

“ Why Water Striders can stand and slide on the Water? ”



A Summer Homework
by Son and Father with TRIZ

Taichiro Miyanishi

(2nd Grader, Kenroku Junior High School / Son)

○ **Katsuya Miyanishi**
(/ Father)

English brushing up supported by Toru Nakagawa (OGU)

2008/09/10



We are from KANAZAWA.

Intro.

Plan

Hypotheses
○○○○○

Com-
firm

Proto
types

Fa-
ther

End



FATHER Katsuya

SON Taichiro

2nd Grader,
Kenroku
Junior High School



Nagamachi



Higashiyama



Kanazawa
Castle



Kenroku-en Garden



Background

Intro.

Plan

Hypotheses
○○○○○

Com-
firm

Proto
types

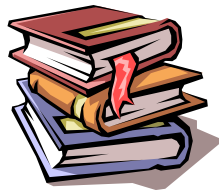
Fa-
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End



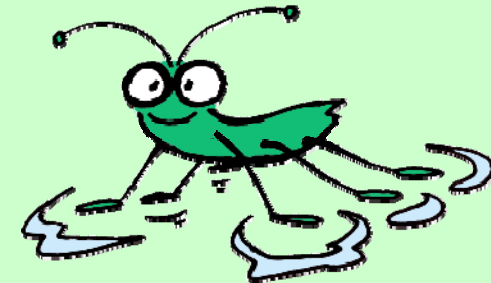
Son

1st Grader,
Junior High



Last summer...

"Why the water striders can stand and slide on the surface of water? I want to study about it as my summer homework."



Good! But if you only survey about it in books and write a report without creativity, you would be just like an elementary school child.



Father



**“Why the water striders
can stand and slide
on the surface of water?”**



- Let's set up hypotheses, and verify them!**
- Let's make conceptual prototypes !**



Approach

Intro.

Plan

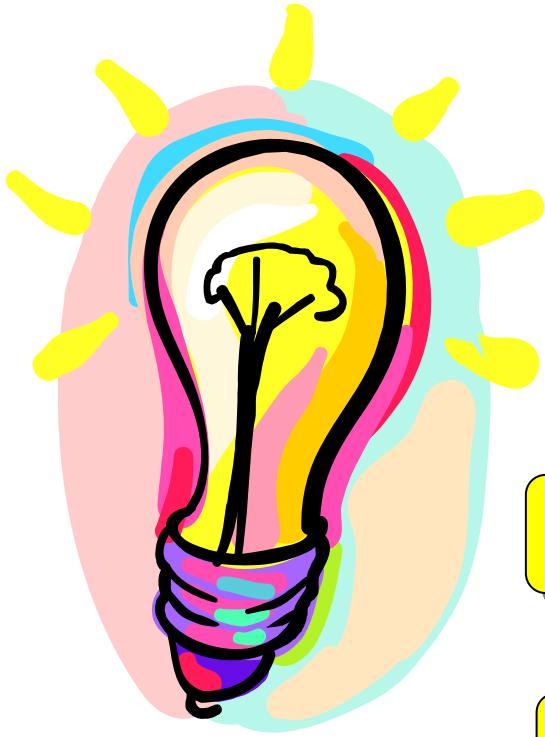
Hypotheses
○○○○○

Com-
firm

Proto
types

Fa
ther

End



Let's use TRIZ-thinking in practice

Planning



Set up hypotheses



Verification

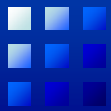


Make a prototype

Think
independently

← survey here





Approach

Intro.

Plan

Hypotheses
○○○○○

Com-
firm

Proto
types

Fa
ther

End

Planning

Purpose, Target, Evaluation standard
Output, Schedule, etc.

Set up hypotheses

Practice

Search for mechanisms

Grouping, Make a TREE

Enhancing ideas

Analysis, Select Candidates

Make ideas for hypotheses

Verification of our ideas

Experiments (Prototypes)

TRIZ Check

Let's use TRIZ-thinking in practice

NAZE-NAZE deployment
Affinity diagramming
Scene deployment, MECE
Strength/weakness analysis
Evaluation, Combine
Product Analysis

SFR

Physical Contradiction Centric Causal Analysis
(Larry Ball @ The 3rd TRIZ Symposium in JAPAN)
Reverse TRIZ



Management (Purpose,Target, Output, Schedule)

Intro.

Plan

Hypotheses
○○○○○

Com-
firm

Proto
types

Fa
ther

End

Overview the Ideal (Goal, Outputs), First!



Schedule



Purpose

(Main) Set up the hypothesis
Why the water striders
can stand and slide
on the surface of water?

(Sub)
Making conceptual prototypes

Target

Making conceptual prototypes
(Size of 5-6cm)
by free and familiar materials

The prototype must float
in the same principle.
(Not necessary to slide)

Complete theme by August 20.

Process

Wants, Purpose, Target

NAZE-NAZE deployment

Own hypothesis

Survey

Confirmation and consideration

Search for similar principles

→ Free and familiar materials

→ Collect resources for prototypes

Sketch the design of prototypes

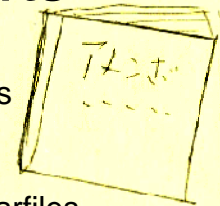
Making prototypes

Experiment

Output Image

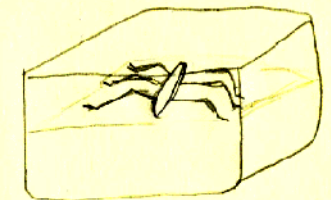
Reports

A4-Size
20-pages



Use Clearfiles

Prototypes



Consideration of
experiment result

Improvement and
Re-experiment

Summary and
Impression



Search for mechanisms

NAZE-NAZE deployment (Root-cause analysis)

How to Stand on Water?

How to Slide on Water?

体内にガスをためて浮ける (ガスを出して進む)	表面張力を使っている	熱気球と同じ原理	ガスを放出して進む (ガスをためて進む)	蓮の葉にのっている	スクリーボーイのかわりに
とても軽い気体が入っている	水より軽い液体が入っている	プロペラっぽいのので下に風を送ろう	足の水に付いているところに	プロペラっぽいのかわりに	水に流される
広がって					
物					
水の	入っている		移動の	いる	ひれがついている
が空気を吸い込んで	体の形が空気に合わせて 水面には空気をためてういている	足の毛で水を吸い取る	つねに足から油を出して その上を歩いている	水上にでるひれで あひいでる	水をかき払いにたどり進む
足のうらに油がついている	足の先から水を出している	足の下に舟っぽいのがある	体の側面、後ろにある穴から 空気を放出して 進む方向を変える	水面を飛んでるから	ほで風をうけて進む

First, Search for many many causes!

- No particular about the water strider.
- Regardless of the concept size.
- Write on the Tag-Paper immediately.
- Mother and younger brother also joined part.

