

Techniques for Enhanced Creativity in Requirements Engineering (RE)

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Purposes of This Tutorial

- **To learn about the place of invention and creativity in the RE context**
- **To relearn an old technique for enhancing creativity in the RE context**
- **To learn a new technique for enhancing creativity in the RE context**

Vocabulary

the problem = the problem at hand

**the system = the system being built to solve
the problem at hand**

the goals = the goals of the system being built

Vocabulary, Cont'd

the requirements = the requirements of the system being built

the software (SW) = the software of the system being built

a SW system (SWS) = a complete system centered around SW

Acronyms to Save Space in Slides

RE = requirements engineering

RElic = requirements elicitation

RA = requirements analyst or engineer

RS = requirements specification

BS = brainstorming 😊

CET = creativity enhancement technique

IG = idea generation

IP = idea pruning

Each will be introduced at its first mention.

Outline

- **RE and Requirements Elicitation**
- **Invention and Creativity in RE**
- **Idea Generation and Idea Pruning**
- **Brainstorming**
 - **In-Course Brainstorming Session**
- **Summary of Other Techniques**
- **EPMcreate**
 - **POEPMcreate**
 - **In-Course POEPMcreate Session**
- **Comparative Discussion about Brainstorming and EPMcreate**

Outline, Cont'd

- **If Time Permits, Details about First Experiments Comparing EPMcreate to Brainstorming**
- **Conclusions**

Kevin Ryan's Definition of RE

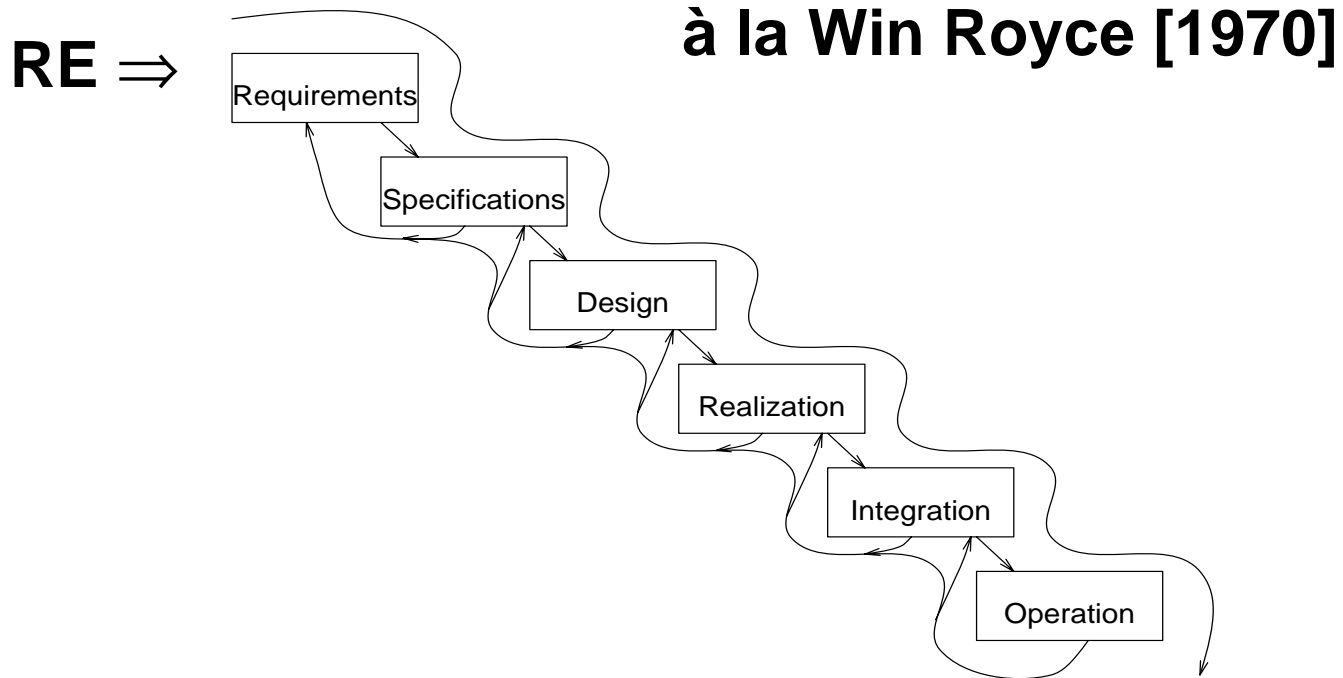
Requirements engineering (RE) is the development and use of cost-effective technology for the *elicitation*, specification and analysis of the stakeholder requirements which are to be met by software (SW)-intensive systems.

Stakeholders

A stakeholder is a person who is directly or indirectly affected by the system under construction, .e.g.,

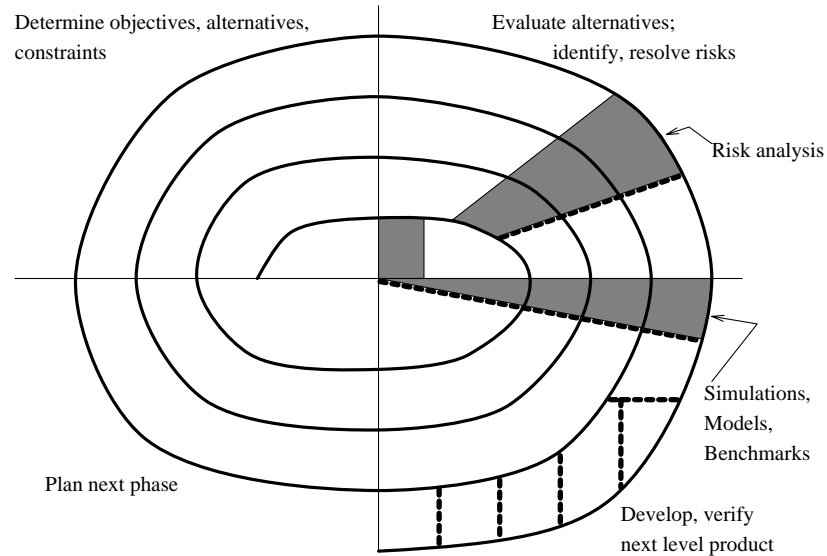
- **customers and users**
- **marketing and sales personnel**
- **RAs, developers, and testers**
- **maintainers**
- **managers**

Traditional Waterfall Lifecycle



More Realistic Lifecycle Model

Spiral Model à la Barry Boehm [1988b]



