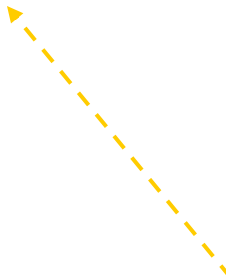


*“To invent, you need a good
imagination and a pile of junk.”*
-Albert Einstein

The Simplicity of Complexity: Rube Goldbergengineering in the Classroom

Nielsen Pereira and Shawn Jordan
Purdue University

November 6, 2009

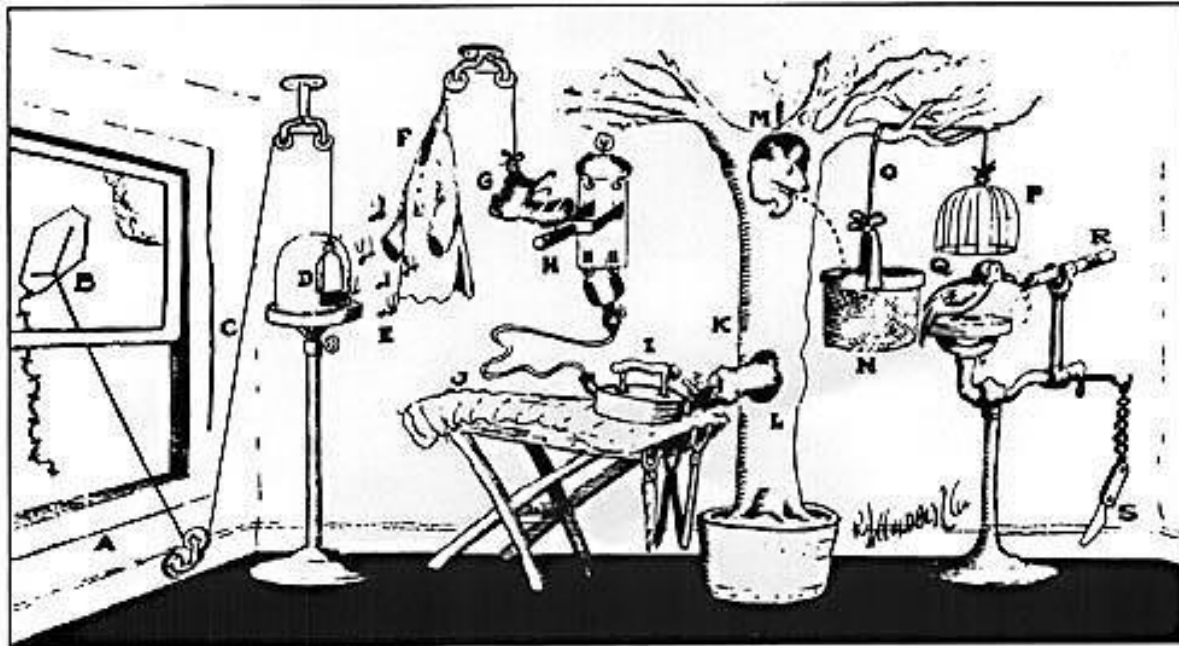


Rube Who?

- Reuben Lucius Goldberg (1883 - 1970)
- Sewer engineer for 6 months
- Left engineering to become cartoonist in 1914
- Pulitzer Prize-winning cartoonist, sculptor, and author
- Drew machines that completed simple tasks in extremely complex and roundabout ways



“Simplified” Pencil Sharpener



Pencil Sharpener RUBE GOLDBERG (tm) RQI 038

Open window (A) and fly kite (B). String (C) lifts small door (D) allowing moths (E) to escape and eat red flannel shirt (F). As weight of shirt becomes less, shoe (G) steps on switch (G) which heats electric iron (I) and burns hole in pants (J). Smoke (K) enters hole in tree (L), smoking out opossum (M) which jumps into basket (N), pulling rope (O) and lifting cage (P), allowing woodpecker (Q) to chew wood from pencil (R), exposing lead. Emergency knife (S) is always handy in case opossum or the woodpecker gets sick and can't work.