Intro.

Plan

Hypotheses
●○○○○

Com-firm

Proto types

Fa ther

End



Grouping, and Make a Logic-Tree

Intro.
Plan
Hypotheses
○○○○
Com-firm
Proto types
Fa ther
End

NAZE-NAZE deployment (Root-cause analysis)

- Affinity diagramming
- Make a Logic-Tree

How to Stand on Water?

Upper concept

Lower concept

Lighter things inside the body

体内に水より軽い物が
入っている

Grouping

Air in the legs

Very light Air inside

Light liquid inside

Gas inside

How to Slide on Water?

Upper concept

Lower concept

Row on the water

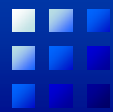
水をかき回す

Grouping

Row by legs

Like a propeller

Fin on the legs



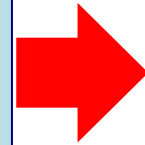
Enhancing ideas by Associative thinking

- Intro.
- Plan
- Hypotheses
○○○○○
- Com-firm
- Proto types
- Fa ther
- End

lighter things inside

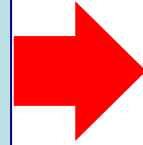
体内に水より軽い物が入っている

足に空気が入ってる
とむね軽い気体が入ってる
水より軽い液体が入ってる
体内にガスをためておける
(ガスを出した時)



associate

Airship
飛行船
風船
Balloon



associate

Example

Jet balloon

(@KOSHIEN Stadium)

Jet balloon

Enhancing by Associative thinking

Slide by any jet pressure

Upper concept

Lower concept (Another concept)

Water pressure

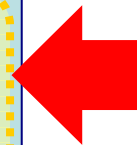
Stand using gas pressure

Slide using gas pressure

体から何か出す圧力で移動する

足先から空気を出している

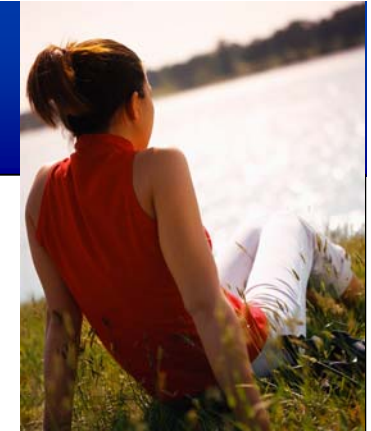
体からガスを押し出して進む (ガスを押し出す)



associate



Imagination of waterside-scene



Enhancing ideas by Scene deployment.

Imagining scenes and actions in daily life gives us new awareness.

Intro.

Plan

Hypotheses
○○○○○

Com-
firm

Proto
types

Fa-
ther

End

Imagination

Change
into ideas

Example-1

Water chopping



Jump on the water surface.

水面を飛んでるから

Example-2

Remora



Ride on other one.

他の物にのる
ことで 浮+移動

Example-3

Ice skating



Slide by freezing water by the foot.

水を足でゼリウムにこぼらせて
そのよをすべる



Completion of hypotheses

Intro.

Plan

Hypotheses
○○○○●

Com-
firm

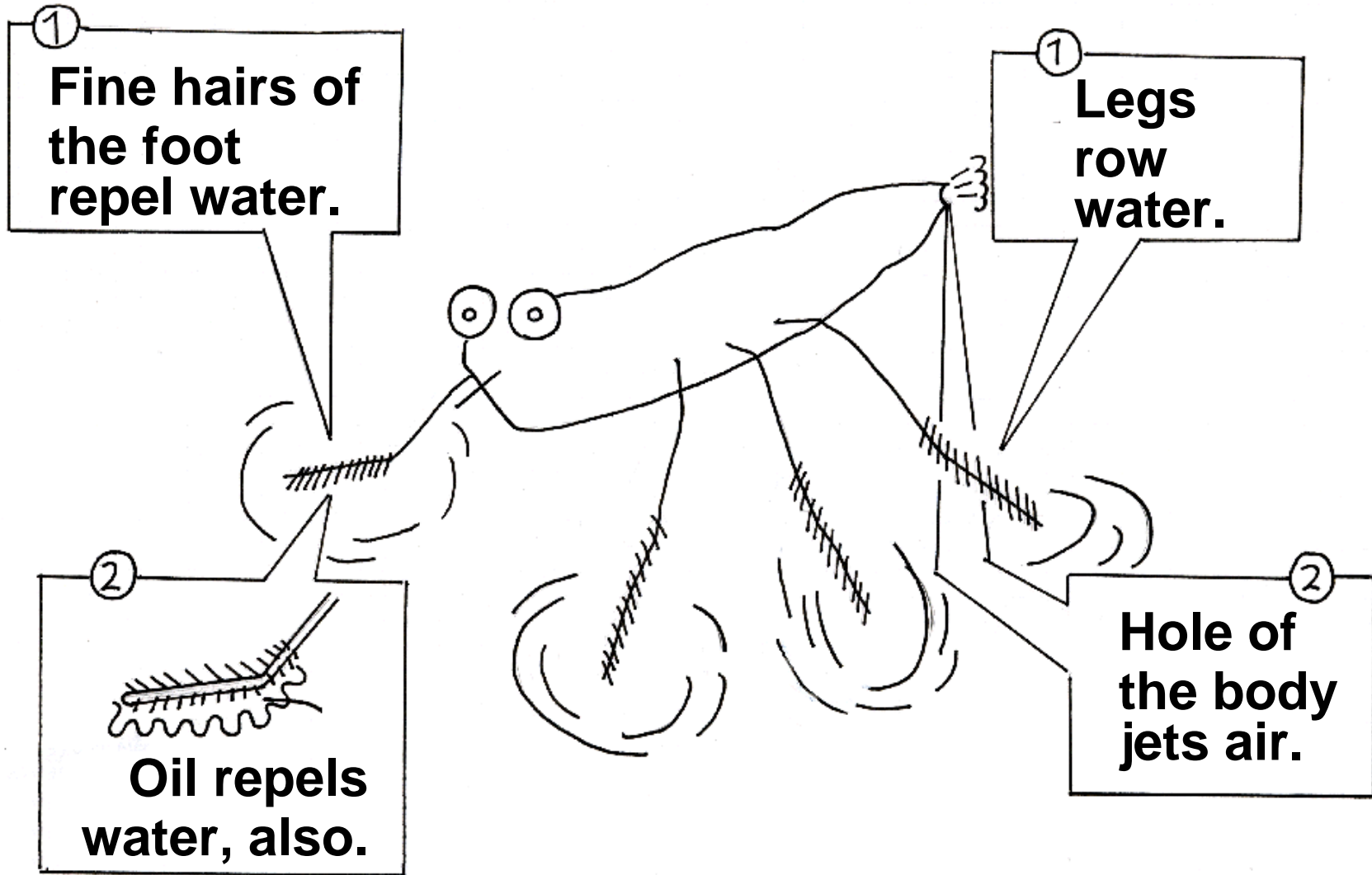
Proto
types

Fa-
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End

How to Stand on Water?