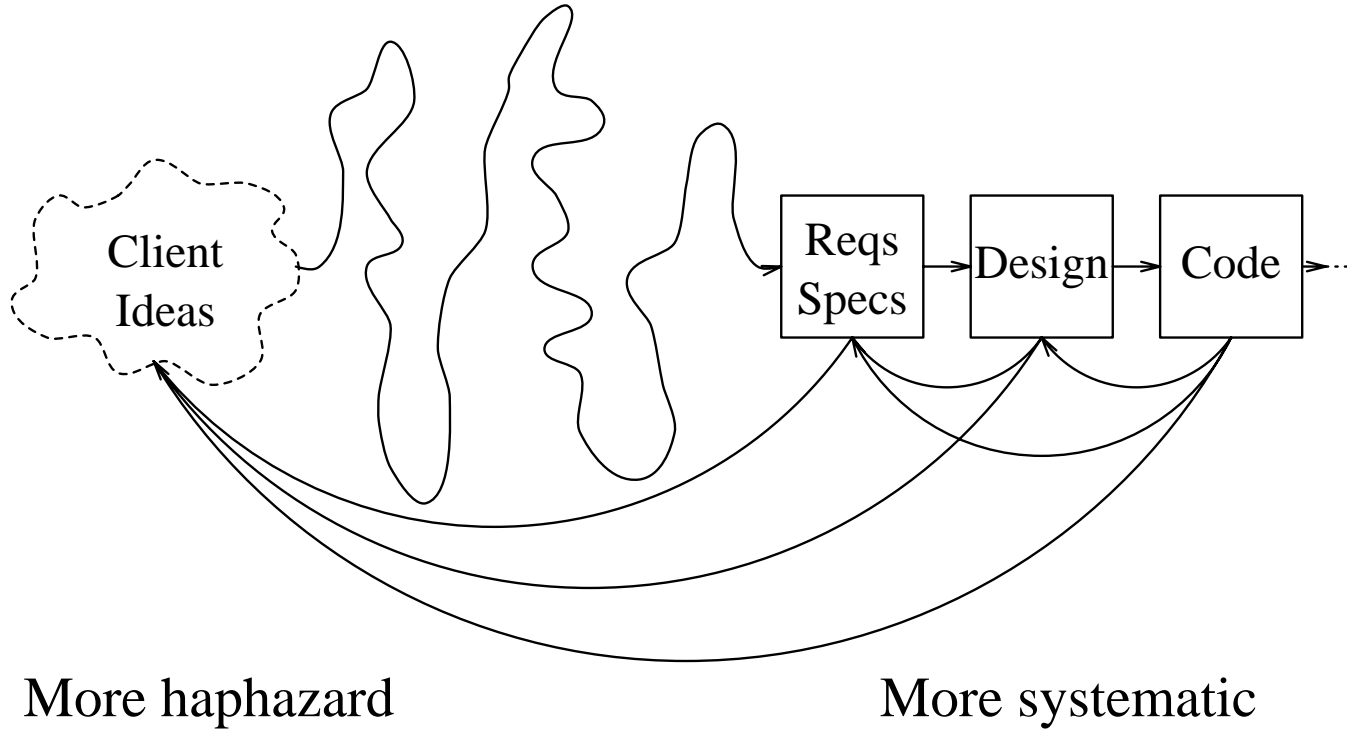
Each Sweep of Spiral

One may even follow the waterfall in each 360° sweep of the spiral.

Alternatively, one may be agile in each 360° sweep of the spiral.

REAL Lifecycle for One Sweep

More difficult than thought to be

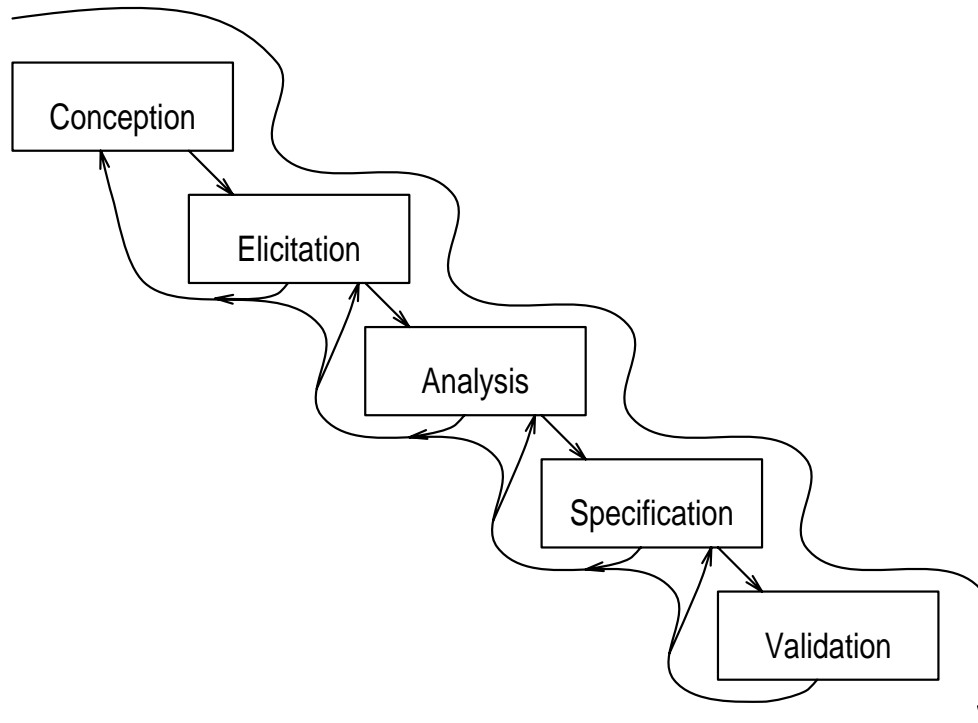


Requirements Engineering

That wavy line between Client Ideas and Requirements Specifications (RSs) is RE.

RE Lifecycle, Idealized

à la Waterfall



RE Lifecycle, Cont'd

This, of course, is an idealization, just as much as the original waterfall.

The reality is that there is a spiral, with each sweep going through this entire subwaterfall, and all the steps in the sweep happening concurrently.

That is, a hurricane model! 😊

Short, Sweet Definitions

Requirements Engineering (RE) is:

How to squeeze requirements out of the client's mind and the environment without damaging the client or the environment!

Requirements Elicitation (RElic) is:

How to squeeze information out of the client's mind and the environment without damaging the client or the environment!

Definitions and Observations

Requirements Analysis is:

How to squeeze as much additional information as possible out of what has been obtained by squeezing the client and the environment!

Changes cause that:

No matter how hard you squeeze, there are new requirements, and the old ones change.

Observations, Cont'd

***Empirical Studies* are concerned with:**

Understanding squeezing by observing it or parts of it in real-life circumstances!

***RE as a Human Activity* is concerned with:**

Understanding how humans do the squeezing as a social activity.

Definition

“to elicit”

means

“to bring out, to evoke, to call forth”

in this case, “... information pertaining to requirements”.

Purpose of RElic

The main purpose of RElic is to get information about:

- **the domain and goals from which the requirements are specified**
- **the requirements from which the system is developed**

Purpose of RElic, Cont'd

You must get information out of clients' minds without damaging the clients or their minds!

Many times this information does not come out easily.

The clients do not know it themselves.

The clients do not want to let it out (subconsciously).

Purpose of RElic, Cont'd

RElic is a human activity involving interaction between human beings:

clients

users

systems analysts

systems developers

Purpose of RElic, Cont'd

If you cannot do the human interaction right, you ain't gonna be able to elicit, no matter what technology and methods you use.

Technology and methods might help, but they can also get in the way.

Why is Creativity Necessary in RE?

Creativity is Needed for Inventing Requirements

Creativity is a part of RE because requirements have to be invented.

Why do requirements have to be invented?

Because if not, we would never advance beyond what we do now.

A Bit of History

Originally, software systems (SWSs), actually programs, were introduced merely to automate existing manual tasks for collecting, processing, or distributing information.