2009 Rube Goldberg Machine Contest

- **Task: Replace an incandescent light bulb with a more energy efficient light emitting design.**
- **Regional and National high school and college competitions held annually at Purdue**
 - Regional competitions: Saturday, February 21, 2009
 - National competitions: Saturday, March 28, 2009
 - See <http://www.uns.purdue.edu/UNS/> for more details



Rube Goldberngineering

- Saturday enrichment class for middle school students focused on designing and building Rube Goldberg machines
- Part of the Purdue College of Education's Gifted Education Resource Institute (GERI) talent-development programs
- 18 student contact hours



Rationale

- Rube Goldberg activities have been used in classrooms for many years, but there is little research on their use
- Numerous textbooks on the design process (Dieter, 2000; Eide, 1997; Pahl, Wallace, & Blessing, 2007; Visser, 2006)
- Cooperative learning can be beneficial to both gifted and non-gifted students when higher levels of understanding are emphasized (Patrick et al, 2005)

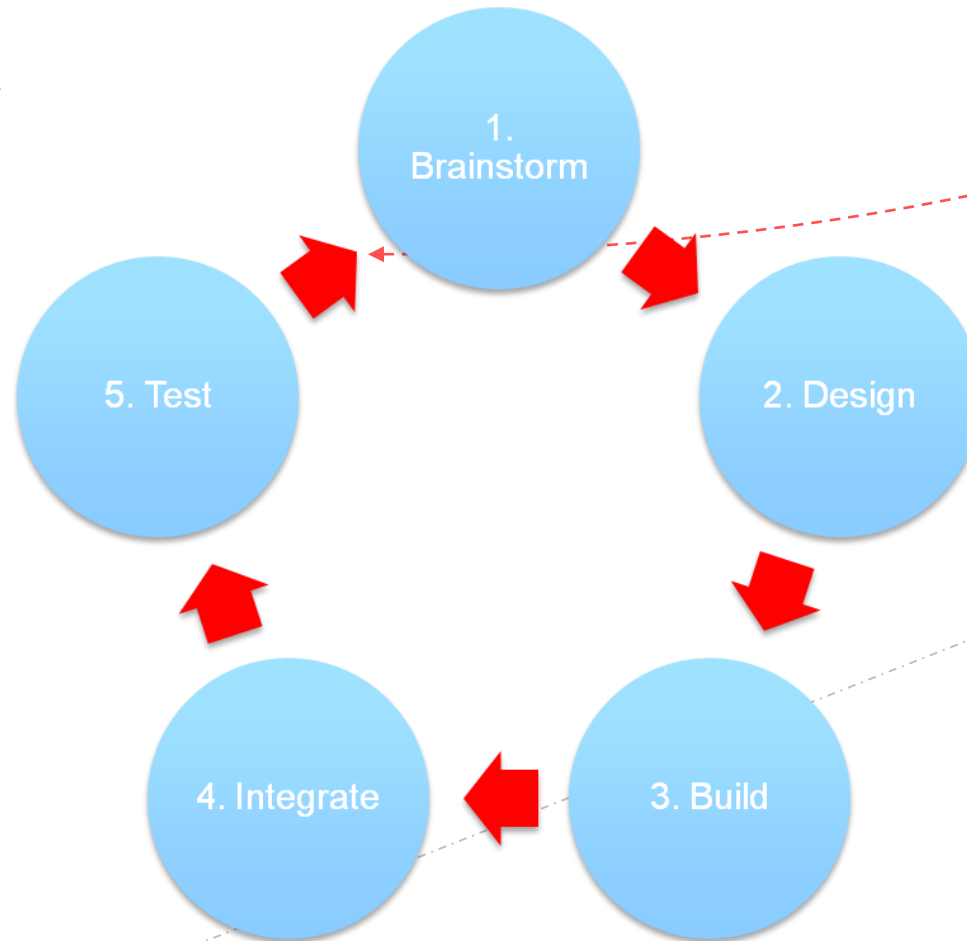


Why Engineering?

