Course "Softwareprozesse"

Agile Technical Practices: eXtreme Programming (XP) , Part II

Lutz Prechelt
Freie Universität Berlin, Institut für Informatik

- Shared Code, Coding Standards
- Refactoring
- Simple Design, Incremental Design

- Practices support each other
- Values and practices

- Criticism of XP
- Usage survey
- When not to use XP
- Introducing XP
- Further technical practices

Practices of XP, XP2, Jeffries' XP

(furthermore, XP2 has 11 "Corollary Practices")

Freie Universität Berlin

XP1 practices ("traditional"):

1.	The Planning Game	M ✓
2.	Small Releases	M ✓
3.	40-Hour Week	M ✓
4.	On-Site Customer	M ✓
5.	Pair Programming	T
6.	Collective Ownership	T ←
7.	Metaphor	T
8.	Simple Design	T ←
9.	Refactoring	T ←
10.	Testing	T ✓
11.	Continuous Integration	T ✓
12.	Coding Standards	T ←

M: Mgmt, T: Technical

XP2 practices ("evolutionary"):

1.	Stories	M ✓
2.	Weekly Cycle	M (✓)
3.	Quarterly Cycle	M ✓
4.	Energized Work	M ✓
5.	Slack	M ✓
6.	Whole Team	M ✓
7.	Sit Together	M ✓
8.	Informative Workspace	M ✓
9.	Pair Programming	T
10.	Incremental Design	T ←
11.	Test-First Programming	T ✓
12.	Continuous Integration	T ✓
13.	Ten-Minute Build	T ✓

J: Jeffries' additional practice:

- Customer tests T ✓

Shared code, XP1/J: Coding standards

Freie Universität Berlin

- Shared Code (corollary practice, XP1: Collective code ownership) means
  - *"Anyone on the team can improve any part of the system at any time."*
- Important for agility
  - especially Simple Design
- Requires a sense of responsibility
  - hence is corollary in XP2

- Coding standards (XP1) means
  - there are rules for code formatting
  - and for naming
- Important to make Shared Code and Pair Programming practical

- No longer in XP2
  - because it has become nearly self-understood

XP1/J: Refactoring

- Refactoring means modifying the structure of a program without modifying its behavior
  - M. Fowler: "*Refactoring: Improving the Design of Existing Code*", Addison-Wesley 2018 (1st ed: 1999)
  - There are a number of well-defined elementary refactoring operations, e.g.:
    - Rename
    - Change Function Declaration
    - Collapse X, Combine X, Decompose X, Encapsulate X, Move X, Remove X, Replace X with Y, Split X
    - Extract Class/Function/Superclass/Variable
      - opposite: Inline Class/Function/Variable
    - Pull Up, Push Down elements in class hierarchy

- Modern IDEs support or even automate some refactoring operations
  - Eclipse, the IntelliJ family, less so Visual Studio Code

What is Refactoring?

- Refactoring is not just
  improving the design structure of a program
  - This is unavoidable in iterative development
- It is
  improving the design structure without changing the behavior
  - This can be a simplification if you have a good test suite
  - It is cumbersome otherwise

- XP allows courageous refactoring: the **automated tests** make it easy to verify whether a refactoring is correct

Fowler: Workflows of refactoring

- Martin Fowler: "Workflows of Refactoring", OOP 2014
  - Video
- TDD refactoring (2:28)
  - post-hoc design
- "Yuck!" refactoring (7:25)
  - clean up bad code
- "I-don't-understand-this" refactoring (10:25)
  - Materialize freshly gained understanding
- *Always: Find the right time (12:38)*
  - *Refactor only if tests are green!*
- "We-should-have-done-it-this-way" refactoring (14:40)
  - prepare for future features
- Planned refactoring (17:30)
  - for all I have not yet learned how to do underway
- Long-term changes (19:14)
  - gradual contributions to large-scale design changes
- Always: Purpose is 'design stamina'

Research: Motivations for refactoring

Freie Universität Berlin

- Silva, Tsantalis, Valente (FSE 2016):
  "**Why we refactor? confessions of GitHub contributors**"
  - Uses tool to monitor many Java GitHub projects for refactoring changes, validate manually →
  - Then immediately ask the author for the change reason
  - Finds that the same refactoring operation can have many different reasons:

Refactoring	TP
Extract Method	468
Move Class	432
Move Attribute	129
Rename Package	105
Move Method	99
Inline Method	58
Pull Up Method	33
Pull Up Attribute	23
Extract Superclass	22
Push Down Method	16
Push Down Attribute	15
Extract Interface	11
Total	1411

11 motivations for "Extract Method" refactoring

Freie Universität Berlin

- Extract reusable method (43)
- Introduce alternative method signature (25)
- Decompose method to improve readability (21)
- Facilitate extension (15)
- Remove duplication (14)
- Replace Method preserving backward compatibility (6)
- Improve testability (6)
- Enable overriding (4)
- Enable recursion (2)
- Introd. factory method (1)
- Introd. async operation (1)

Similarly, found several motivations for other refactorings, too:

- Move class: 9
- Move method: 5
- etc.

XP1/J: Simple Design
XP2: Incremental Design

COMMON?

