Deterministic Design

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Today

The design process explained

Designing for developing countries

The Design Process

Break down problems into manageable chunks

The Design Process

Break down problems into manageable chunks

Works in any system and across disciplines

Deterministic Design

Designing with a purpose

Deterministic Design

Designing with a purpose

And justifying it!

Metrics

Evaluate a design's performance

Metrics

Evaluate a design's performance

Time

Cost

Risk

Manufacturability

...

Choosing Metrics

What is important to you?

Choosing Metrics

What is important to you?

What is important to the user?

Choosing Metrics

What is important to you?

What is important to the user?

Can't have it all: maximize what is important.

Tradeoffs

Not all dreams can come true.

Tradeoffs

Not all dreams can come true.

Cost vs. Performance

Innovation vs. Risk

Precision vs. Manufacturability

Design

Creating something new...

Design

Creating something new...

Design

Creating something new...

methodically.

Creativeering

Channel creativity with a deterministic process.

Creativeering

Channel creativity with a deterministic process.

Creativeering

Channel creativity with a deterministic process.

Use your creativity to come up with new ideas.

Creativeering

Channel creativity with a deterministic process.

Use your creativity to come up with new ideas.

Use your engineering skills to assess and develop them.

Design Process

Start vague and become more specific

Design Process

Start vague and become more specific

Strategy

Concept

Module

Component

Strategy

A plan of how to do something.

Strategy

A plan of how to do something.

Strategy

A plan of how to do something.

How will you go accomplish your design goals?

Strategy

A plan of how to do something.

How will you go accomplish your design goals?

Don’t sweat the details.

Concept

A device that will meet your design goals.

Concept

A device that will meet your design goals.

Concept

A device that will meet your design goals.

How does it stack up (metrics)?

Concept

A device that will meet your design goals.

How does it stack up (metrics)?

Don’t sweat the details.

Module

A chunk of your device.

Module

A chunk of your device.

Module

A chunk of your device.

Focus on most important modules first.

Module

A chunk of your device.

Focus on most important modules first.

Start sweating the details.

Component

A specific engineered part.

Component

A specific engineered part.

Component

A specific engineered part.

All of the details are figured out.

Deterministic Design

Evaluate with your metrics at every stage

Deterministic Design

Evaluate with your metrics at every stage

Strategy

Deterministic Design

Evaluate with your metrics at every stage

Strategy

Concept

Deterministic Design

Evaluate with your metrics at every stage

Strategy

Concept

Module

Deterministic Design

Evaluate with your metrics at every stage

Strategy

Concept

Module

Component

Notebooks!

Put all of your designs and analysis in a design notebook.

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Put all of your designs and analysis in a design notebook.

Sturdy bound notebook (composition is fine).

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Sturdy bound notebook (composition is fine).

This is super important!

Design Evaluation

FRDPAARC technique

Design Evaluation

FRDPAARC technique

FR = Functional Requirements

Design Evaluation

FRDPAARC technique

FR = Functional Requirements

DP = Design Parameters

Design Evaluation

FRDPAARC technique

FR = Functional Requirements

DP = Design Parameters

A = Analysis

Design Evaluation

FRDPAARC technique

FR = Functional Requirements

DP = Design Parameters

A = Analysis

R = Research

Design Evaluation

FRDPAARC technique

FR = Functional Requirements

DP = Design Parameters

A = Analysis

R = Research

R = Risk

Design Evaluation

FRDPAARC technique

FR = Functional Requirements

DP = Design Parameters

A = Analysis

R = Research

R = Risk

C = Countermeasures

Design Problem

Design a pump to help farmers irrigate their fields in developing countries

Design Problem

Design a pump to help farmers irrigate their fields in developing countries

Functional Requirements

What does the design have to do?

Functional Requirements

What does the design have to do?

Functional Requirements

What does the design have to do?

Pump:

Pump water out of well 10m deep

Operated by a single person

Can be made out of local materials

Design Parameters

How are you going to meet your functional requirements?

Design Parameters

How are you going to meet your functional requirements?

Design Parameters

How are you going to meet your functional requirements?

Pump:

- Archimedes screw
- Buckets
- Chamber pump

Design Parameters

This is where you can be creative!

Design Parameters

This is where you can be creative!

Design Parameters

This is where you can be creative!

What are your design freedoms?

Design Parameters

This is where you can be creative!

What are your design freedoms?