Duplicated Original Processes

A program was used

- **to speed up,**
- **to reduce errors, or**
- **to do both**

for existing clerical tasks without changing the basic processes in which these tasks were carried out.

Duplicating, Cont'd

If the original task produced a report on paper, the automated version produced the same report, so that the automated task could be carried out, albeit faster and with fewer errors, *in the original task's place.*

First E-Type Systems

However, as observed by Meir Lehman [1980], the introduction of these SWSs began to affect the processes in which these automated tasks were embedded.

Different and better processes were enabled by the automated tasks, even to the points of

- **making the automated task unnecessary, and**
- **eliminating some people's jobs!**

New Peripherals

New peripheral devices were introduced to allow the computer to sense and control more than just data, e.g., production lines and aircraft.

New Peripherals Allowed

These peripherals allowed the introduction of SWSs to change more and more processes and ...

to fundamentally alter the way things are done in many real-world, man-made systems not at all related to computing.

Example of Fundamental Change

Originally, commercial systems evolved in the presence of only paper and carbon paper.

Joint evolution of:

- **the form to contain all information that might ever be required about a transaction, and**
- **creating multiple copies of a document.**

Multiple Copies

Creating and distributing multiple copies of a form became the way to make sure that all potentially needed information about a transaction were distributed rapidly and in parallel to all involved in the transaction.

At first, with photocopiers and later with printers, the production of the multiple copies was automated.

Unchanged Workflow

However the basic workflow, and in particular the distribution of the copies, was unaltered.

Then, new high-resolution screens and networks became available.

Creative SW engineers noticed that it was no longer necessary to print and distribute multiple paper copies of all possible needed information.

Creative Change

Instead, it suffices to put a network of computers, each with a high-resolution screen, on the desks of all persons involved in all transactions.

Each is able to access directly precisely the information he or she needed for his or her part of the transaction at the time he or she needed it.

Making any paper copy of the information is totally unnecessary.

Advantages

On one hand, the operation of the transaction has improved.

The information needed for the transaction is distributed instantaneously to all involved in the transaction.

A person involved in the transaction looks up only the information that he or she needs.

More Advantages

If the source of the information on the old form is readily available, there is no need for an electronic version of the form to be filled out in advance with all information that might conceivably be needed in the transaction.

Only the usual information is requested with the assumption that in the rare case additional information is needed, the source can be queried on the spot.

Thus, the transaction is made more efficient.

Disadvantages

On the other hand, there are some negative consequences.

No paper copies are distributed (good!).

Therefore, all who were involved with production, purchasing, distribution, & disposal of paper and printed reports find their jobs reduced and possibly eliminated.

Organizational Transformation

The organization has been transformed.

The introduction of any SWS has the potential to transform any organization into which it is introduced.

Nowadays

Clearly, we give each person who needs to see data a workstation through which he or she looks at precisely the data that he or she needs to see.

A no brainer!

First Time

How did this happen the first time?

Some creative person put the available technology and the need to access data together and invented a new way to see the data!

Without Innovation

Without the innovation, we would still be using the old paper-bound work flow, ...

although we might be using the computer and laser printers to print 5 hard copies of the form data.

Still Need 5 Copies?

Of course, I have heard of places that have the workstations and *still* print the 5 copies ...

for the benefit of 5 fossilized senior VPs who refuse to learn to use a computer. ☹️

Apple's Creativity

Consider Apple and Steve Jobs

We have seen a steady stream of very creative inventions from Apple driven by Jobs.

It is clear that each of these inventions involves invented requirements galore!

Role of Requirements Analyst

We now consider the requirements analyst (RA)'s role in light of all of the above.

RA's Job

- **Understand the problem from each stakeholder's point of view.**
- **Extract the essence of the stakeholders' requirements.**
- ***Invent better ways to do the user's work.***
- **Negotiate a consistent set of requirements.**
- **Record the results in a RS.**

Invent Better Ways

Once an RA has an understanding of the work the users of a system are trying to accomplish, ...

the RA may be able to suggest requirements that would help them, because ...

- **the RA is aware of technology that could help them or**
- **the RA can identify patterns in their work of which they are not aware.**

Invent a Better Way

Inventing a better way is often overlooked during RElic.

It's important to determine what the client wants and to document it.

If the RA stops there, then the built system will conform to ...

only the limited notion of what the client thinks is possible.

Invent a Better Way, Cont'd

For real success, the RA must give to the client, not what he or she wants, but ...

**what he or she never even dreamt of having;
and ...**

when he or she gets it, ...

**it's exactly what he or she wanted all the time
(IKIWISI).**

How to Invent a Better Way

- **Ask *why* documented requirements are desired.**
- **Consider giving the user more creative control over his or her transactions.**
- **Brainstorm (BS) to invent undreamed of requirements.**

Goguen's Observation

Joseph Goguen observed in 1993 that

“It is not quite accurate to say that requirements are in the minds of clients; it would be more accurate to say that they are in the social system of the client organization. They have to be invented, not captured or elicited, and that invention has to be a cooperative venture involving the client, the users, and the developers. The difficulties are mainly social, political, and cultural, and not technical.”

Creative Personality

Creativity researcher Mihaly Csikszentmihalyi (מִיחַיִי צ'יקסנטמִיחַיִי) explains in his article, “The Creative Personality: Ten paradoxical traits of the creative personality” from his book *Creativity: Flow and the Psychology of Discovery and Invention*, that

“Creative people tend to be smart yet naive at the same time.”

Studies of Creativity

Even before software existed, even before computers were a twinkle in von Neumann's eyes, ...

many, including Henri Poincaré [1914] and Erich Fromm [1959], investigated the subject of creativity.

Even during the software age, people like Herbert Simon [1972] investigated the subject of creativity.

Studies of Creativity, Cont'd

Some have investigated creativity experimentally and in the context of the development of information systems [Nagasundaram 1995, Cougar 1996].

There are many definitions of creativity.

Fortunately, there appears to be convergence among researchers on a concept of creativity, related to problem solving [Rickards 1974, Leigh 1983], encompassing also problem finding and solution thinking.

Definition of Creativity

Creativity is the generation of innovative, unexpected solutions to complex, non-trivial problems, or to ill-formed, wicked problems.

Wicked Problem

A wicked problem [Rittel & Webber 1973] is one whose very definition is part of the problem itself.

RE is a Wicked Problem

Therefore, ...

RE for any non-trivial software-intensive system is wicked.

Creativity in RE

Maiden and Gizkis [2001] asked from where requirements come and identified 3 kinds of creativity needed in RE:

- 1. exploratory creativity: explores a possible solution space and discovers new ideas**
- 2. combinatorial creativity: combines two or more ideas that already exist to create new ideas, and**
- 3. transformational creativity: changes the solution space to make impossible things possible.**

Tension of Creativity in RE

An RA, after having done extensive, *documented* RE, may see a radically different way to achieve the goals.

- **Adopting the new way requires throwing out some of the documented RE that has been done.**
- **However, *exciting and cool* new ideas can motivate willingly and enthusiastically abandoning old-fashioned ideas.**

Dilemma of Creativity in RE

- **Some (e.g., mentioned earlier) recognize creativity as a fundamental factor in software development.**
- **Still others see creativity as a threat that must be controlled carefully to prevent it from compromising their projects [Nguyen, Carroll & Swatman 2000].**

So, some try to give a structured and controlled way that fosters creativity in RE to help deal with the wickedness of RE.