- The design is completed step-by-step, along with the code
  - It is not invented all at once beforehands
    - which would be known as "Big up-front design" (BUFD)
  - At any time, the design is oriented only towards the current requirements, not to those just *expected* to come later
  - When new functions require design changes, Refactoring is used as the first step
    - in order to minimize risk

- Criticism:
  - When used naively, this may lead to very high amounts of rework, because "architecture breakers" may then occur frequently
    - In particular, the XP 1 phrasing *"Simple design"* can mislead

Simple Design:
Kent Beck's XP1 formulation

Freie Universität Berlin

[Beck99]:

- *"[Do] the simplest thing that could possibly work"*

- Simple Design:
  1. *"runs all the tests,*
  2. *communicates everything the programmers want to communicate,*
  3. *contains no duplicate code, and*
  4. *has the fewest possible classes and methods."*

Incremental Design: Kent Beck's XP2 formulation

- *"Invest in the design of the system every day.*
  - *Strive to make the design of the system an excellent fit for the needs of the system that day.*
  - *When your understanding of the best […] design leaps forward, work gradually but persistently to bring the design back into alignment with your understanding."*
  - *"Without daily attention to design, the cost of changes does skyrocket."*
- *"[Do not] minimize design investment over the short run, but […] keep the design investment in proportion to the needs of the system so far."*

- *The question is not whether or not to design,*
  - *the question is when to design.*
  - *Incremental design suggests that the most effective time to design is in the light of experience."*

- *"The simple heuristic […] is to eliminate duplication."*

What makes a design "simple"? Low redundancy

- A low amount of duplication is not the only attribute of a high-quality design
  - but worth particular attention when a design is created incrementally

- Slogan: *"Do everything once and only once"* (OAOO)
- Slogan: *"Don't repeat yourself"* (DRY)

- Eliminating redundancy usually leads to a system that can easily be extended and adapted
  - However, recognizing and eliminating redundancy is difficult!

What makes a design "incremental"? Avoid implementing ahead (YAGNI)

Freie Universität Berlin

- Experience suggests that we are not good at predicting what changes will be needed in the future
  - Some we do not see coming at all
  - Others we see coming only vaguely
    - So our precautions against them may be the wrong ones
- Investing in flexibility mechanisms (to accommodate changes) is then risky

- Slogan: *"You ain't gonna need it"* (YAGNI)
  - Do not invest into flexibility mechanisms that are not yet needed.
  - Build flexible designs
    - if that flexibility is required now or
    - if implementing that flexibility does not cost anything
  - Think ahead, but do not implement ahead.

- Depressingly little research has been done on this idea

Simple design option cost example

Assume you build the simplest possible design **D** today:

- Assume change A becomes necessary 1 year later:
  - €1000 D cost today
  - €1500 A cost next year
- Assume incompatible change B becomes necessary instead:
  - €1000 D cost today
  - €1500 B cost next year

Assume you build **D'** anticipating a change A:

- Assume change A becomes necessary 1 year later:
  - €1500 D' cost today
  - €50 interest (10% of D'-D)
  - €500 A cost next year
- Assume incompatible change B does instead:
  - €1500 D' cost today
  - €50 interest (10% of D'-D)
  - €500 A rework cost next year
  - €1500 B cost next year

If the uncertainty of A vs. B is high, D' may be a bad idea!

Why is Incremental Design critical?

- Incremental Design (I.D.) is a lot of work
  - you often shift around lots of things with no immediate functional benefit
- Non-technical stakeholders get in the way:
  - I.D.'s benefit is even harder to see than that of tests
- ➔ It is easy for a team to neglect this practice
  - requires lots of discipline to keep it up
- ➔ XP is perhaps a better starting point than Scrum

https://newsbook.com.mt/en/squirrels-stash-of-winter-walnuts-causes-car-chaos/

XP1/2/J: Pair Programming (PP)

USED INTERMITTENTLY

- All production code is written by two programmers working together at a single computer.
  - Thus, a better design can be found,
  - many mistakes can be caught immediately,
  - the partners learn from each other
    - technology, operating style, design process, project details, etc.
  - at least two people are highly familiar with each piece of code.
  - Pairs switch frequently (e.g. twice daily)
  - Collective ownership and Coding standards make PP practical.

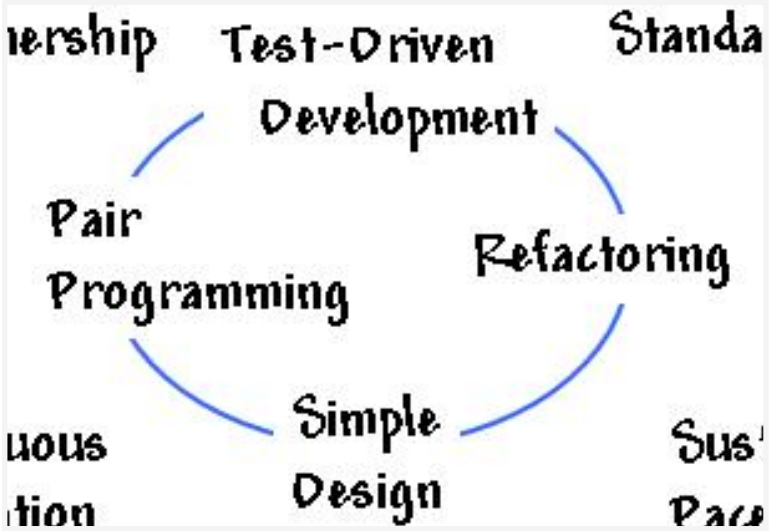
- Criticism:
  - How can this *possibly* pay off?

- (Detailed discussion next week)

Practices support each other!