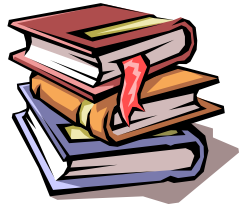
How to Slide on Water?





Confirmation of real facts

Intro.
Plan
Hypotheses
Com-firm
Proto types
FATHER
End

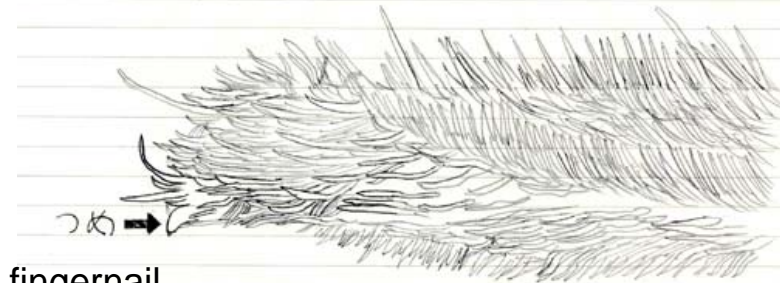


Surveyed books and references in the library for the known facts.

How to Stand on Water?

- **Fine hairs** are on the feet.
- **Oil** comes out of the feet, also.
- **Very light weight** (40mg)
- Therefore, **surface tension** can hold the weight..

アメンボの足図



fingernail

- **The hairs hide the fingernail.**

How to Slide on Water?