- Importance of infusing an “engineering mind” in children from an early age
- Provides the hands-on opportunities that are necessary for both students and instructors



Engineering Design Process



Class Goals

- **Work together in small groups**
- **Understand and be able to apply an engineering design process to a problem**
- **Understand the science and engineering concepts used in Rube Goldberg machines**
- **Build the machines that they design**



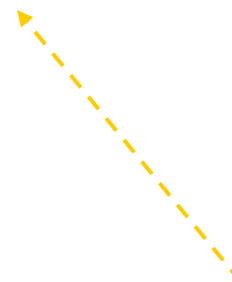
Class Outline

- **Week 1**
 - Introduction to class, design process, and basic mechanics
 - Brainstorm and design module 1
- **Weeks 2 - 3**
 - Finish design, build, and test module 1
 - Introduction to electricity, magnetism, and fluid mechanics
 - Brainstorm and design module 2
- **Week 4**
 - Finish design, build, and test module 2
- **Week 5**
 - Systems integration and testing
- **Week 6**
 - Presentations and demonstrations



Teamwork and Roles

- Chief Idea Officer (CIO)
- Chief Design Officer (CDO)
- Chief Testing Officer (CTO)
- Chief Recordkeeping Officer (CRO)



Research Questions

1. How do generated design ideas evolve across different stages of the design process?
2. How do group interactions influence design process outcomes?
3. How effective is teaching an engineering design process?



Participants

- **15 students in an enrichment program**
 - Students choose to take the class
 - 12 males, 3 females
 - 5th and 6th grade
 - High-ability students
 - At least 4 low-socioeconomic status students



Data Sources

- Interest inventory
- Pre-assessment
- Brainstorming artifacts
- Design sketches
- Final posters
 - Written and pictorial representations
- Pictures and videos of final products
- Reflective teaching journals
- Student class evaluation: My Class Activities (Gentry & Gable, 2001)



RQ1 Results: Theme Ideas

RQ1: How do generated design ideas evolve across different stages of the design process?

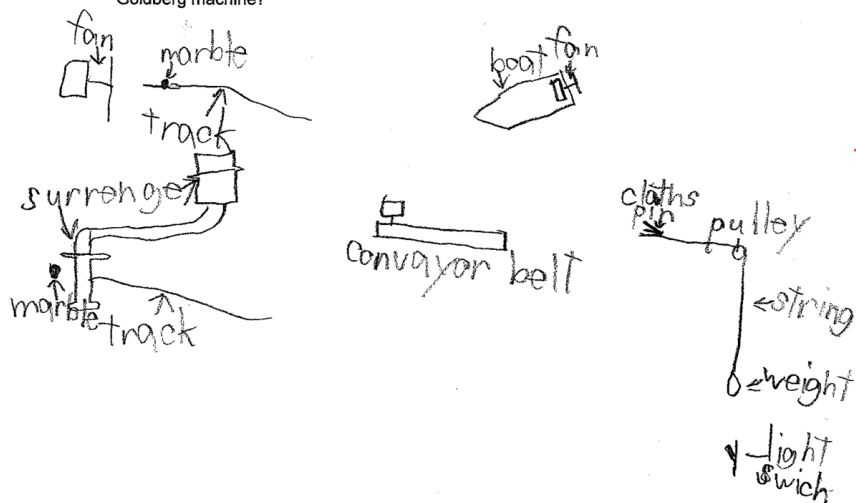
Team	Ideas Generated
Team 1 (3 girls)	Willie Wonka, bookworms, drawing, shopping, roller skating, pop star, school, outer space, science, computer, junk food, chocolate, baseball, football, biology, holiday, messy room, swimming, math, seasons, carpentering, safety, water , family
Team 2 (4 boys)	Chocolate factory , Willie Wonka, Hershey Park, Martian chocolate
Team 3 (4 boys)	The machine ate our Milky Way
Team 4 (4 boys)	Football, Star Wars, Legos, cars, robots , school, mindstorms, people, soccer, hazers, building materials, factory, buildings, science