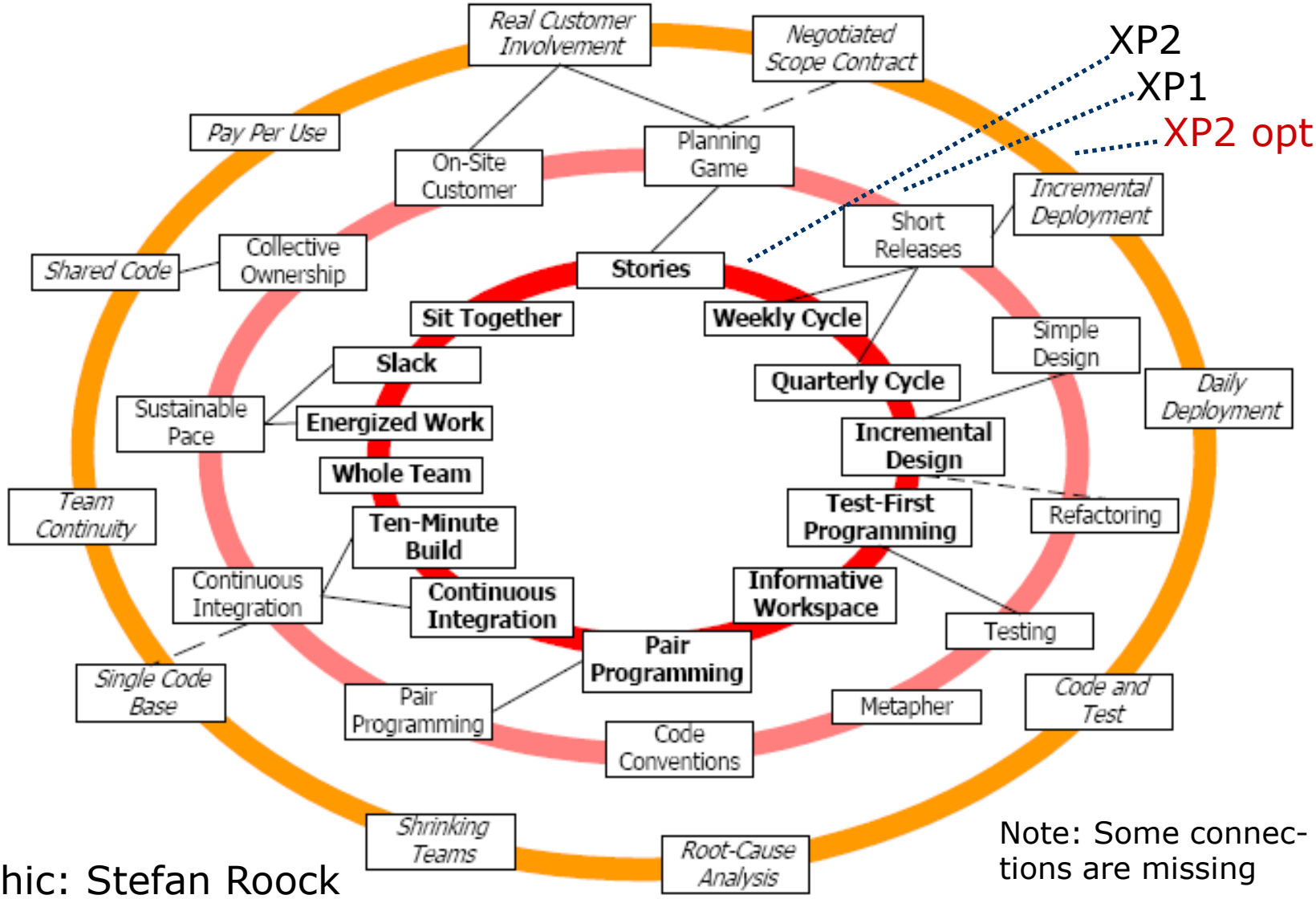
For instance:

- Incremental Design simplifies PP and TDD
- Refactoring helps
  create Incremental Design, perform PP, and perform TDD
- TDD makes Incremental Design and Refactoring
  less frightening
- PP helps maintain discipline for Incremental Design,
  Refactoring and TDD
- …and so on with other practices



Jeffries' XP core

XP corollary practices



Graphic: Stefan Roock

Note: Some connections are missing

XP2 Corollary practices

Chapter 9:

- Practices that are difficult or dangerous when the Primary practices are not yet fully in place.
  - *"Trust your nose about what you need to improve next.*
  - *If one of the following practices seems appropriate, give it a try.*
  - *It might work or you might discover that you have more work to do before you can use it to improve your development process."*

Interesting ones:

- Real Customer Involvement **M**
  - not only a proxy
- Team Continuity **M**
  - *"Keep effective teams together."*
- Root-cause Analysis **M T**
  - Remove *causes* of defects
- Code and tests **T**
  - all else will be generated
- Single Code Base **T**
  - → toggles, not branches

and others

XP values revisited

- Communication, Feedback, Courage, Respect
  sound like humanist agile *blah*.

- The values may not look technical
  but all of them are *reflected* in the technical practices

So let us look at that:

Values: Communication

- Very many problems in projects are related to communication that failed or simply did not happen
  - e.g. tacit assumptions about requirements
  - e.g. uncoordinated technical decisions **T**
  - e.g. missing information about design ideas **T**
  - e.g. missing notification about technical changes **T**