- Middle legs **row the water** like oars.
- 左右の後ろ足の広げかたを変えて進む向きを調整する

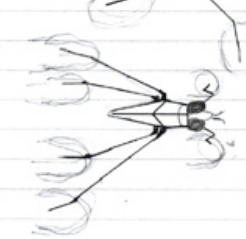
アメンボの進む手順

1



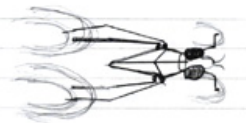
- 中足を、横に大きく広げる

2



- Middle legs **row the water backward.**

3



- 中足をまっすぐ後ろまでかくと、体が前に進む

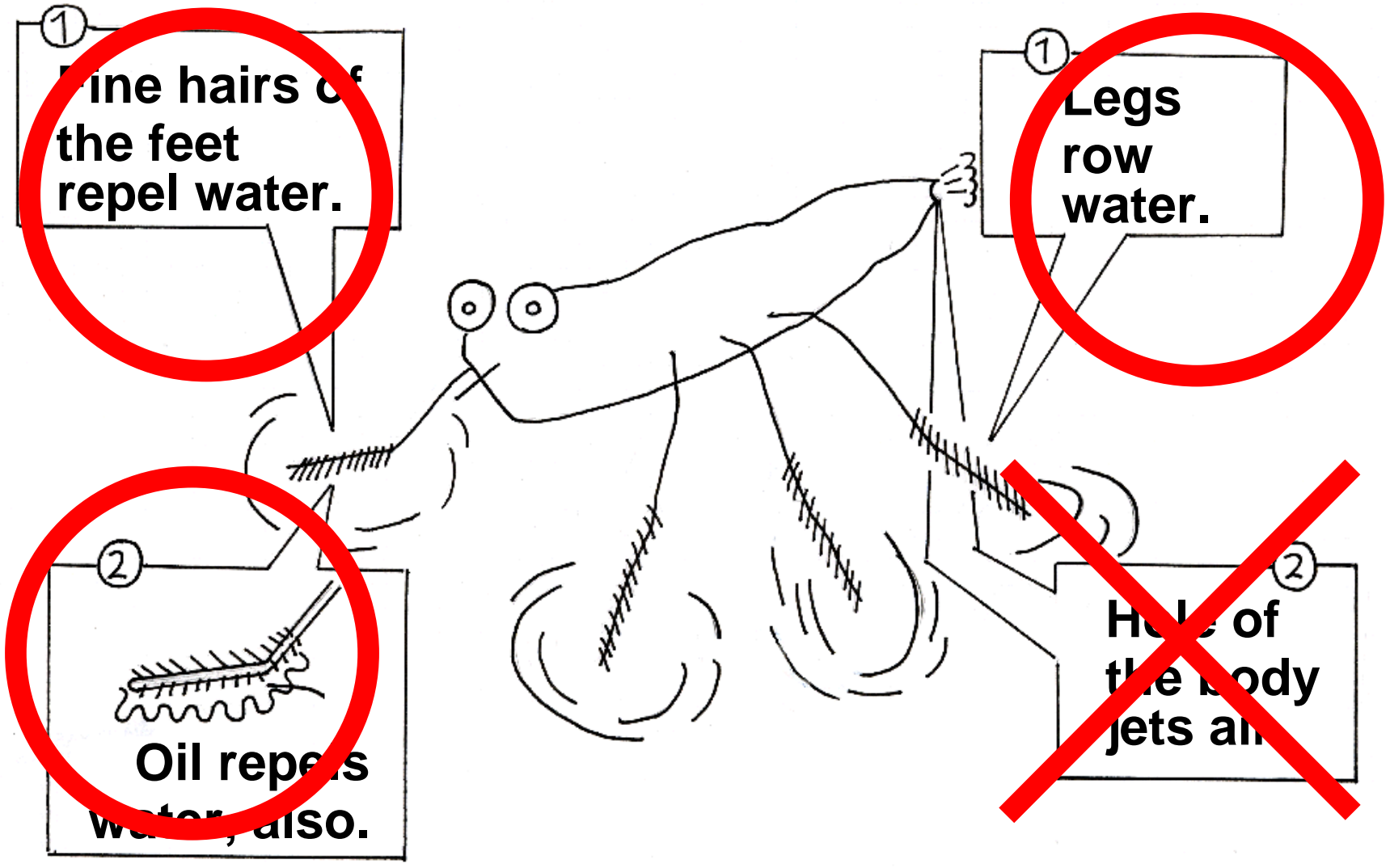


Confirmation of own hypothesis

- Intro.
- Plan
- Hypotheses
○○○○○
- Com-firm**
- Proto types
- Fa ther
- End

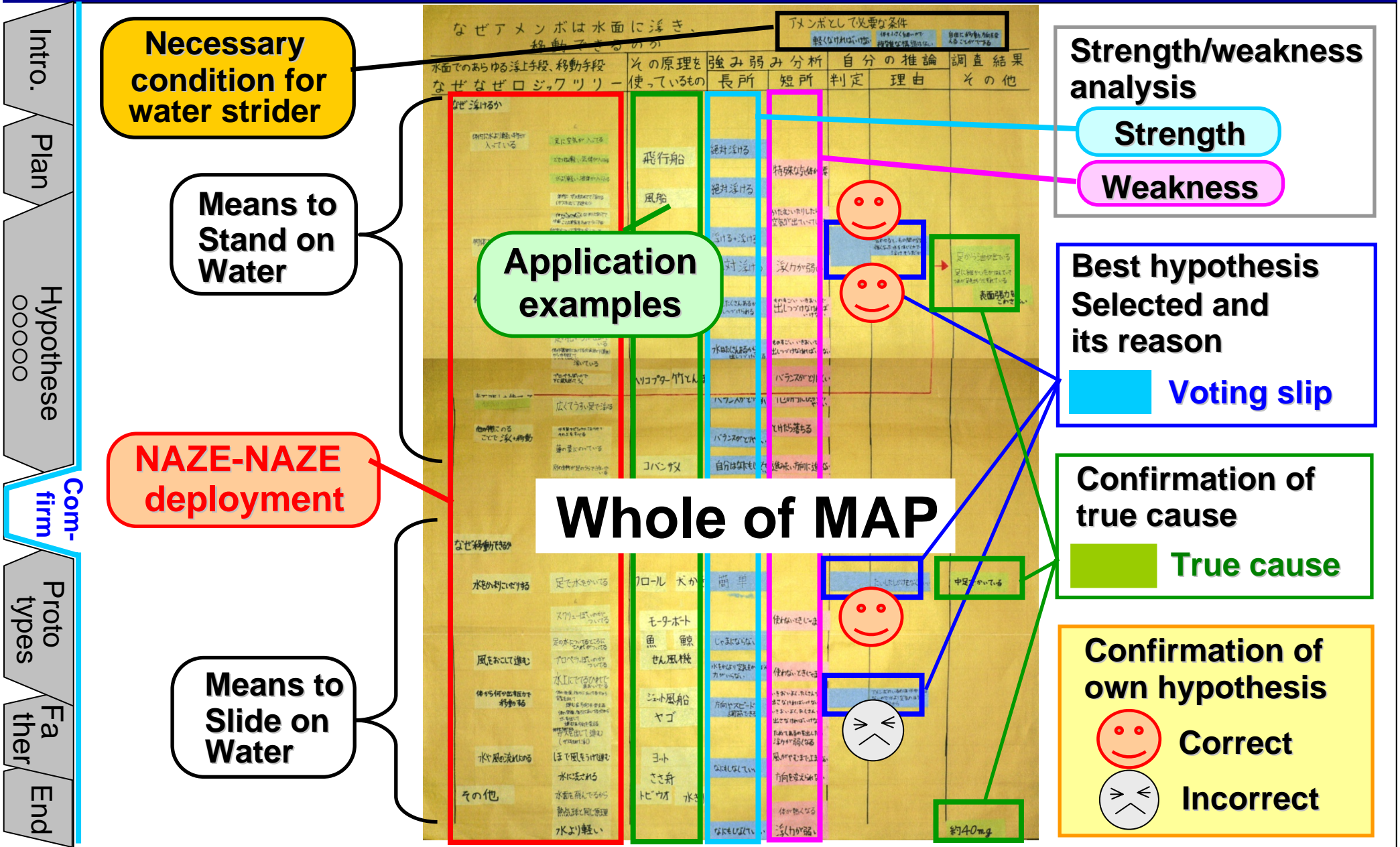
How to Stand on Water?

How to Slide on Water?





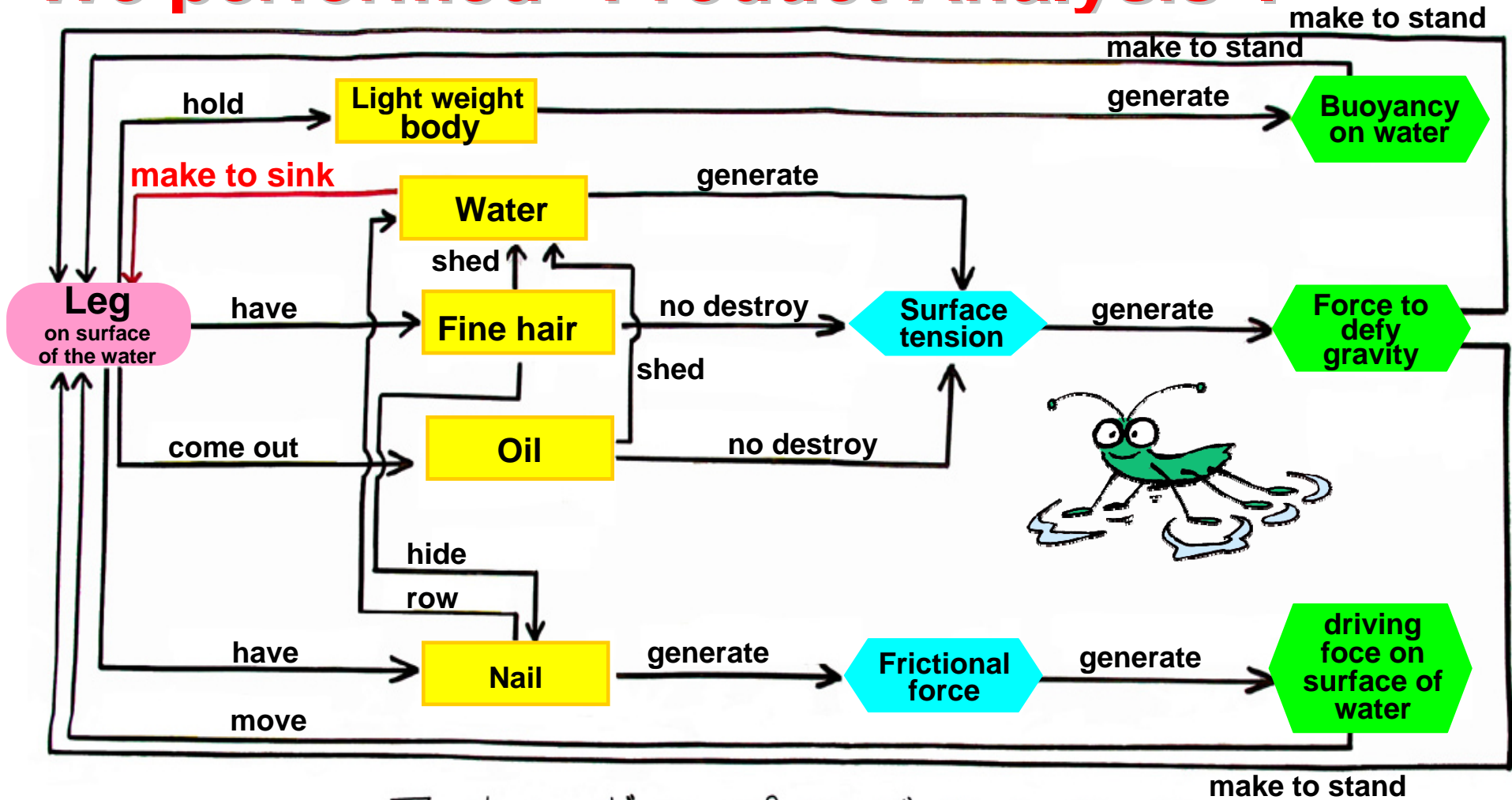
Whole of NAZE-NAZE deployment map





Deep understanding of the mechanism

We performed "Product Analysis".