Our Opinion

Just as with the goose that laid the golden egg, we think that attempts to control creativity will just kill it.

Let creativity create what it can!

You may always just not use what creativity created.

LM Observes about Creativity

Creativity Enhancement Techniques (CETs) have been introduced to support creative problem solving.

Let's apply them to RE too!

These CETs have resulted in innovative solutions ...

and have helped companies, organizations, and individuals to find smarter ways to fulfill their goals and requirements.

DB Observes about Creativity

In any domain of discourse, creativity is often a *mistake*, relative to conventions of the domain of discourse, that turned out to be a good idea after all.

Example of DB's Observation

An innovative composer with a whole new style of music is not following the current convention or any previously followed convention.

Perhaps the composer made a mistake in following a convention, but ...

after hearing played what she wrote, she decided that the sound was good after all.



Dilbert Says:

“Creativity is allowing yourself to make mistakes. Art is knowing which ones to keep.”

Scott Adams, *The Dilbert Principle: A Cubicle’s-Eye View of Bosses, Meetings, Management Fads & Other Workplace Afflictions*

Surely, a case of great minds thinking alike!



Creativity Enhancement Techniques

Now, we move on to consider several and to learn two creativity enhancement techniques (CETs).

Overview of Techniques

The typical CET process consists of two main phases:

- 1. idea generation (IG)**
- 2. idea pruning (IP)**

Idea Generation

IG is the generation of raw, uncensored ideas.

***Quantity* is the focus — generate as many ideas as you can!**

Idea Pruning

IP is the removal of *useless* raw ideas and the refining what is left.

***Quality* is the focus — make the best ideas that you can!**

Creativity in IP

Creativity is needed in IP to avoid to throwing out an idea just because it *looks* useless, hazardous, or uneconomical.

Other stakeholders need to be involved here.

IP is a decision making process to which marketing and development people might have something relevant to contribute.

The Typical CET

What distinguishes one CET from another is mainly its IG phase.

So we quickly cover a general IP phase that is applicable to most CETs.

General IP Techniques

Prune the generated ideas into a final list.

The goal is to get a list of workable size of good ideas worth exploring further.

IP, Cont'd

There are several choices of how:

voting with threshold

voting with campaign speeches

ranking ideas by priority or quality

blending ideas

Voting with Threshold

Each person is allowed to vote up to n times.

Keep those ideas with more than m votes.

Have multiple rounds thereof with smaller n and m .

Voting with Campaign Speeches

Each person is allowed to vote up to n times.

Keep those ideas with at least one vote.

Have someone who did not vote for an idea defend it for the next round.

Have multiple rounds thereof with smaller n .

Ranking Ideas

Rank ideas by priority, quality, innovativeness, cost-effectiveness, pervasiveness of requirements coverage, speed of implementation, cheapness of implementation, etc., ...

or any combination thereof.

Ranking Ideas, Cont'd

The group works to rank ideas by some method, e.g., writing each on a card and placing cards into an ordering or lattice.

Find cut-off point in the ranking, above which ideas are kept and below which ideas are discarded.

Blending Ideas

Consider pairs, triples, etc. of ideas for combining in some way.

Then go into one of the ranking or voting procedures.

Brainstorming (BS)

BS is already part of our culture, but beware of bad BS.

A bad BS session is a brainblizzard because it freezes your brain, leaves you under mounds of snow, and leaves you cold

We will give rules for BS that help avoid the brainblizzard.

BS, Cont'd

BS, like other CETs, is a two-phase activity:

- 1. IG**
- 2. IP (Previously discussed)**

We talk about only the BS IG phase here.

BS IG

The leader throws out a question or problem.

People try to think of solutions, never mind how outrageous or outlandish; their purpose is to get as many ideas as possible out there.

An outrageous outlandish idea could trigger another good idea.

BS IG Rules Are Simple:

No criticism of an idea or debate about ideas is allowed — if you don't like someone's idea, leave it be, but *improve* on it.

Let your imagination soar. Wild is *GOOD!*

Shoot for quantity.

BS IG Rules, Cont'd

Mutate and combine ideas.

Nothing anyone says is to be held against him or her after the session. Feel free to be gloriously *wrong*.

Who Participates?

In the case of RElic:

- **Developers, domain experts, end-users, clients, ..., just about any stakeholder can take part.**
- **It's useful to invite people from outside the project, e.g., roving idea people, to get out-of-the-project-box ideas.**

Participant Caveat

***BUT*, try to minimize the effect of the participants' powers in the global organization.**

If a person and his or her boss are in the group, the boss's power should be left outside the meeting ...

So that the person can contribute freely.

How Many Participants?

Keep the number of participants manageable, so that everyone gets a chance to contribute.

With too many people, the shy shut up and only the loud will be heard.

How Long?

Keep going until the first of the following:

- **The ideas stop coming.**
- **Two hours have passed.**

Beyond this limit, efficiency of IG and the quality of the ideas drops significantly.

Two Special Roles

- 1. Scribe — Role is to write down all ideas. May also contribute ideas. May ask clarifying questions, but not critical questions.**
- 2. Moderator— Two schools of thought on role of moderator:**

Moderator, Cont'd

- 1. Traffic cop — Enforces rules, but doesn't lead.**
- 2. Agent provocateur — Actively leads. Comes prepared with wild ideas and throws them out as IG wanes. May look for variations and combinations of other ideas. Also acts as traffic cop.**

BS Session Here

Form groups of two.

Two RElic problems:

- **Bituach Leumi Web Site**
- **Bidirectional Wordprocessor**

Assign Problems to Groups

Half of the groups get one problem, and the other half of the groups get the other problem.

Each group keeps its list on someone's laptop; one acts as scribe, self-enforcement of rules.

Each idea goes into a separate line.

Each group reports the number of lines at the end.

20 minute session.

Two Problems

Both are to generate ideas that must be found during requirements analysis, before implementation, in order that they be easily implementable.

Bituach Leumi Web Site

Find ideas for improving the user interface (UI) of the Web site for Bituach Leumi (National Insurance) that everyone just *loves to hate* for its poor UI. (☹)

<http://www.btl.gov.il/Pages/default.aspx>

BTL Web Site, Cont'd

For those of you who don't read Hebrew, a pretty good English translation is at:

<http://www.btl.gov.il/English%20homepage/Pages/default.aspx>

The layout of its UI is a mirror image of the Hebrew page. (😊)

Bidi Wordprocessor

Find ideas for improving the bidirectional version of Microsoft Word (BDMSW) to make it completely Unicode compatible, to be able to handle

- **left-to-right (L-R) and right-to-left (R-L) text, each able to contain:**
 - **L-R and R-L subtext (e.g., an apartment number in an address), and each able to be embedded within:**
 - **L-R or R-L subdocuments (e.g., a chapter).**

BDMSW, Cont'd

Because BDMSW must be Unicode compatible, all text is stored in files in *logical order* (the characters of a file are stored in the file in the order that the characters are spoken when read) ...

while being displayed in visual order (with the text of each language shown in its natural writing direction).