What are your design constraints?

Analysis

For each design parameter, is it feasible?

Analysis

For each design parameter, is it feasible?

Analysis

For each design parameter, is it feasible?

Pump:

- What power is needed to operate?
- What are the costs?
- What are the component stresses?
- What are the fluid dynamics?

Research

Don’t reinvent the wheel!

Research

Don’t reinvent the wheel!

Research

Don’t reinvent the wheel!

Pump:

Look at other pumps in developing countries

Risks

Risks

What will bite you in the ass?

Risks

What will bite you in the ass?

Risks

What will bite you in the ass?

Each design parameter will have specific risks

Risks

What will bite you in the ass?

Each design parameter will have specific risks

Risks

What will bite you in the ass?

Each design parameter will have specific risks

Pump (chamber pump):

Seals don’t work

Countermeasures

When it hits the fan, how will you recover?

Countermeasures

When it hits the fan, how will you recover?

Countermeasures

When it hits the fan, how will you recover?

Pump (chamber pump DP):

- Use better seals
- Tighten tolerances
- Use a fluid as the seal

Treadle Pump

"Money-Maker Pump"

Treadle Pump

"Money-Maker Pump"

Chamber-pump

Treadle Pump

"Money-Maker Pump"

Chamber-pump

Uses water around the pistons as a seal

Developing Countries

Present some delightful design constraints

Developing Countries

Present some delightful design constraints

Have some tremendous design opportunities

Developing Countries

Present some delightful design constraints

Have some tremendous design opportunities

Developing Countries

Present some delightful design constraints

Have some tremendous design opportunities

Biggest difficulty: frame of reference

Frame of Reference

You do not live in a developing country.

Frame of Reference

You do not live in a developing country.

How do you determine what is important to the design?

Frame of Reference

You do not live in a developing country.

How do you determine what is important to the design?

How do you select your goals?

Frame of Reference

You do not live in a developing country.

How do you determine what is important to the design?

How do you select your goals?

Frame of Reference

You do not live in a developing country.

How do you determine what is important to the design?

How do you select your goals?

Community Partners!

Community Partners

Do live in developing countries!

Community Partners

Do live in developing countries!

Community Partners

Do live in developing countries!

Know their customers

Community Partners

Do live in developing countries!

Know their customers

Know their capabilities

Community Partners

Do live in developing countries!

Know their customers

Know their capabilities

Can provide incredible feedback

Community Partners

Do live in developing countries!

Know their customers

Know their capabilities

Can provide incredible feedback

Need to know how to ask

Design Constraints

What limits your designs?

Design Constraints

What limits your designs?

Design Constraints

What limits your designs?

- Mild steel only

Design Constraints

What limits your designs?

Mild steel only

Limited manufacturing precision

Design Constraints

What limits your designs?

Mild steel only

Limited manufacturing precision

Lack of machine tools

Design Constraints

What limits your designs?

Mild steel only

Limited manufacturing precision

Lack of machine tools

Cultural risk aversion

Design Constraints

What limits your designs?

Mild steel only

Limited manufacturing precision

Lack of machine tools

Cultural risk aversion

Harsh use conditions

Design Opportunities

What can you exploit?

Design Opportunities

What can you exploit?

Bicycle components

Design Opportunities

What can you exploit?

Bicycle components

Local repairmen

Design Opportunities

What can you exploit?

Bicycle components

Local repairmen

Make-do culture

Become a Ninja

Become a Ninja

of design!

Become a Ninja

of design!

Become a Ninja

of design!

develop your creativity and analytical skills

Become a Ninja

of design!

develop your creativity and analytical skills

practice

Become a Ninja

of design!

develop your creativity and analytical skills

practice

enjoy the process

Summary

Summary

Metrics to guide your design.

Summary

Metrics to guide your design.

Broad to focused approach.

Summary

Metrics to guide your design.

Broad to focused approach.

Notebooks!

Summary

Metrics to guide your design.

Broad to focused approach.

Notebooks!

Use FRDPARRC to evaluate your design.

Summary

Metrics to guide your design.

Broad to focused approach.

Notebooks!

Use FRDPARRC to evaluate your design.

Seize design opportunities, know design constraints.

Summary

Metrics to guide your design.

Broad to focused approach.

Notebooks!

Use FRDPARRC to evaluate your design.

Seize design opportunities, know design constraints.

Use your community partners!

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