アメンボのプロダクト分析
 Product analysis of water strider

- Intro.
- Plan
- Hypotheses
○○○○○
- Com-firm
- Proto types
- Fa ther
- End



Collect resources for prototypes

Collect free and familiar resources (materials). Decided by voting.

- Materials obtainable free and easily (in our house).
- ◐ Obtainable but not easy to use.
- Vote by TAICHIRO (Son)
- Vote by KATSUYA (Father)

Requirement

Materials

Light weight Body	Styrene foam ● ●	Cotton	● Paper	● ● Straw	● Stalk of Statice		
	● ● ● Balsa	● Vinyl	● Sponge	● Aluminum foil	◐ Lace		
for surface tension Fine hair	◐ shuttle	● ● Mogol	● Tooth brush	◐ Duster	Corn	◐ ● Setaria	Leaf of morning-glory
	Hair of peach	◐ Parakeet's shuttlecock	● ● Wool	◐ Stuffed animal	◐ ● Shuttlecock	◐ Brush	◐ Brush for glass
for surface tension Oil	● ● ● Waterproof spray	● Meat tray	Fluorine				
Light & strong Legs	● ● Mogol	● ● Lead	● Cut straw	● Leaf of pine			
	● ● Hair of brush	● Straw	● ● Stalk of Brush	● Fine wire			

Intro. Plan Hypotheses 00000 Com-firm Prototypes Fa ther End



Designing conceptual prototypes

Intro.

Plan

Hypotheses
○○○○○

Com-
firm

Proto-
types

Fa-
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End

Sketch the design of prototypes.



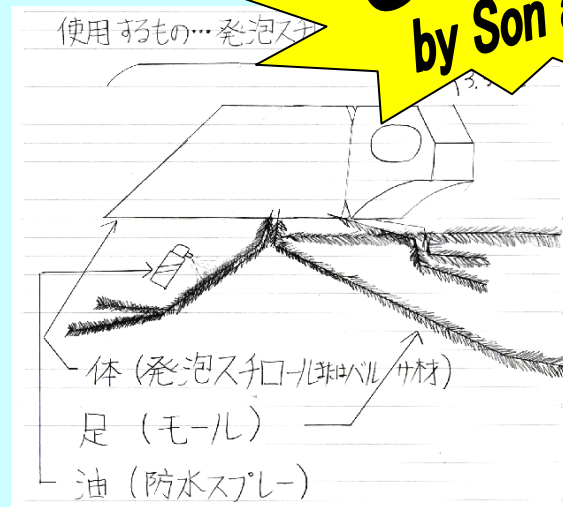
Son



Father

Compete
by Son and Father.

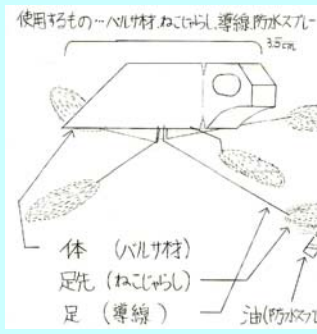
- Body Styrene foam
- Leg Mogol
- Hair Mogol
- Oil Waterproof spray



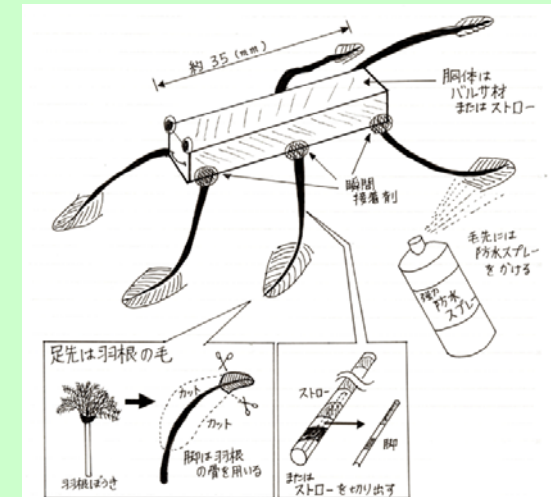
1st prototype

2nd prototype

- Balsa
- Lead
- Setaria
- Waterproof spray



- Body Balsa
- Leg Stalk of Brush
- Hair Hair of brush
- Oil Waterproof spray





Experiment ! Stand on Water ?

Intro.

Plan

Hypotheses
00000

Com-
firm

Proto
types

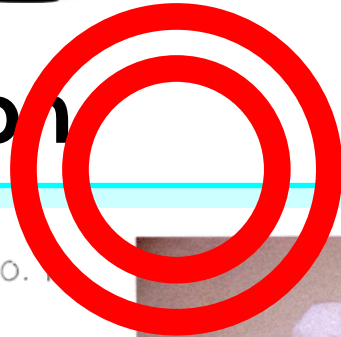
Fa-
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End



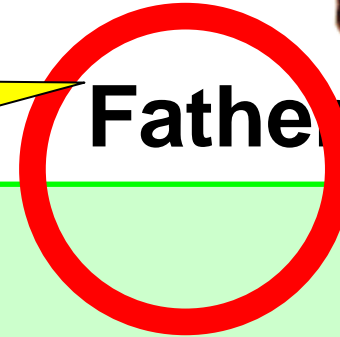
Son Won !

Son



Compete
by Son and Father.

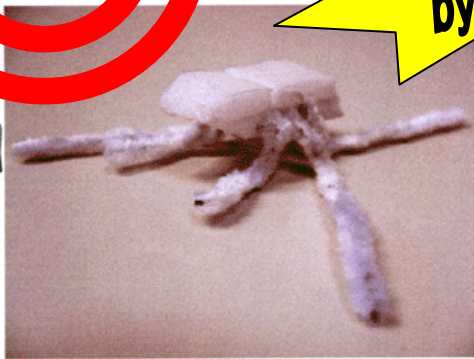
Father



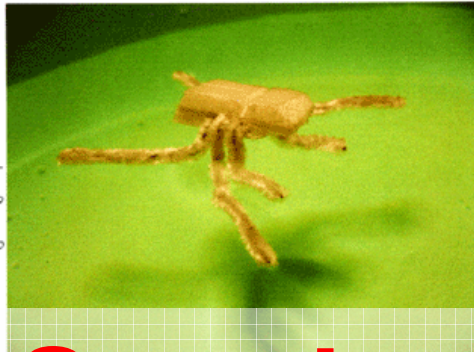
太一郎作 No.