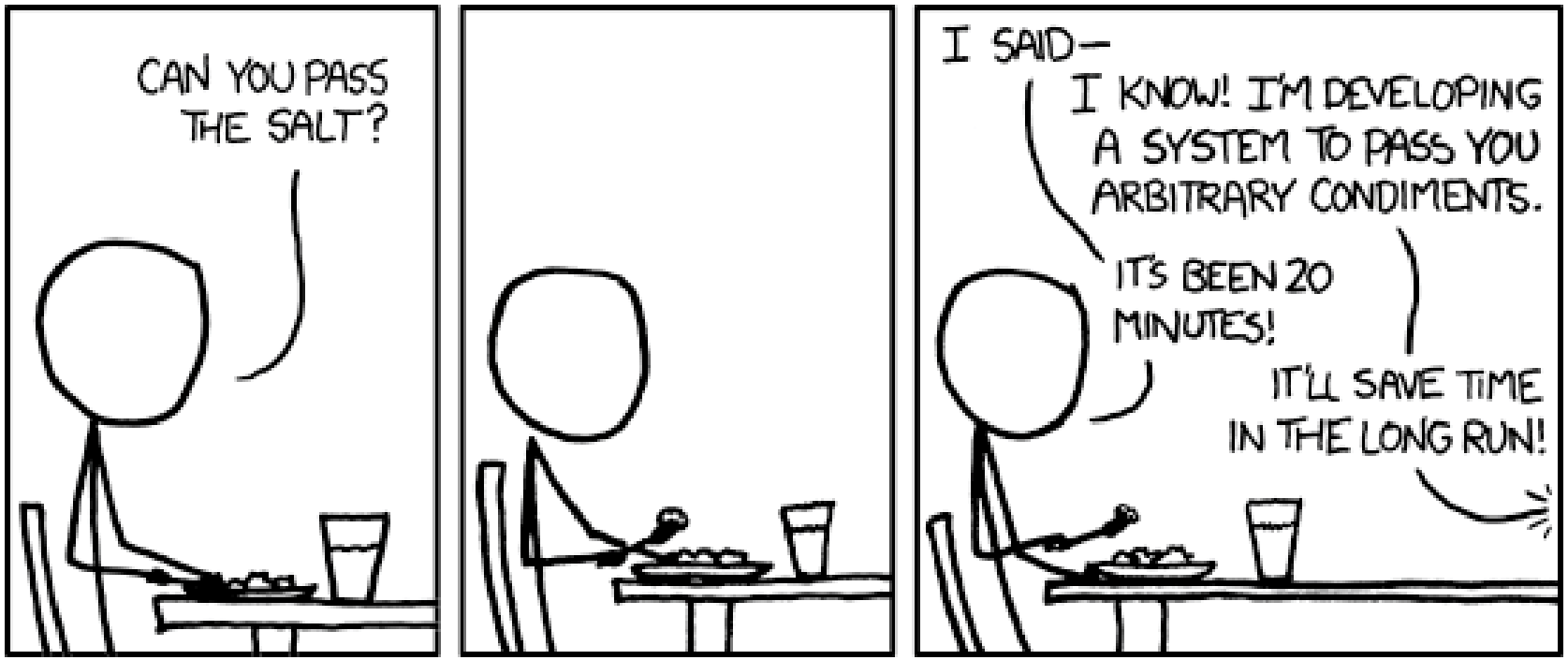
- Therefore, XP uses practices that enforce early, frequent, successful communication
  - Practices that *require* communication:
    - continuous integration **T**
    - effort estimation in the planning game
  - Practices that *create* communication:
    - pair programming **T**
    - informative workspace
    - frequent releases

Values: Simplicity

- Simple solutions have many nice properties:
  - they are easy to design **T**
  - they are easy to implement **T**
  - they are easy to test and debug **T**
  - they are easy to communicate and explain **T**
  - they are easy to change **T**
- This is true for both product and process **T**

- Therefore, XP requires to always use the simplest solution that is sufficient for today's requirements
  - and not build something more complicated in the hope that it will be needed later.
  - Slogan: **"You Ain't Gonna Need It!" (YAGNI)**

YAGNI illustrated: "You Ain't Gonna Need It"



T

Values: Feedback

- It is immensely helpful for a project if it always gets quick feedback about the consequences of actions or plans
  - How expensive would it be to realize this new requirement?
  - Is this new piece of code correct? **T**
  - Does it fit with the rest of the system? **T**
  - How useful is the system overall?

- Therefore, XP integrates concrete and immediate feedback into the process wherever possible:
  - Immediate effort estimation for each storycard
  - Short iterations and frequent releases
  - Continuous integration, a rapid build **T**
  - Unit tests for each piece of code **T**

Values: Courage

- Many aspects of realizing the first three values require courage:
  - e.g. communicating that you will change an oft-used interface
  - e.g. building a simple solution only, although you firmly expect it to become insufficient later
  - e.g. facing negative feedback about incorrect code, incompatible interfaces, infeasible requirements, or impractical aspects of a delivered system
- Therefore, XP uses a culture practice that encourages courage
  - pair programming! **T**
- and creates an infrastructure that allows to be courageous or even bold
  - in particular with automated testing **T** and continuous integration **T**

Values: Respect

- Respect
  - of one developer for another,
  - of developers for customer, and
  - of customer for developers (so we can keep up XP practices **T**)

- is an important basis for continually realizing
  - communication,
  - feedback, and [e.g. respect asks to write all those tests **T**]
  - courage