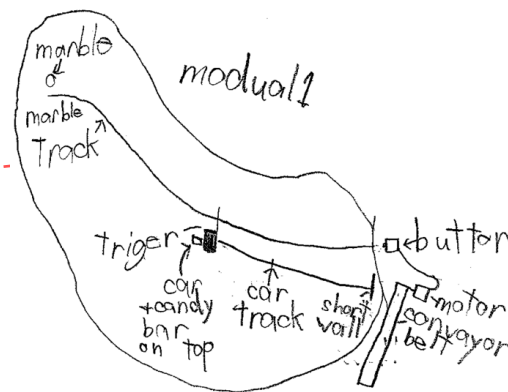
RQ1 Results: Designs

Step Brainstorming

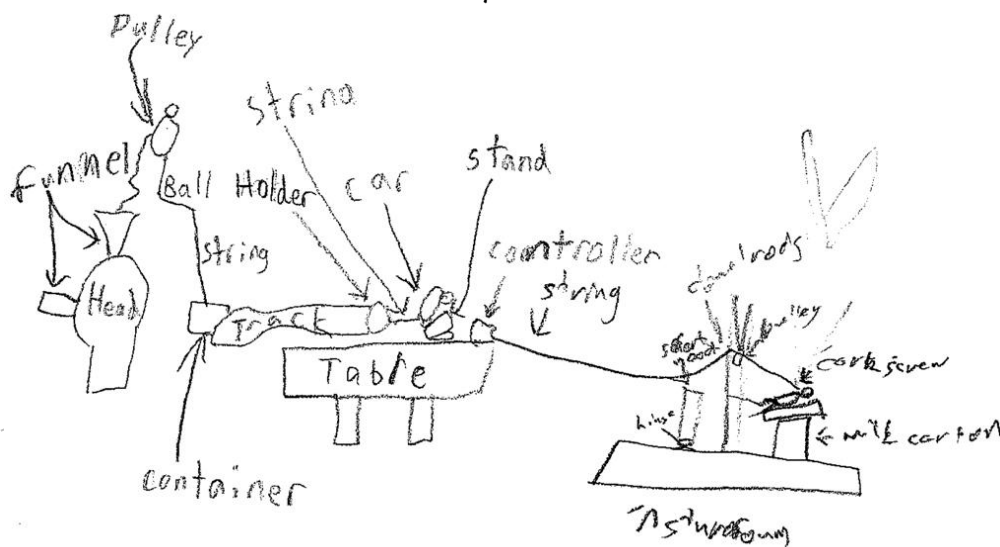
What electrical, magnetic, or fluid modules could your team build into your Rube Goldberg machine?



Early Design

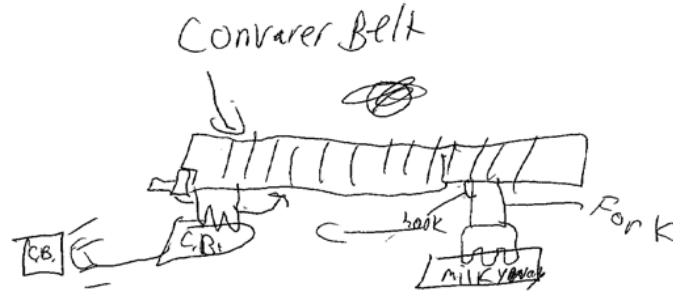


Final Design



RQ2 Results: Team 3 Sketch

RQ2: How do group interactions influence design process outcomes?



My Idea!

Button makes the conveyor Belt with the Rocks and they fall and hit the chomper!



RQ3 Results: Effectiveness

RQ3: How effective is teaching an engineering design process?

- **Challenges**

- Applying the engineering design process
- Jumping to final design
- Generating design documentation
 - Useful in disagreement mediation

- **Class Evaluations**

- Above-average ratings for Challenge, Choice, and Enjoyment evaluation dimensions



Recommendations

- Research → practice
- Smaller, more frequent goals
- Motivate the need for using a design process
- Encourage collaboration between groups
- Model could be more appropriate for older students



The Second Iteration: Summer

- **7th and 8th graders in 2-week residential program**
- **30 student contact hours**
 - 25 hours of “regular” class
 - 5 hours of independent study





Innovation Talks



1. Bring in your favorite innovative invention
2. Tell us about it – and how it works! (2-3 min)

Q: How do I figure out how it works?