表面張力を利用していることが、水のまわりのへこみからできる影でよく分かった。

横から見ても、水面に立っているように見えた。また長時間浮いてくれた。ワモっぽい体は別として、バランスがいいので気に入っている



は発泡スチロール

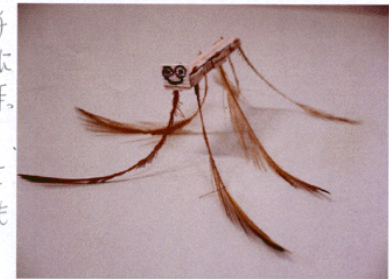


Stand well

※ 2nd idea was abandoned, because fixation was difficult.

父がバルサ材(発泡スチロールのような木材)を体に羽根ぼうきを足にして作った。足が長すぎて、僕の作った2つと比べると背が2倍高い。そのためバランスがとても悪く、30秒ほどでものすごくかたむく。アメンボにはバランスも必要なことかはきり分かる作品だ。

僕は顔がヘンなので、おまじ気に入っていない。



流れかたむきバランスの悪く、泳げないアメンボ



Stand so-so



Confirmation by spiteful experiments

Intro.

Plan

Hypotheses
○○○○○

Com-
firm

Proto
types

Fa-
ther

End

Working on the real principle ?

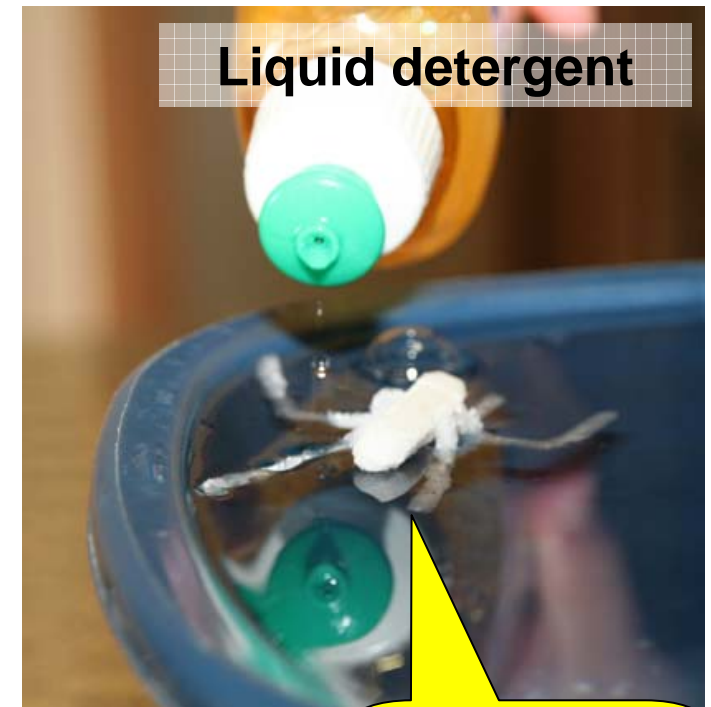
Q) Without the fine hairs, the model water strider cannot stand on water?



Right

Without hairs this model cannot stand on water.

Q) Does it sink when the surface tension is reduced?



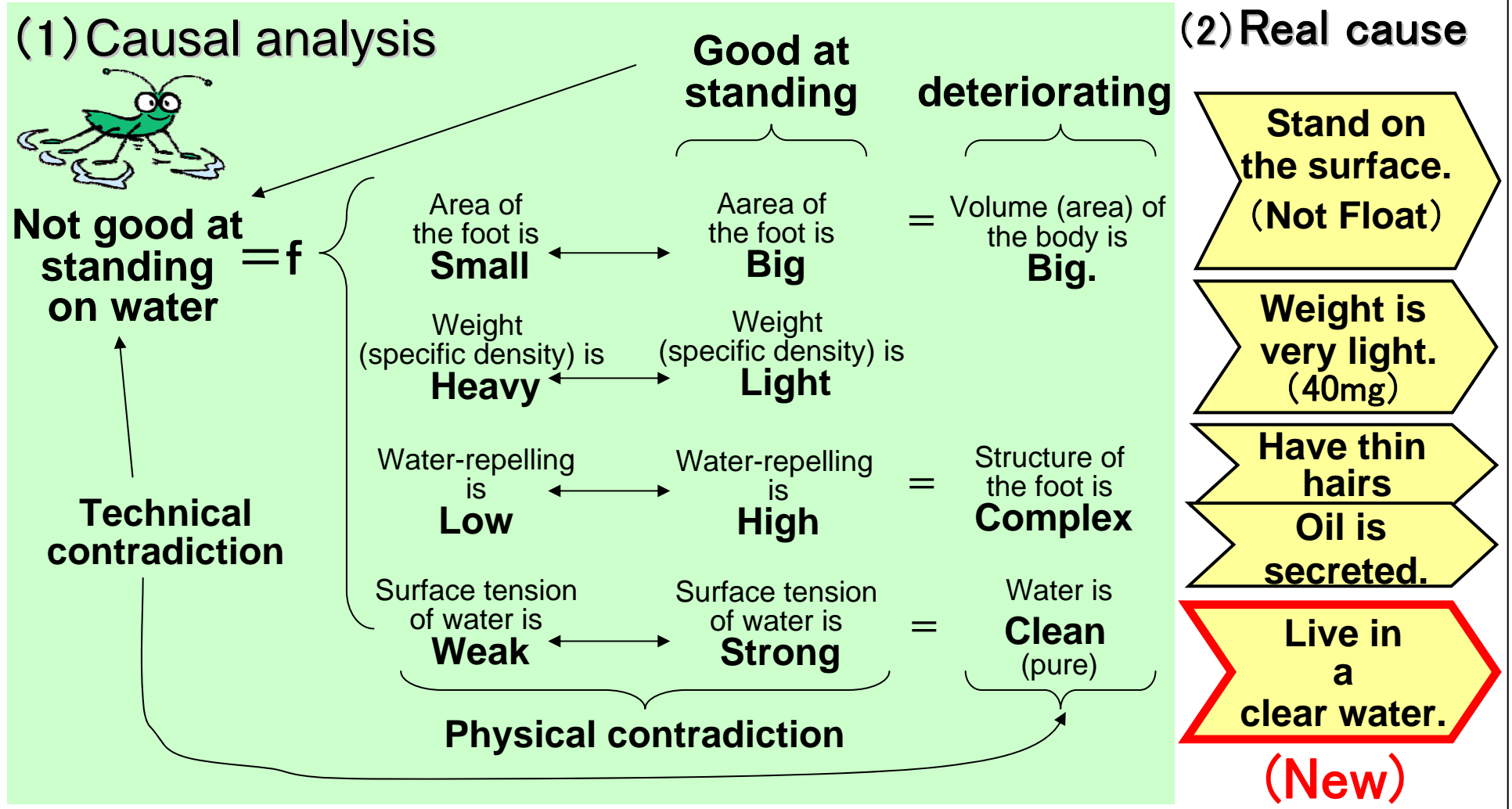
Right

It sinks.