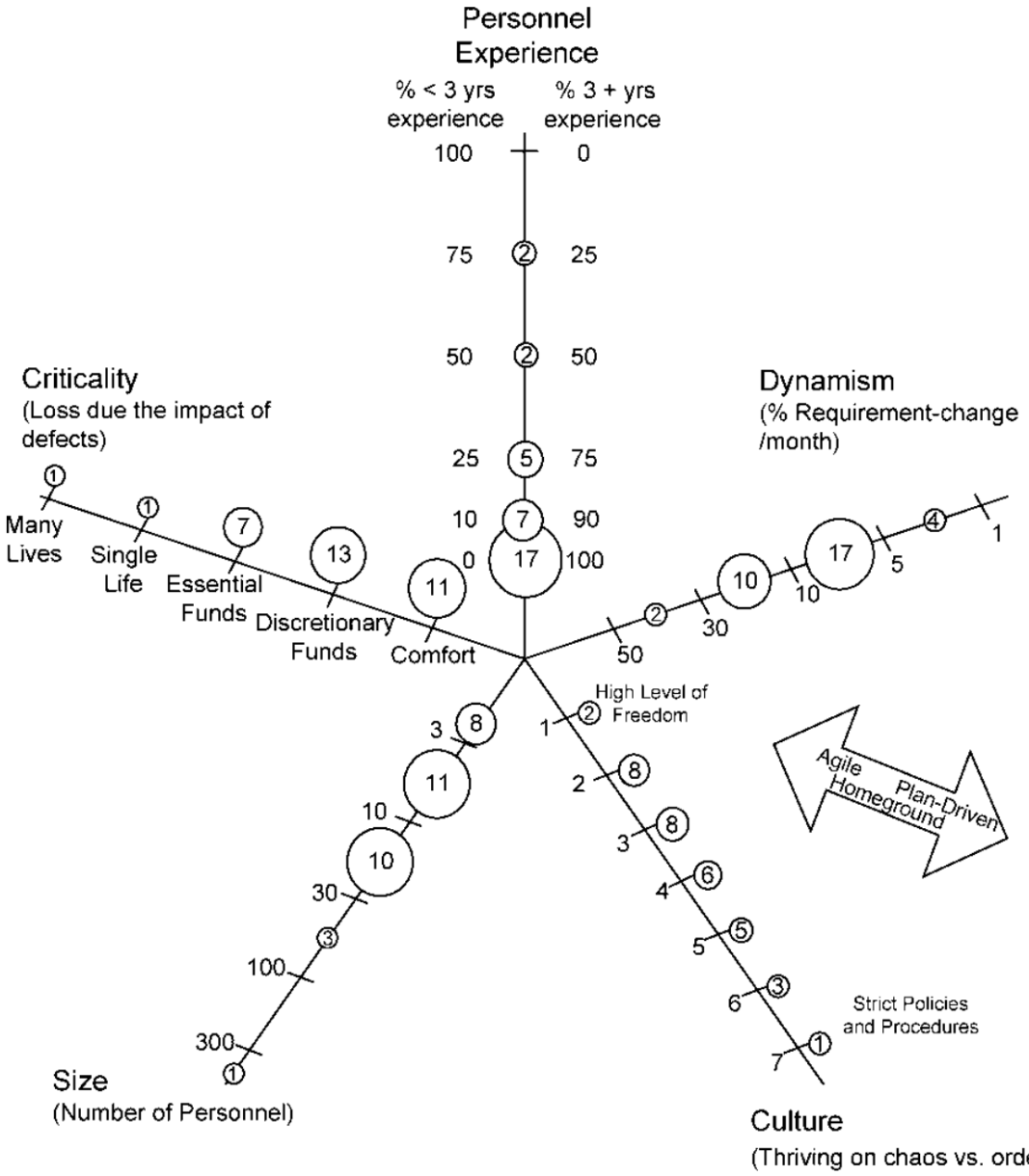
Criticism

- Gerold Keefer: "Extreme Programming Considered Harmful for Reliable Software Development 2.0", 2003
  (an earlier version appeared in the conference Conquest 2002 by isqi.org)
  - Provides overview of XP-related literature until 2002
- Critically reviews the claims and reports about XP and argues that it is recommendable only in rare situations:
  - Requires staff competence far above average
    - XP reply: People can learn
  - No documentation: Requires unusually high team stability
    - XP reply: Not unusual for us!
  - Cannot work if finding a suitable architecture is difficult
    - XP reply: Often it is not. If it is, XP-style experiments can help.
  - Is applicable only to projects of modest size
    - XP reply: Large projects can use restricted XP at team level
- Who is right?
  - Depends! (Barry Boehm's balanced judgement is a better source)

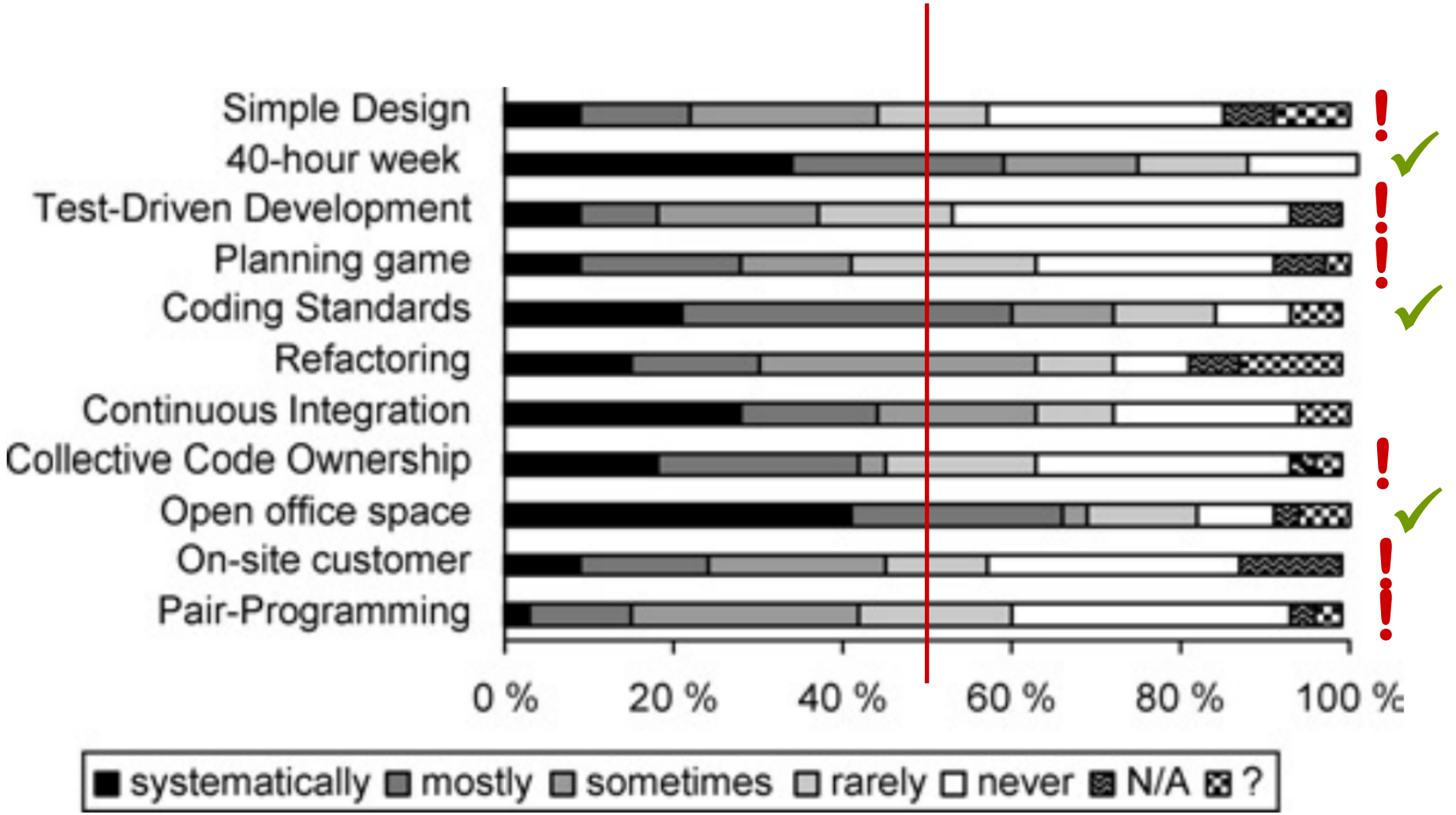
A survey of XP use in embedded(!) systems projects