A: Take it apart, ask your parents, or look it up on the Internet (e.g., howstuffworks.com)



Summer Outline

- **Project 1: Build a machine**
- **Introduce an engineering design process**
- **Project 2: Given inputs and outputs, design and build a machine**
- **Project 3: Brainstorm, design, and build a machine**



365-Stage Class Model: Stage 1

- ***Task:*** To pick up, move, and deliver a drink box in a complex way
- **Brainstorm and design a machine as a class**
- **Build and test the machines in teams**
- **Demonstrations! 😊**



Three-Stage Class Model: Stage 2

- **Task:** To turn off playing music in a complex way
- **Brainstorm a theme as a class**
- **Provide machine module list to the class**
- **Design modules, build, integrate, and test in teams**
- **Demonstrations! 😊**



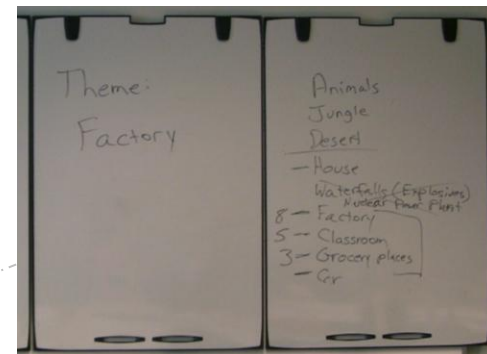
Machine Module List

Module	Description
1. Input: <i>Start.</i> Cell phone vibration Output: Wheel rolling	
2. Input: Wheel turning Output: Salt poured (mass)	
3. Input: Salt (mass) Output: Billiard balls rolling	
4. Input: Billiard balls Output: Nail popping balloon	
5. Input: Popped balloon Output: Music stops playing. <i>Task complete.</i>	



Three-Stage Class Model: Stage 3

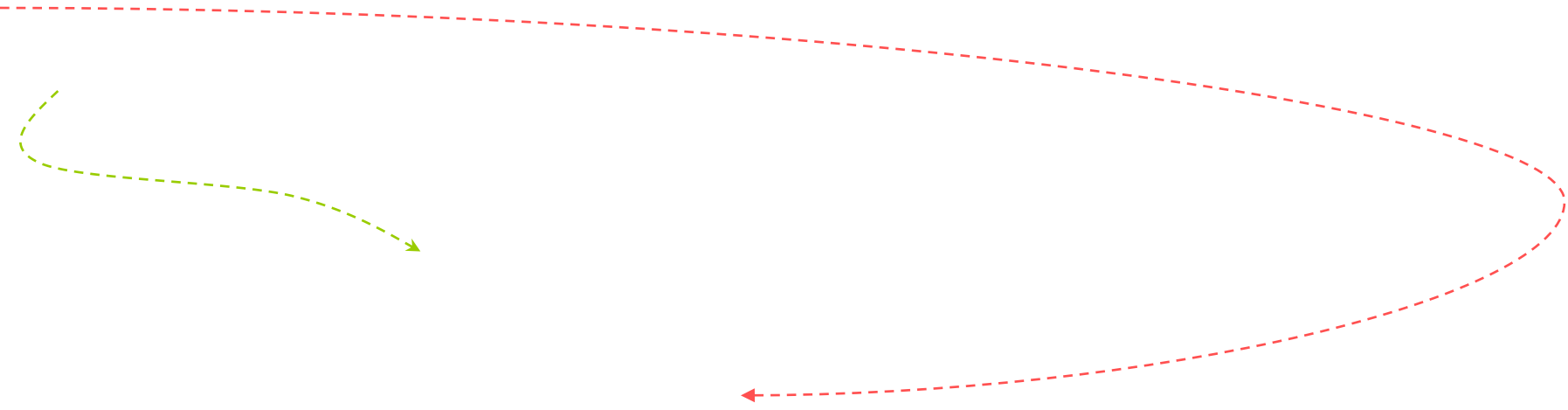
- Brainstorm task and theme as a class
- Storyboard, design, build, integrate, and test in teams
- Demonstrations! 😊