BDMSW, Cont'd

BDMSW should have the ability to make any text L-R or R-L regardless of its natural direction (e.g., to show how Hebrew is stored in logical order in files).

Session

Other BS Ideas

BS can be carried out over e-mail.

But a leader is needed to prevent flaming and race conditions.

Optimizing BS

Data show that individual BS is more effective than group BS.

The quantity and quality of ideas generated by an individual is higher when he or she works alone than when he or she works with a group.

Surprise!!!

One Final Point!

With lots of good, outrageous, outlandish ideas, the brainstorm is loads of fun!!

Fun motivates people to do well!!!

Other CETs

Some other CETs are very simple, e.g.,

- **Creative Pause Technique**

More Other CETs

Some other CETs have more systematic or more focused IG.

- **Six Thinking Hats**
- **NHK Method**
- **Creative Problem Solving**
- **Gordon Synectics**
- **EPMcreate**

Creative Pause Technique

Basically, just clear your mind regularly or when you are stuck.

Six Thinking Hats

[http://www.debonogroup.com/
six_thinking_hats.php](http://www.debonogroup.com/six_thinking_hats.php)

‘You and your team members can learn how to separate thinking into six clear functions and roles. Each thinking role is identified with a colored symbolic “thinking hat.” By mentally wearing and switching “hats,” you can easily focus or redirect thoughts, the conversation, or the meeting.’

Six Thinking Hats, Cont'd

White hat: facts

Yellow Hat: optimism

Black Hat: judgment

Red Hat: intuition

Green Hat: alternatives

Blue Hat: the thinking process itself

NHK Method

Developed by Hiroshi Takahashi (author of The Creativity Handbook) during his years working for NHK

A general method with an IG phase and an IP phase.

IG starts by each participant writing 5 ideas, each on a separate card.

Then IP begins.

Creative Problem Solving

Developed by Osborn and Parnes

A 6-step “finding” process

- **Explore the Challenge: Objective, Fact, and Problem Finding (3)**
- **Generate Ideas: Idea Finding (1)**
- **Prepare for Action: Solution and Acceptance Finding (2).**

Synectics

Developed by Gordon and Prince.

**A 9-step process that includes brainstorming,
...**

- **Set up a classroom environment.**
- **Pick a strategy: comparing, classifying, metaphors, and/or analogies,**
- **Brainstorm.**
- **Use graphic organizers for the ideas.**
- **Assess and evaluate the ideas.**

A New Creativity Technique

Innovative technique, EPMcreate.

**Based on Elementary Pragmatic Model (EPM)
of pragmatics of communication.**

**EPM developed more than 30 years ago by
Piero de Giacomo and Alberto Silvestri**

**to describe relational patterns of interacting
subjects, and ...**

to predict their evolution.

Interesting Joint Effort

de Giacomo was a psychiatrist, and

Silvestri was a physicist and computer scientist.

The Elementary Pragmatic Model

EPM is a model of the pragmatics of communication, created to help analyze interactions between two people in order to determine the relational attitude bases for their interaction behaviors.

The model may be applied to groups of more than two by considering all possible pairings within the group.

Therapeutic Use

Since end of 1970s, EPM has been applied successfully in therapy for relationship problems in

- **families and**
- **work teams**

Modeling Use

EPM has been applied successfully to model

- **electronic communication in CSCW and**
- **users of e-learning Web sites**

Facilitative Use

EPM has been applied successfully to foster

- **mental flexibility.**
- **individual problem solving**
- **individual creativity enhancement**

New Use of EPM

Mich proposed and we tested using an EPM-based technique, EPMcreate, to foster creativity in RE,

in sort of the inverse of the therapeutic use, in which EPM is used to learn what is really happening.

We use EPM to tell us what to do next.

At the Highest Level

EPMcreate supports IG in RElic by focusing the RA's search for ideas on only one logical combination of two stakeholders' viewpoints at a time.

16 combinations are possible, corresponding to the 16 basic boolean functions, f_i for $0 \leq i \leq 15$, of two variables.

16 Boolean Functions of 2 Variables

<i>V1</i>	<i>V2</i>	<i>f0</i>	<i>f1</i>	<i>f2</i>	<i>f3</i>	<i>f4</i>	<i>f5</i>	<i>f6</i>	<i>f7</i>
0	0	0	0	0	0	0	0	0	0
0	1	0	0	0	0	1	1	1	1
1	0	0	0	1	1	0	0	1	1
1	1	0	1	0	1	0	1	0	1

<i>V1</i>	<i>V2</i>	<i>f8</i>	<i>f9</i>	<i>f10</i>	<i>f11</i>	<i>f12</i>	<i>f13</i>	<i>f14</i>	<i>f15</i>
0	0	1	1	1	1	1	1	1	1
0	1	0	0	0	0	1	1	1	1
1	0	0	0	1	1	0	0	1	1
1	1	0	1	0	1	0	1	0	1

About Tables

In these tables, “ V_n ” means “Stakeholder n ’s Viewpoint”.

The bits in each column f_i , read from top to bottom, form the binary encoding for i .

The interpretations of some of these functions in terms of combining the viewpoints of stakeholders $SH1$ and $SH2$ are given on subsequent slides.

f0

f0 = 0 represents the RA's looking for ideas that disagree with everything, independently of both *SH1*'s viewpoint and *SH2*'s viewpoint, i.e., looking for nothing (= a creative pause).

f1

f1 = SH1* \wedge *SH2 represents the RA's looking for ideas that agree with *SH1*'s viewpoint and with *SH2*'s viewpoint.

f2

$f2 = SH1 \wedge \neg SH2$ represents the RA's looking for ideas that agree with *SH1*'s viewpoint but disagree with *SH2*'s viewpoint.

f3

$f3 = SH1$ represents the RA's looking for ideas that agree with *SH1*'s viewpoint completely, independently of *SH2*'s viewpoint.

f4

$f4 = \neg SH1 \wedge SH2$ represents the RA's looking for ideas that agree with *SH2*'s viewpoint but disagree with *SH1*'s viewpoint.

f5

$f5 = SH2$ represents the RA's looking for ideas that agree with *SH2*'s viewpoint completely, independently of *SH1*'s viewpoint.

...

f8

$f8 = \neg SH1 \wedge \neg SH2$ represents the RA's looking for ideas that disagree with *SH1*'s viewpoint and with *SH2*'s viewpoint.

...

f10

$f10 = \neg SH2$ represents the RA's looking for ideas that disagree with *SH2*'s viewpoint completely, independently of *SH1*'s viewpoint.

...

*f*15

***f*15 = 1** represents the RA's looking for ideas that agree with everything, independently of both *SH1*'s viewpoint and *SH2*'s viewpoint.

More Than 2 Types of Stakeholders

If there are more than two types of stakeholders, the technique can be applied several times, for each relevant pair of stakeholder types, up to $\binom{n}{2}$ times for n stakeholders.

EPMcreate in Practice

EPMcreate can be used whenever IG is needed during RElic.

When a lead RA determines that EPMcreate should be applied during RElic for the system being built, ...

EPMcreate in Practice, Cont'd

she chooses 2 kinds of stakeholders, *SH1* and *SH2*, usually users of the system with different roles.

E.g., the selected stakeholder types could be

- students and lecturers for an e-learning application, and
- employees of the selling and buying companies for a system supporting a company's B2B activities.

