared to your normal level of productivity, how productive do you consider the previous session?

[1 2 3 4 5 6 7]

Please specify the activities (tasks, meetings, breaks, etc.) you performed on in the previous session:

Quick insert: Planned meeting Unplanned meeting (helped co-worker) Lunch Break

Thank you!

Personal Analytics: Mini-Survey

Please fill out the survey. It will take about 1 min.

Take Survey now

Take Survey in 5 mins

Take Survey in 1 hour

Take Survey in 1 day

Thank you!
Productivity patterns

Higher productivity in the afternoon

Lower productivity during lunch
## Productivity models

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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** The table represents productivity models with various metrics and their corresponding values for different participants and activities. The graph below the table visualizes the distribution of ratings.
# Productivity models

<table>
<thead>
<tr>
<th>Participant</th>
<th>51</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratings (total)</td>
<td>45</td>
</tr>
<tr>
<td>Ratings (discarded)</td>
<td>0</td>
</tr>
<tr>
<td>Ratings (included in model)</td>
<td>45</td>
</tr>
<tr>
<td>Ratings (distribution)</td>
<td></td>
</tr>
</tbody>
</table>

**Session Duration (in hours)**

**Percent of Session Before Noon**

**Per Minute**

- # self-reported tasks: +
- # activity switches: NA
- # meetings: NA
- # instant messaging switches: NA
- # keystrokes: +
- # mouse clicks: +

**Percent Activity**

- Dev. Coding: NA
- Dev. Debugger Use: NA
- Dev. Code Reviews: NA
- Dev. Version Control: NA
- Email:
  - Planning: NA
  - Read / write documents: +
  - Planned meeting: NA
  - Informal meeting: NA
  - Instant messaging: NA
- Work related browsing: NA
- Work unrelated browsing: NA
- Other: NA
- Other RDP: NA
- Idle: NA
# Productivity models

<table>
<thead>
<tr>
<th>Participant</th>
<th>S2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratings (total)</td>
<td>101</td>
</tr>
<tr>
<td>Ratings (discarded)</td>
<td>29</td>
</tr>
<tr>
<td>Ratings (included in model)</td>
<td>72</td>
</tr>
<tr>
<td>Ratings (distribution)</td>
<td></td>
</tr>
</tbody>
</table>

**Session Duration (in hours)**

**Percent of Session Before Noon**

**Per Minute**

- # self-reported tasks
- # activity switches
- # meetings
- # instant messaging switches
- # keystrokes
- # mouse clicks

**Percent Activity**

- Dev. Coding
- Dev. Debugger Use
- Dev. Code Reviews
- Dev. Version Control
- Email
- Planning
- Read / write documents
- Planned meeting
- Informal meeting
- Instant messaging
- Work related browsing
- Work unrelated browsing
- Other
- Other RDP
- Idle

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# Productivity models

<table>
<thead>
<tr>
<th>Participant</th>
<th>S3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratings (total)</td>
<td>62</td>
</tr>
<tr>
<td>Ratings (discarded)</td>
<td>3</td>
</tr>
<tr>
<td>Ratings (included in model)</td>
<td>59</td>
</tr>
<tr>
<td>Ratings (distribution)</td>
<td></td>
</tr>
</tbody>
</table>

**Session Duration (in hours)**

**Percent of Session Before Noon**

<table>
<thead>
<tr>
<th>Per Minute</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td># self-reported tasks</td>
<td></td>
</tr>
<tr>
<td># activity switches</td>
<td></td>
</tr>
<tr>
<td># meetings</td>
<td>NA</td>
</tr>
<tr>
<td># instant messaging switches</td>
<td>NA</td>
</tr>
<tr>
<td># keystrokes</td>
<td></td>
</tr>
<tr>
<td># mouse clicks</td>
<td>+</td>
</tr>
</tbody>
</table>