Causal Analysis with Larry Ball's Method.

A new condition "Good water" was recognized.

Intro.
Plan
Hypotheses
Com-firm
Proto types
Fa
ther
End



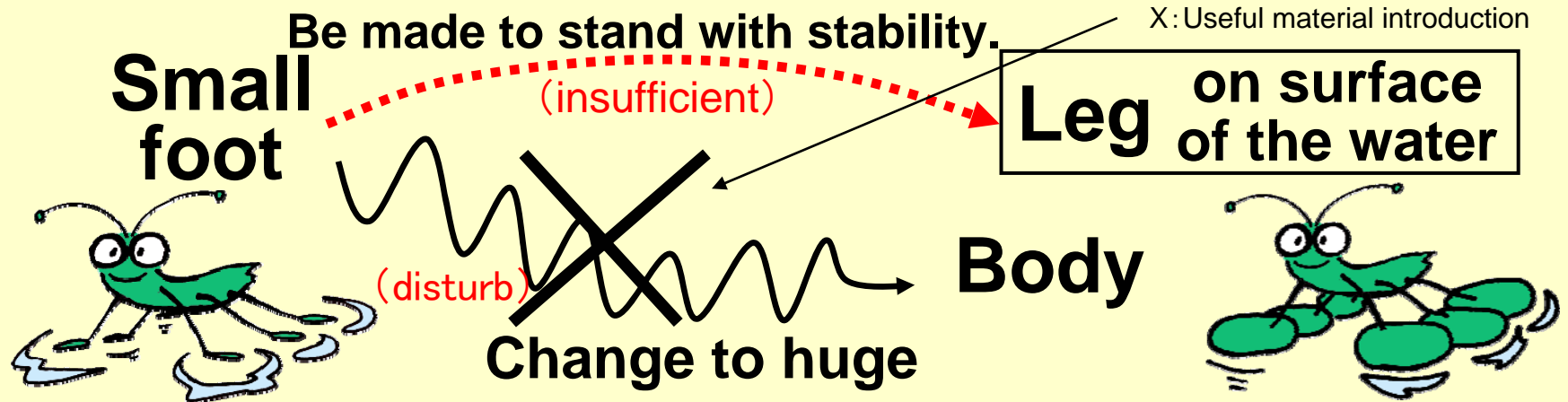
(ref.) 「Hierarchal TRIZ Algorithms」 Larry Ball (Honetwell, USA), The 3rd TRIZ Symposium in JAPAN 2007 doc. P.77

Modeling of problem for Reverse-TRIZ

Intro.
Plan
Hypotheses
Com-firm
Proto types
FATHER
End

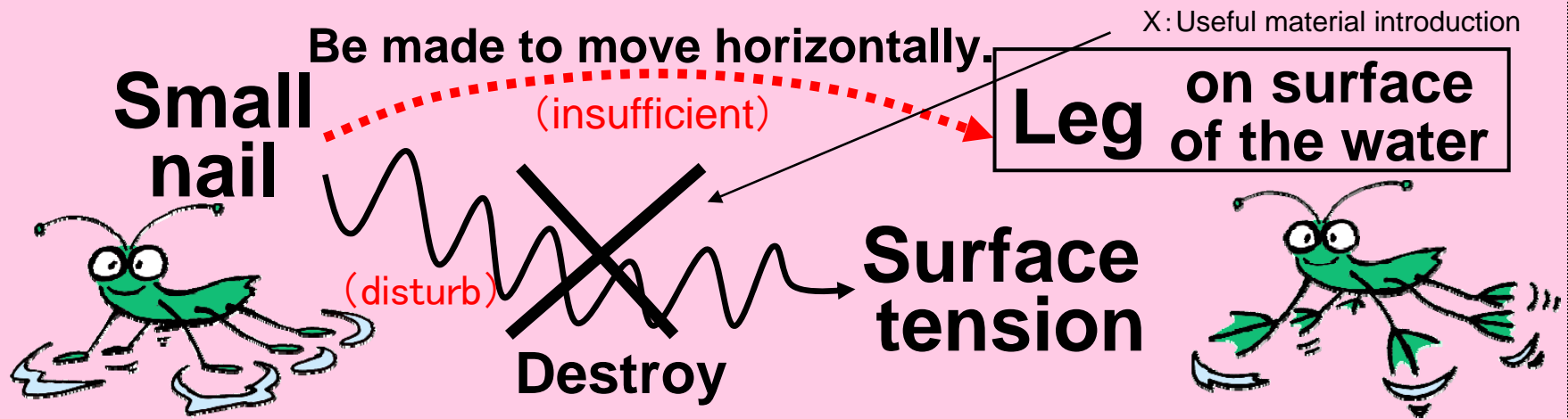
Model-1 (Stand)

The foot is enlarged, and used as a float.



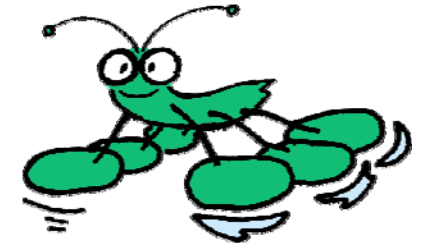
Model-2 (Slide)

The nail or fin of the foot rows water.



Reverse-TRIZ

Why Water Striders can "stand" on the water?



【Wish】

To stand on the water by foot with stability.

【Easy Approach】

The foot is enlarged, and used as a float.

EC1

EC2

Improving

Worsening

Foot and body can be reduced.

Not possible to float with stability on water.

7

Volume of moving object

27

Reliability

Improving

Worsening

possible to float with stability on water.

Foot becomes huge.

27

Reliability

7

Volume of moving object

14. Spheroidality-Curvature

1. **Segmentation**

Foot-structure is subdivided into hair level.

40. **Composite materials**

Has Hairs at the front part of foot.

11. **Beforehand cushioning**

Oil is secreted from the hair.

3. **Local Quality**

Foot has Fine hairs at the part that touches water.

24. **Intermediary**

To prevent the foot from destroying the surface tension of water, Hair and Oil, and Air between the foot and water are used.

Actual 'principle for standing' can be derived from TRIZ.

Intro.

Plan

Hypotheses
○○○○○

Com-firm

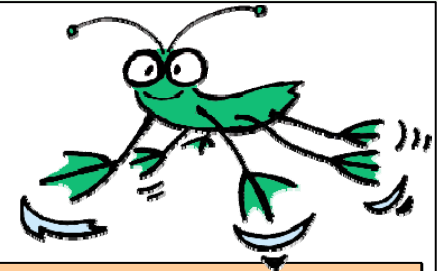
Proto types

Father

End

Reverse-TRIZ

Why Water Striders can "slide" on the water?