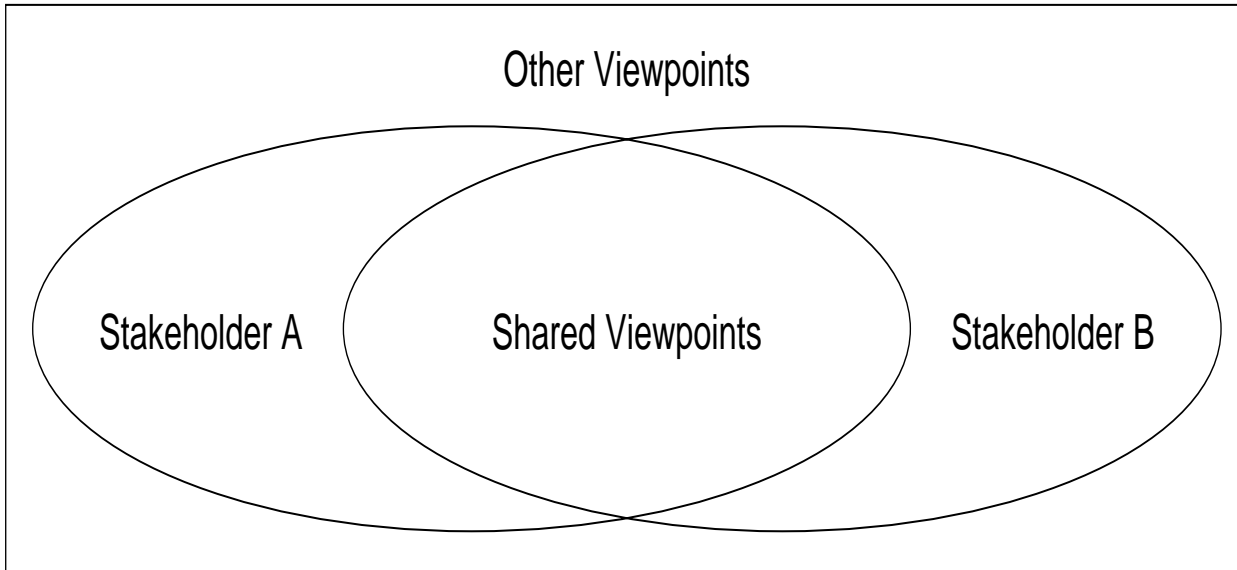
EPMcreate in Practice, Cont'd

Normally, not all pairs of stakeholder types are used.

The lead RA chooses pairs she believes to be informative.

She then convenes a group of RAs and shows them the Venn Diagram on the next slide.

Venn Diagram of Viewpoints



The two ellipses represent 2 stakeholders' viewpoints.

Instructions given to RAs

The lead RA tells all convened RAs:

“Today, we are going to generate requirement ideas for the system *S* in 16 IG steps. In all the steps, you will be pretending to think from the viewpoints of two particular stakeholders of *S*, *SH1* and *SH2*.

Step 0, for $f_0 = 0$

In Step 0, you will blank out your minds.

Step 1, for $f_1 = SH_1 \wedge SH_2$

In Step 1, you will try to come up with ideas for problem solutions that are needed by both SH_1 and SH_2 .

Step 2, for $f2 = SH1 \wedge \neg SH2$

In Step 2, you will try to come up with ideas for problem solutions that are needed by $SH1$ but not by $SH2$.

Step 3, for $f3 = SH1$

In Step 3, you will try to come up with ideas for problem solutions that are needed by $SH1$ without concern as to whether they are needed by $SH2$.

Step 4, for $f4 = \neg SH1 \wedge SH2$

In Step 4, you will try to come up with ideas for problem solutions that are needed by *SH2* but not by *SH1*.

Step 5, for $f5 = SH2$

In Step 5, you will try to come up with ideas for problem solutions that are needed by *SH2* without concern as to whether they are needed by *SH1*.

...

Step 8, for $f8 = \neg SH1 \wedge \neg SH2$

In Step 8, you will try to come up with ideas for problem solutions that are needed neither by $SH1$ nor by $SH2$, but are needed by other stakeholders.

...

Step 10, for $f10 = \neg SH2$

In Step 10, you will try to come up with ideas for problem solutions that are not needed by *SH2* without concern as to whether they are needed by *SH1*.

...

Step 15, for $f_{15} = 1$

In Step 15, you will try to come up with ideas for problem solutions without concern as to whether they are needed by either *SH1* or *SH2*.”

Optimization, POEPMcreate

We demonstrated in experiments that one optimization of EPMcreate, the Power-Only EPMcreate (POEPMcreate), is more efficient in supporting IG for RElic.

POEPMcreate does only the 4 steps whose names include the powers of 2, namely Steps 1, 2, 4, and 8.

“more efficient” means that more and better ideas are generated in the same amount of time.

Why More Efficient?

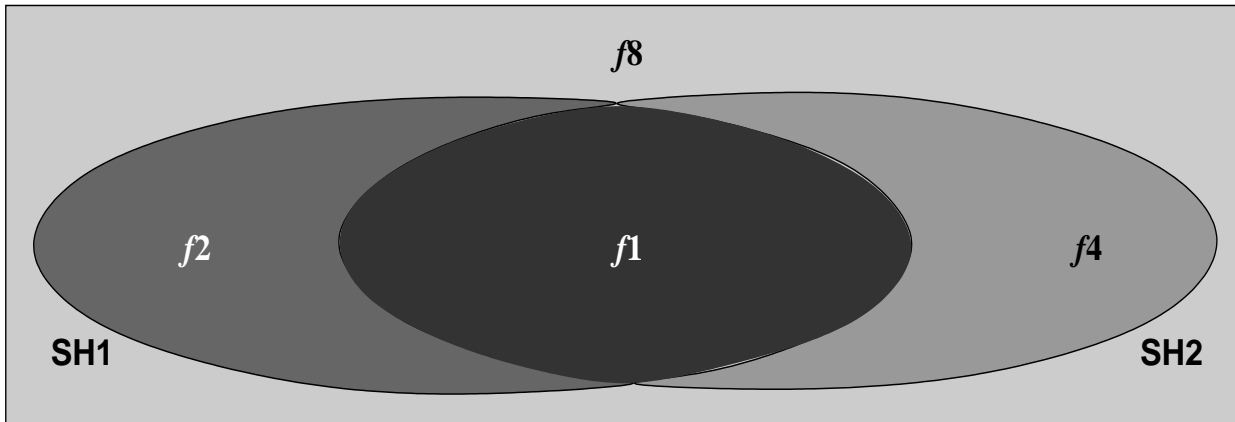
As shown below,

$$f1 = SH1 \wedge SH2$$

$$f2 = SH1 \wedge \neg SH2$$

$$f4 = \neg SH1 \wedge SH2$$

$$f8 = \neg SH1 \wedge \neg SH2$$



Why, Cont'd

the Boolean function of each of the power-of-2 steps corresponds to exactly one of the four regions of the Venn Diagram shown before.

Thus, the 4 power-of-2 steps suffice to cover the entire space of potential ideas, ...

and the other 12 steps just repeat the coverage.