Freie Universität Berlin

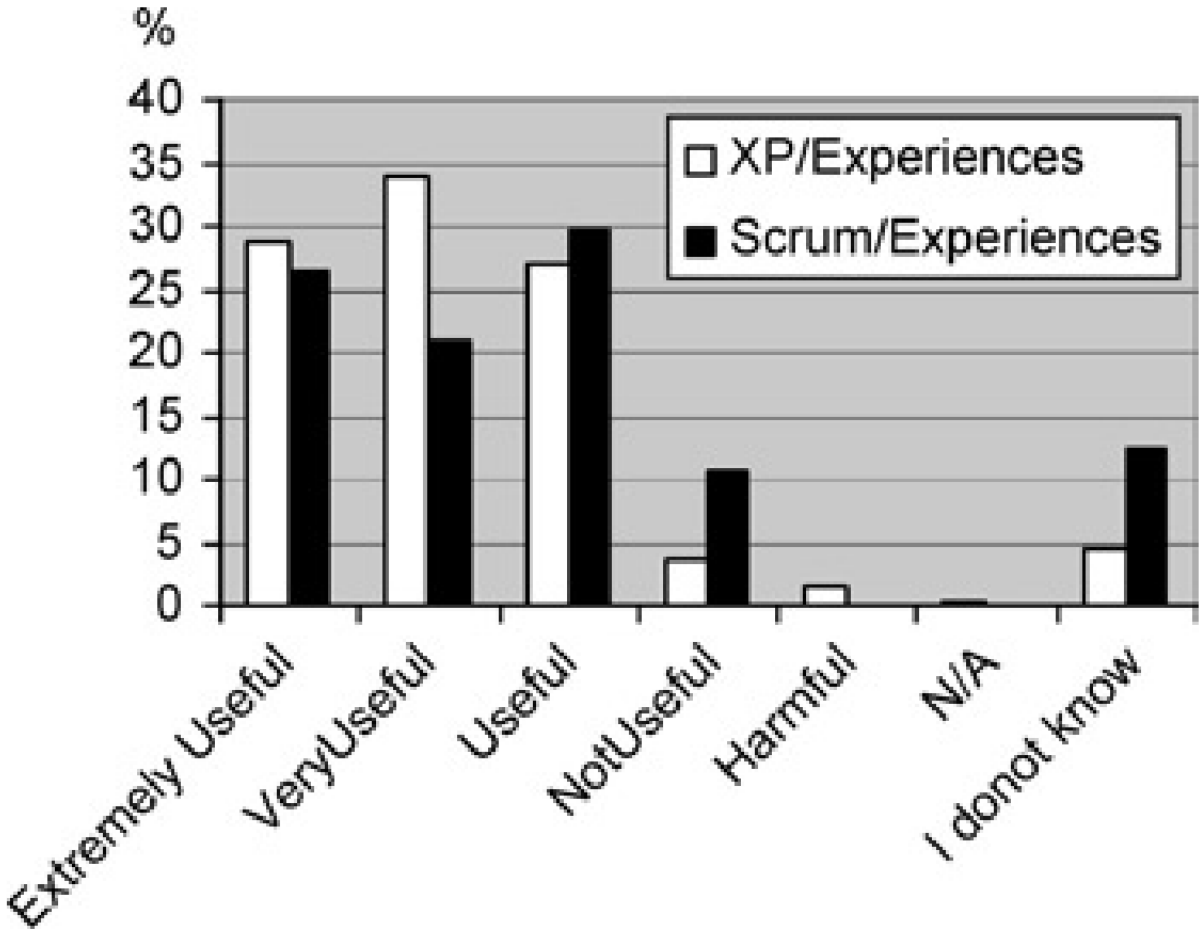
- O. Salo, P. Abrahamsson: "Agile methods in European embedded software development organisations: a survey on the actual use and usefulness of Extreme Programming and Scrum", IET Software, 2008, pp.58-64
- Responses from 35 projects
  from 13 organizations
  from 8 countries



Results: Use of XP practices



Results: Experienced usefulness



XP perceived as more useful than Scrum.

Expectations of respondents *without* XP experience were 28% negative.