**Percent Activity**

<table>
<thead>
<tr>
<th>Dev. Coding</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dev. Debugger Use</td>
<td>NA</td>
</tr>
<tr>
<td>Dev. Code Reviews</td>
<td>NA</td>
</tr>
<tr>
<td>Dev. Version Control</td>
<td></td>
</tr>
<tr>
<td>Email</td>
<td></td>
</tr>
<tr>
<td>Planning</td>
<td></td>
</tr>
<tr>
<td>Read / write documents</td>
<td>+</td>
</tr>
<tr>
<td>Planned meeting</td>
<td>NA</td>
</tr>
<tr>
<td>Informal meeting</td>
<td>NA</td>
</tr>
<tr>
<td>Instant messaging</td>
<td>NA</td>
</tr>
<tr>
<td>Work related browsing</td>
<td></td>
</tr>
<tr>
<td>Work unrelated browsing</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
<tr>
<td>Other RDP</td>
<td>NA</td>
</tr>
<tr>
<td>Idle</td>
<td></td>
</tr>
</tbody>
</table>

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Productivity models

No two explanatory models are the same.

Perceived productivity depends on the individual.
Productivity models

No single factor provides explanatory power across all participants.

The Number of Keystrokes and the Number of Mouse Clicks (7× each) have more often positive influence.

The percent of activities Email (5×), Planned Meeting (6×), Work Unrelated Browsing (5×), and Idle (6×) have more often negative influence.
Towards personas of developers

No two developers are the same but some are similar to each other

413 developers at Microsoft

Clustering based on survey responses
Perceptions of productivity

I feel more productive in the morning than in the afternoon.
I feel more productive in the afternoon than in the morning.
I feel productive on a day with little to no meetings.
I feel productive when I do code reviews.
I feel productive when I write code.
I feel productive when I listen to music.
I feel productive when I take a quick break, e.g., on Facebook.
I feel productive when I help my co-workers.
I feel productive when I read fewer emails than usual.

... (nine additional statements on productivity)
Six types of developers

Based on perceptions of productivity in a survey of 413 developers at Microsoft.

**Social developer**
- Feels productive when helping coworkers, collaborating, and doing code review

**Lone developer**
- Avoids disruptions such as noise, meetings, and code reviews
- Feels productive when they are not interrupted

**Focused developer**
- Feels most productive when working on a single task

**Balanced developer**
- Less affected by disruptions
- Feels unproductive when unfamiliar with tasks or when the tasks are unclear

**Leading developer**
- More comfortable with meetings
- Places less importance on coding activities than other developers

**Goal-oriented developer**
- Feels productive when completing or making progress on tasks
- Feels less productive when multi-tasking, without goals, or stuck
- More positive about meetings
Shared perceptions across the types

**HIGHER SCORES**

- I feel productive when I write code (5 of the 6 types)
- I feel productive on a day with little to no meetings (4 of the 6 types)
- I feel productive when I am happy (4 of the 6 types)
- I feel productive when I have fewer interruptions (4 of the 6 types)

- The time I spent coding (5 of the 6)
- The longest period focused on a task without an interruption

**LOWER SCORES**

- I feel productive when I send more emails than usual (5 of the 6 types)
- I feel I had a productive work day when my email inbox is emptier in the evening than in the morning (4 of the 6 types)
- I feel productive when I visit social networks or news websites to do a quick break (4 of the 6 types)
- If I have many program windows open on my screen, it decreases my perceived productivity
- I feel productive on a particular day of the week, e.g., on Wednesdays (5 of the 6)
- I feel more productive in the morning than in the afternoon (5 of the 6 types)
- I feel less productive after lunch compared to the rest of the day (4 of the 6 types)
Personas based on time spent

Acantha, the Autonomist Acumen
Lilo, the Continuous Learner
Isabelle, the Investigator
Cameron, the Communicator
Iman, the Interactive
Ava, the Advisor
Ciara, the Team Coder

Denae Ford, Thomas Zimmermann, Christian Bird and Nachiappan Nagappan
Characterizing Software Engineering Work with Personas Based on Knowledge Worker Actions
In International Symposium on Empirical Software Engineering and Measurement (ESEM 2017)
Opportunities for research

PSP on Steroids
Opportunities for research

PSP on Steroids

“Personal” Process Mining
Opportunities for research

PSP on Steroids

“Personal” Process Mining

Personal Tutors
Observing developers

Participants felt fairly productive, yet switched frequently between tasks (13.5 times/hour) and between activities (47 times/hour)

Cost of a context switch varies

Productivity models

No two explanatory models are the same.
Perceived productivity depends on the individual
YOU HAVEN'T SEEN ANYTHING UNTIL YOU'VE SEEN EVERYTHING*
Thank you!