Why, Cont'd

In other words, these 4 regions are the 4 atoms of the 16-element free Boolean algebra that is generated from the two stakeholder viewpoints.

That oughta convince all you mathies out there! 😊

EPMcreate Session Here

We will do POEPMcreate to save time, ...

to be able to finish the EPMcreate session in the same 20 minutes allocated to the BS session!

EPMcreate Session

Same two RElic problems as before:

- **Bituach Leumi Web Site**
- **Bidirectional Wordprocessor**

Assign Problems to Groups

Each group gets the problem that it did not get for BS.

Each group keeps its list on someone's laptop; one acts as scribe, self-enforcement of rules.

Each idea goes into a separate line.

Each group reports the number of lines at the end.

20 minute session.

Bituach Leumi Web Site

Stakeholders for Viewpoints:

- **B.L. Clerks**
- **Citizen Customers**
- **Ombudspersons**
- **M.K.s**

Pick two viewpoints for your session.

Bidirectional Wordprocessor

Stakeholders for Viewpoints:

- **Native Right-to-Left Language Speakers**
- **Non-native Right-to-Left Language Speakers**
- **Non-speakers of Right-to-Left Languages**
- **Hebrew Speakers**
- **Arabic Speakers**

Pick two viewpoints for your session.

Session

To each group:

Now pick your two stakeholders, *SH1* and *SH2*, whose viewpoints you will use in your session.

Step 1, for $f1 = SH1 \wedge SH2$

Now, look for ideas that agree with $SH1$'s viewpoint and with $SH2$'s viewpoint.

Step 2, for $f2 = SH1 \wedge \neg SH2$

Now, look for ideas that agree with $SH1$'s viewpoint but disagree with $SH2$'s viewpoint.

Step 4, for $f4 = \neg SH1 \wedge SH2$

Now, look for ideas that agree with $SH2$'s viewpoint but disagree with $SH1$'s viewpoint.

Step 8, for $f8 = \neg SH1 \wedge \neg SH2$

Now, look for ideas that disagree with *SH1*'s viewpoint and with *SH2*'s viewpoint.

Discussion:

Comparison of Techniques

With which CET did your group perform better?

Why do you think that your group did as it did?

Experimental Validation

Just in case we run out of time, we state for the record:

To evaluate EPMcreate's feasibility for, applicability to, and effectiveness for RElic, we conducted experiments on two very different projects,

In each experiment, we compared the performances of two analysis teams, one using EPMcreate and the other using BS.

Validation, Cont'd

The results of the experiments were analyzed both

- **quantitatively, counting the numbers of generated ideas and requirements, and**
- **qualitatively, comparing the feasibility and the novelty of the generated ideas and requirements.**

Validation, Cont'd

Each experiment showed that EPMcreate is more effective than BS!

Three more experiments have confirmed these results.

Our Experiments Show

$EPM_{create} \geq BS$

and

$POEPM_{create} \geq EPM_{create}$

“ $A \geq B$ ” \equiv “ A is more effective than B in helping to generate requirement ideas”.

Natural Questions to Ask

Why $EPM_{create} \geq BS$?

Why $POEPM_{create} \geq EPM_{create}$?

Our Observations Show

**After having observed subjects using these
CETs, ...**

**and having heard their comments about what
they had done and were thinking...**

we can venture answers to these questions.

EPMcreate vs. BS

Why $EPMcreate \geq BS$?

We suspect that any space-covering variation of EPMcreate is more effective than BS, because EPMcreate gives a way to systematically visit the entire idea space.

With BS, one may wander aimlessly, overvisiting some parts of the space and undervisiting other parts of the space.

POEPMcreate vs. EPMcreate

Why $\text{POEPMcreate} \geq \text{EPMcreate}$?

We suspect that POEPMcreate is more effective than EPMcreate because it gives a way to visit the entire space in fewer steps and with fewer mind shifts between the steps.

POEPMcreate vs. EPMcreate

Moreover, if the amounts of time allocated to EPMcreate and POEPMcreate sessions are the same, there will be on average 4 times as much time available for each POEPMcreate step as for each EPMcreate step.

A POEPMcreate group will have more time than an EPMcreate group to explore each considered combination of viewpoints.

First Experiments' Details

- **Design of the Experiments**
- **Results of the Experiments**

Goal: to demonstrate the feasibility of the EPMcreate technique in RElic

Design of the Experiments

We conducted an experiment on each of two projects with very different characteristics.

In each experiment, we compared the effectiveness of, i.e., the numbers of ideas generated by, two analysis teams,

- **one using EPMcreate and**
- **the other using BS.**

Design, Cont'd

This comparison is useful because BS is a well-known and widely used IG technique.

BS is used in many studies of effectiveness of CETs as the basis for comparison.

First Experiment: Corsi Online

Corsi Online is a Web-based system for distant learning, maintained at Università di Trento.

Subjects: students; each had worked before becoming a student and had RE experiences comparable to those of junior analysts in industry.

Second Experiment: Civilia

Civilia is a SW system for public administration developed by a private company.

Subjects: professional analysts working for the company.

Groups of Subjects

For each experiment, two 4-person groups were created.

For the Corsi Online Experiment (COLE), the 8 subjects were assigned randomly to the 2 groups.

For the Civilia Experiment (CiE), the subjects' experiences with analysis and with Civilia itself were considered to make balanced groups.

Groups' Techniques

In each experiment, after assigning subjects to the 2 groups, lots were drawn to determine which group would use EPMcreate.

Independent Creativity Test

We gave each subject a short version of the Williams creativity test, to allow us to more accurately interpret the results.

Creativity Test, Cont'd

The creativity test results confirmed that the COLE groups were balanced also in personal creativity.

However, for the CiE, the members of the BS group showed more personal creativity than the members of the EPMcreate group.

Creativity Test, Cont'd

This imbalance did not effect the final result, since the group whose members had less personal creativity ended up being the more creative group!

In essence, the final result was strengthened!

Conduct of Experiment

In each experiment, the groups met at the same time.

Each group was given a short training session about its technique.

Each group worked for a maximum of two hours applying its technique to its experiment's problem.

Stakeholders for COLE

The Corsi Online system of the first experiment was a Web application to help manage on-line courses for the Faculty of Economics at Università di Trento, providing services mainly to students and lecturers participating in the courses.

Therefore, we asked the subjects to consider the viewpoints of lecturers and students in applying the EPMcreate steps.

Stakeholders for CiE

The Civilia system supports community services for citizens. Civilia is modular, with one subsystem for each kind of target user.

We asked the subjects to focus on the people subsystem (dealing with registration of people) and the territory subsystem (dealing with registration of land) as the sources of stakeholders and viewpoints.

Evaluation of Ideas

The original analysts for the Corsi Online system helped the experimenter evaluate the ideas generated in the COLE.

The Civilia project manager helped the experimenter evaluate the ideas generated in the CiE.

Evaluation of the Data

The lists of ideas and requirements produced by the four groups were analyzed both

- **quantitatively, counting the numbers of generated ideas and requirements, and**
- **qualitatively, comparing the feasibility and novelty of the generated ideas and requirements.**

Bottom Line Result

Comparing the results of the two subject RA teams of each experiment confirmed that EPMcreate was more effective quantitatively and qualitatively than BS in generating ideas and requirements.