When you should not use XP

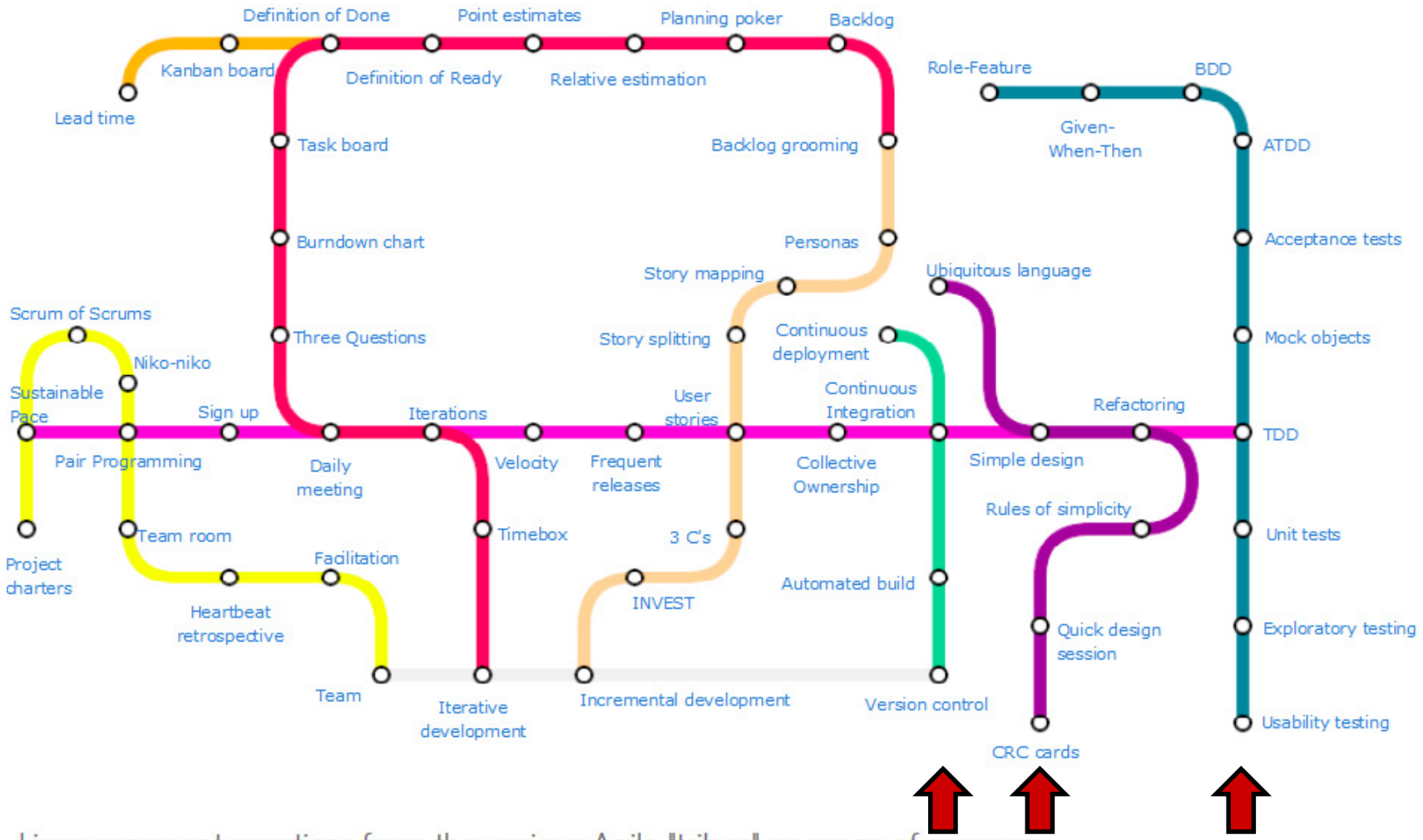
From the XP book:

- Too-big teams
  - XP works for teams of 10, can work for teams of 20
  - For teams of 100, integration (that is, design coordination) will become a bottleneck
- Unbelieving customers and organizations
  - XP requires full concentration;
    it cannot work in a culture of continuous extensive overtime
  - Customers who insist on a thick specification document
    break the whole XP process
- Change-hampering technology or constraints
  - e.g. replacing a database that absolutely must be compatible with 164 different applications
  - e.g. working with technology that makes builds take 10 hours
  - e.g. working with insufficient opportunity for immediate communication

Introducing XP

- It is difficult to introduce all XP practices at once
  - Most need to be learned!
- They can be introduced one-by-one as follows:
  - Find the worst problem/weakness of the current process
    - "Change begins with awareness."
  - Select the XP practice that can help most with this problem
  - Introduce it until the problem is much reduced
  - Find the now-worst problem and start over
- Good candidates for first practice to introduce:
  - Sit Together
  - Quarterly Cycles (→ Stories)
  - Continuous Build & Testing
  - Pair Programming

Further practices (technical & mgmt.)



https://www.agilealliance.org/agile101/subway-map-to-agile-practices/

Summary

- Agile development must work to keep design structure intact
  - Refactoring may be useful for doing this
  - Refactoring is difficult to research
- Incremental Design means avoiding to look ahead too much
  - and aim for a healthy SW structure despite the many changes
- XP practices support each other
  - and support the XP values
- XP should often be introduced practice-by-practice
  - many agile teams use technical practices too little

Thank you!

(extra slides follow)

Preamble: Why we look at XP

- In the early 2000s, XP was the most well-known agile method
  - most popular, most discussed

- Today, it is much less talked about, because many of its practices have become mainstream.
  - Many XP practices are used with most other agile methods
    - Sometimes explicitly, but often as a matter of course
  - So the relevance of knowing XP is as high as it was

- XP is still the most complete agile process model.
    - So the relevance of knowing XP is higher than it is for, say, Scrum or Kanban
  - XP focusses on technical work, less on management
  - Scrum and Kanban focus on mgmt., hardly on technical work

History

- XP is based on ideas that have been around for a long time
- XP was developed into a method in the context of one single software project (using Smalltalk)
  - "C3": *Chrysler Comprehensive Compensation*,
    a project to develop a payroll system for the 87000 employees of Chrysler Corporation.
  - 1995-01: C3 starts
  - 1996-03: C3 has not delivered any working functionality.
    Kent Beck is hired as an advisor, brings in *Ron Jeffries*,
    reduces project staff, and starts putting C3 into XP mode
  - 1996 to 1998: A period of high productivity in the project
  - 1998-08: C3 system is piloted and payrolls 10 000 employees
  - 2000-02: C3 project is canceled after Chrysler/Daimler-Benz merger

XP2/J: Whole Team, XP1: On-site customer

OFTEN VIOLATED

- All qualifications and competences required should be represented in the team
  - this includes specialized technical knowledge
  - as well as business/requirements knowledge ("on-site customer")
  - as well as project-level responsibles (coach, plan tracker)
- Thus, the team can always proceed without interruption

- Criticism:
  - It is often impossible to find a single person representing all requirements knowledge (or to bring several into the team)
  - XP requires all members to be full-time, but very specialized (and rare) technical knowledge may be needed in multiple projects

XP2: Sit Together

COMMON?