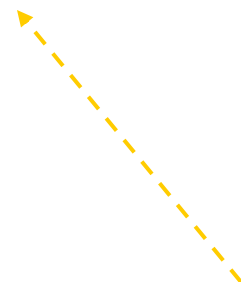
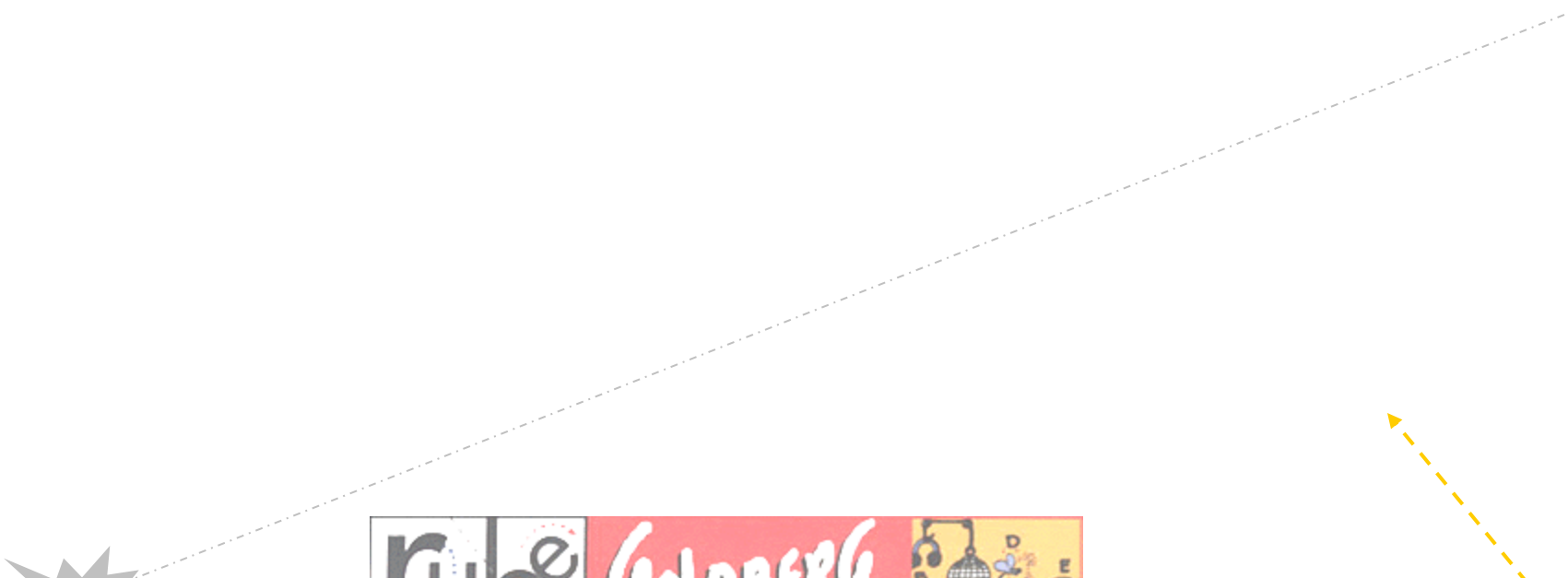
Concluding Thoughts

- **Rube Goldberg experience exposes students to engineering design**
 - Brings together people from a variety of backgrounds
 - Strong team-building opportunity
 - Using a more scaffolded approach helped students accomplish their task
- **Many of the issues the middle school students had are the same ones we see with college freshmen**



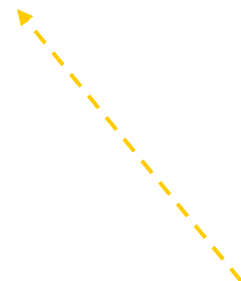


Let's try it!





Human Rube Machine



Questions?