Intro.
Plan
Hypotheses
Com-firm
Proto types
Fa
ther
End

【Wish】

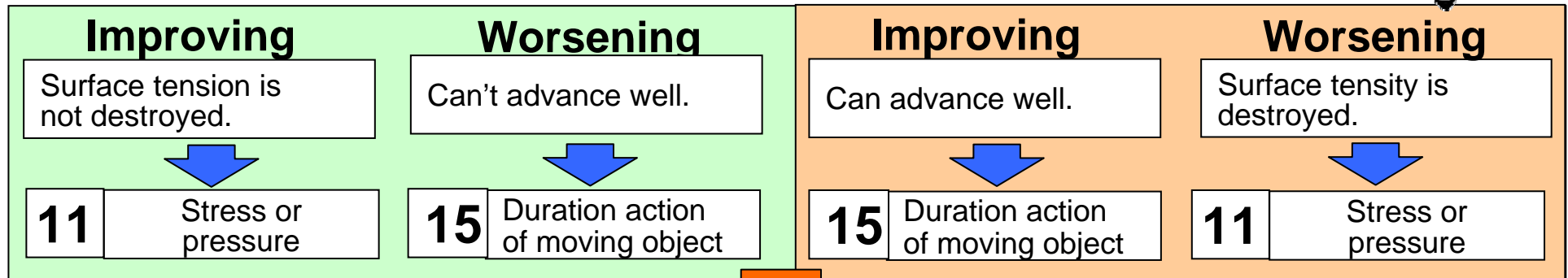
To slide on the water by foot.

【Easy Approach】

The nail or fin of the foot rows water.

EC1

EC2



19. Periodic Action
Inside foot is latched and advances as Oar.

3. Local Quality
"Nail" hidden in hair doesn't destroy the surface tension and water is rowed.

27. Cheap short-living objects
?????



What does this 3rd principle mean?

Reverse-TRIZ

Why Water Striders can "slide" on the water?

- Intro.
- Plan
- Hypotheses
○○○○○
- Confirmation
- Prototypes
- Failure
- End

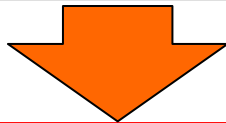
MIT had clarified my mystery of 3rd principle.

(Massachusetts Institute of Technology)

<http://web.mit.edu/newsoffice/2003/robostrider.html>

(Excerpt from right record homepage)

As the insect rests on the surface, the tips of its thin legs create miniscule valleys. It sculls the middle set of its three pairs of legs like oars, causing the water behind those legs to propel it forward as the surface of the valley rebounds like a trampoline.



27. Cheap short-living objects
The miniscule valley of water is used.



massachusetts institute of technology

MIT news

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MIT leaps to solution of walking-on-water mystery
 August 6, 2003

CAMBRIDGE, Mass.—MIT researchers report in the Aug. 7 issue of Nature that they now understand how the insects known as water striders skim effortlessly across the surface of ponds and oceans.

...advised Robostrider, a mechanical water strider, to use the same dynamics to move, although not as natural counterpart.

...the locomotion of these water striders (Belostomatidae and others) is poorly understood. In addition to water striders, he has also applied his theories to other surface locomotion.

...is a 1993 problem known as Denny's Paradox. It has been thought that water striders moved by creating waves that pushed them forward. Stanford University marine biologist Mark W. Denny pointed out that, theoretically, baby water striders could not swim because their legs weren't fast enough to create waves. But in fact, newly hatched water striders row across the surface just as well as adults.

"Denny's Paradox called out for a careful experimental investigation," Bush said.

Using mathematics, high-speed photography and a variety of flow visualization techniques, Bush, mathematics graduate student David L.

Photo / John Bush, David Hu, Brian Chan

A water strider passes over a layer of water that has been dyed blue and lit from below, illuminating the stopping vortices shed during the deceleration phase of the strider's motion.

Photo / Denny Soyars

MIT

'Sliding principle' can be proven from TRIZ, also.



Summary of study

Intro.

Plan

Hypotheses
○○○○○

Com-
firm

Proto
types

Fa
ther

End

“Why the water striders can stand and slide on the surface of water?”

なぜアメンボは
水面に^{立っている}浮き、移動できるのか

We solved this mystery by using TRIZ-thinking.

Planning

Set up hypotheses

Verification

Make prototypes

Think independently

← survey here

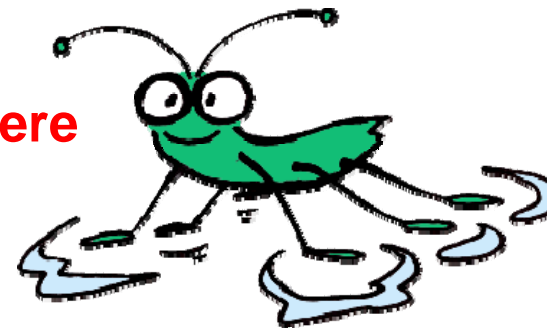
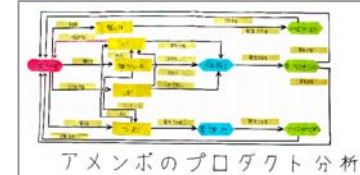


表1 なぜアメンボは水面に浮き、移動できるのか
なぜアメンボは水面に浮き、移動できるのか
なぜアメンボは水面に浮き、移動できるのか

機能	目的	手段	原理
浮く	水面に浮く	表面積を大きくする	表面積を大きくする
移動	水面を移動する	表面積を小さくする	表面積を小さくする



Nature and living thing teach us many good ideas.
All principles have been proven by TRIZ.



Son's and father's comments ··!?

Intro.

Plan

Hypotheses
○○○○○

Com-
firm

Proto-
types

Fa-
ther

End

Due to "NO criticisms", I could learn things from father much more gently than usual.

I can report son's outputs, today.

I could do my homework by using a state-of-the-art technique. And, I won A Fine-Work-Prize from Kanazawa Kid's Science Center .

I can say to my co-workers, "Even junior high school students can utilize "TRIZ" if they find a problem".



WIN
WIN





Conclusion and Proposal

- Intro.
- Plan
- Hypotheses
○○○○○
- Com-firm
- Proto types
- Fa ther
- End**



TRIZ can be used for everything if you find a problem.

Let's use it more flexibly, freely and actively.



**Curiosity
Inquiring mind
Try to think!**

Make TRIZ familiar for children and teens.



TAICHIRO (Top author)'s greeting



- Intro.
- Plan
- Hypotheses
○○○○○
- Com-firm
- Proto-types
- Fa-ther
- End**