- The whole team should work as close together as possible, ideally in a single large office.
  - This greatly simplifies communication and makes it more likely to succeed
  - It greatly increases informal communication
    - by overhearing other pairs working

- Criticism:
  - 10 people in one room leads to high background noise and reduces concentration

XP1: Informative Workspace

COMMON

Freie Universität Berlin

- All important information about the project status should be available directly in the workspace, e.g.
  - currently open tasks
  - build and test status
  - architectural design sketch
- This can often be done by hanging note cards or flip chart sheets on the walls

Practice: Energized Work

COMMON?

Freie Universität Berlin

- All members of the team are motivated and work energetically at any time
  - In particular, there are no extended stretches of working overtime
    - This was formerly called "40 hour week" which was too inflexible in practice
  - Also, since Pair Programming (see below) is very intensive, a good routine of breaks and fun interludes is important

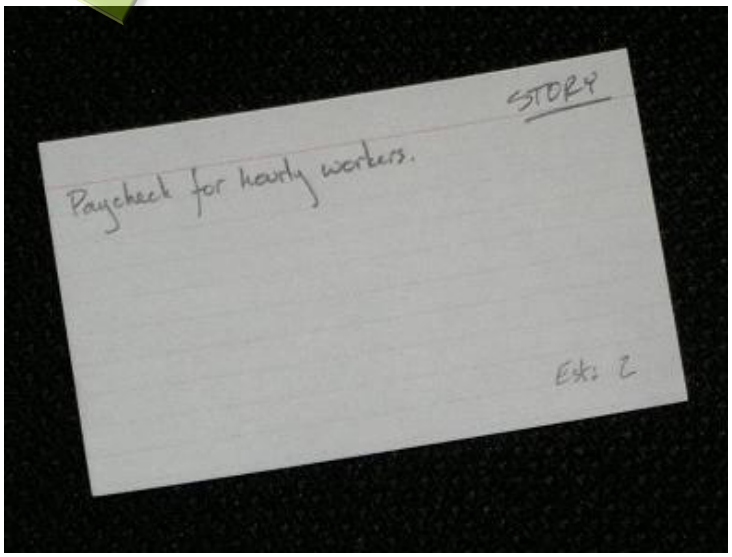
- Criticism:
  - Can you really call "working energetically" a *practice* that you consciously adopt?

Practice: Stories

COMMON

Freie Universität Berlin

- All requirements are stated in the form of stories
  - A short reminder is written on a card
  - Most of the information transfer is done verbally
  - The number of such cards must be modest
    - Mostly cards for the current iteration, never cards beyond the current release
- Criticism:
  - For some types of functionality, stories are just too imprecise
  - Non-functional requirements cannot be expressed by stories
    - but need to be considered early



www.jamesshore.com/Multimedia/Beyond-Story-Cards.html

Practice: Weekly Cycle

- The finest granularity of project-level planning is the so-called "iteration"
  - Each iteration implements one or more stories
  - An iteration should take about one week, maybe two
- The iteration is the elementary progress step visible for the customer
- During an iteration, requirements are fixed
  - Programmers can work without interruption
  - Programmers can estimate the effort well for work of this size

Practice: Quarterly Cycle

- The larger granularity of project planning is the release
  - There should be about four releases per year
  - A release is deployed into actual use by actual users (at least a pilot group) in actual business processes
- Frequent releases provide regular reality checks of the value generated by the project
  - and provide a rhythm for reflecting on the development process

- Criticism:
  - Rollout of a release is often very difficult and cannot be done frequently (e.g. because of required process changes)

Practice: Slack

- Developers have some freely available time (slack time) to be used for non-project work
  - e.g. learning about new technology.
- This time will also allow to eliminate delays from misestimation, e.g.:
  - fix yet-unknown defects
  - improve yet-unknown gaps in existing design structure
    - ("repay technical debt")
  - (in a strong XP team, these two items will be small)

- Criticism:
  - It is extremely difficult to keep up this practice in normal project reality for most organizations

Research: Refactoring impact

Freie Universität Berlin

Interpretation is difficult

- AlDAbd18: "Empirical Evaluation of the Impact of OO Code Refactoring on Quality Attributes: A SLR"
  - based on 76 studies, many using multiple datasets

	Quality attribute	++	+	Insign. 0	0	-	–
Estimated External	Maintainability	0	39	0	13	41	0
	Understandability	0	30	0	13	40	0
	Reusability	0	35	0	13	40	0
	Adaptability	0	25	0	13	40	0
	Flexibility	0	9	0	0	1	0
	Testability	0	31	0	12	35	0
	Extensibility	0	7	0	2	0	0
	Effectiveness	0	7	0	0	0	0
Measured External	Reliability	1	8	4	0	0	1
	Maintainability	6	0	4	0	0	24
Internal	Coupling	3	108	18	129	146	21
	Cohesion	52	201	54	48	72	0
	Complexity	3	89	1	69	112	13
	Size	1	42	7	17	42	4
	Inheritance	0	30	3	100	13	0
	Composition	0	2	0	3	2	0
	Data encapsulation	0	2	0	3	3	0
	Polymorphism	0	1	0	1	5	0

Research: Refactoring impact Interpretation problems

Freie Universität Berlin

- Most of the metrics applied are naive
  - e.g. coupling is a static measure: Each coupling counts the same
  - but in practice, some couplings hurt much more than others
- Tradeoffs occur:
  - To reduce coupling here, I sometimes increase coupling there
    - Perhaps avoidable, but if it costs more work and does not pay off…
- The competence of people and teams varies enormously
- (Probably several other problematic factors)
- What was even *counted* as a refactoring in those studies?
  - Refactorings are wildly mixed with other changes

Conclusion:

- The SLR does not tell us much about Refactoring.