Quantitative Comparisons

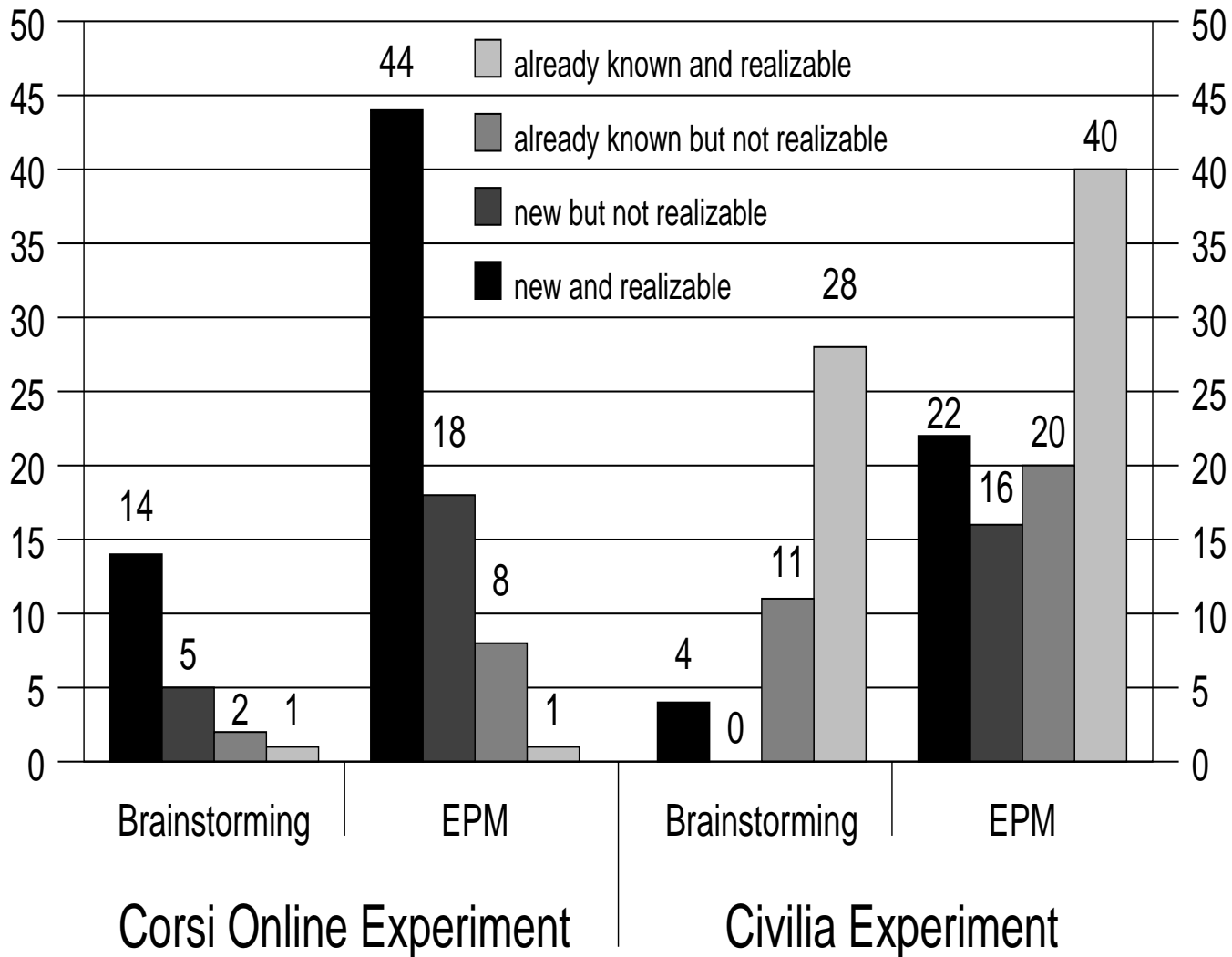
Experiment	COLE	CiE
Group		
EPMcreate	71	93
Brainstorm	22	43

Qualitative Comparisons

To measure the quality of the ideas, with the help of the domain expert judges, we classified each idea into one of four categories:

- **new and realizable**
- **new but not realizable**
- **already known but not realizable**
- **already known and realizable**

The next slide shows the data.



About Quality Data

In the COLE, the ranking of the categories was essentially the opposite of that in the CiE.

The largest category in each group of the COLE was the new-and-realizable category, while

The largest category in each group of the CiE was the already-known-and-realizable category.

About Quality Data, Cont'd

This difference in ranking can be explained by the difference in levels of development of the two systems.

Civilia is already a mature commercial system that has undergone several revisions.

Thus, it is natural that the subjects, who had not been involved in Civilia's development, would find requirements that had already been discovered by the Civilia development team.

About Quality Data, Cont'd

This explanation was confirmed by the project manager who had assisted in the classification of the ideas.

Even so, the EPMcreate group found 22 new ideas ideas while the BS group found only 4 new ideas.

Encouraging Results

The results are very encouraging.

They point to the higher effectiveness of the EPMcreate technique to generate creative ideas in RE.

However, the results are hardly conclusive.

Threats

The threats to the validity of the conclusions include the facts that

- **there are too few data points for a statistically significant conclusion.**
- **in the COLE, students were used as subjects instead of professional RAs; however these students had had experience in industry before becoming students.**
- **EPMcreate was compared to only BS.**

More Work Needed

The strongly positive results do say that EPMcreate has merit and do call for additional experimentation:

- **aimed at obtaining statistically significant results,**
- **using only professional analysts, and**
- **comparing EPMcreate to other creativity fostering techniques.**

Noted During Experiment

- **Data show that odd numbered steps were more effective than even numbered steps; perhaps there is an abbreviated sequence that is more efficient.**
- **Data suggest that alternative orderings of the steps, e.g, starting with *f8*, may be more effective.**
- **EPM could be useful to help an inexperienced RA improve her RId, because it makes the process of finding new ideas more systematic.**

Follow Up to Address Threats

We have conducted and published papers about controlled experiments which used the Web site of a Canadian High School as the system about which to elicit requirement ideas.

Controlled Experiment Results

These controlled experiments concluded with statistically significant results that

$EPM_{create} \geq BS$

and

$POEPM_{create} \geq EPM_{create}$.

Summary

- **RE and Requirements Elicitation**
- **Invention and Creativity in RE**
- **Creativity Enhancement Techniques**
 - **Idea Generation and Idea Pruning**
 - **Brainstorming**
 - **In-Course Brainstorming Session**
 - **Summary of Other Techniques**
 - **EPMcreate**
 - **POEPMcreate**
 - **In-Course POEPMcreate Session**

Summary, Cont'd

- **Comparative Discussion about Brainstorming and EPMcreate**
- **If Time Permits, Details about First Experiments Comparing EPMcreate to Brainstorming**
- **Conclusions**

Conclusions

We hope that you have

- **learned about the place of invention and creativity in the RE context,**
- **relearned an old technique for enhancing creativity in the RE context, and**
- **learned a new technique for enhancing creativity in the RE context.**

Conclusions, Cont'd

We hope that you will be able to apply what you have learned in your work and elsewhere!

If you need some consultation about applying EPMcreate, please contact Dr. Luisa Mich at the e-mail address given in the first slide.