Nielsen Pereira

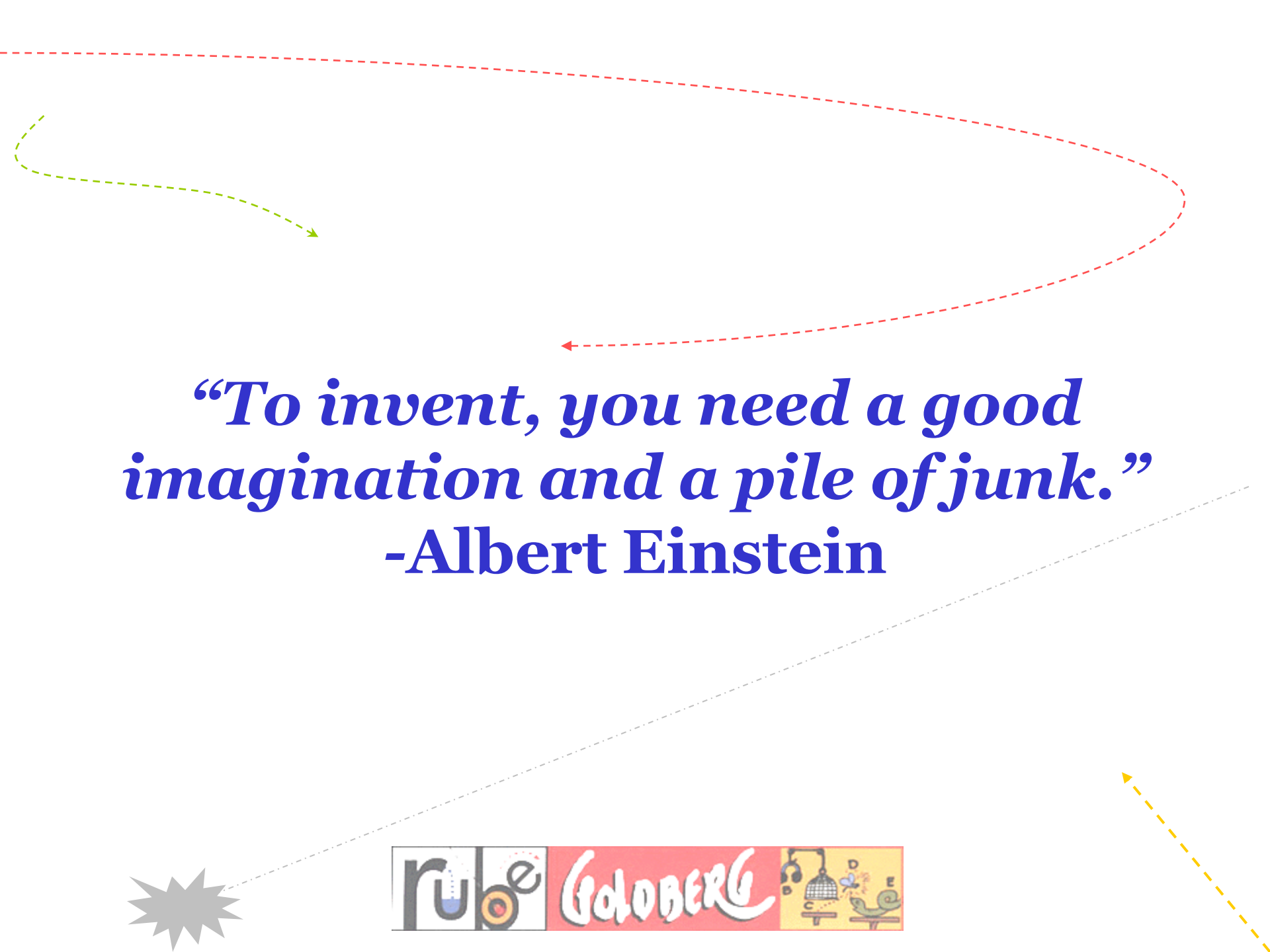
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***“To invent, you need a good
imagination and a pile of junk.”
-Albert Einstein***

