A Study on Constructing Physical Models under the Black-box Experiments Situation

Developed at 2010 EASE Summer School
National Taiwan Normal University
Taipei, Taiwan
July 18~23, 2010

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EASE(2010.7)

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What is

“**black-box experiment** ”?

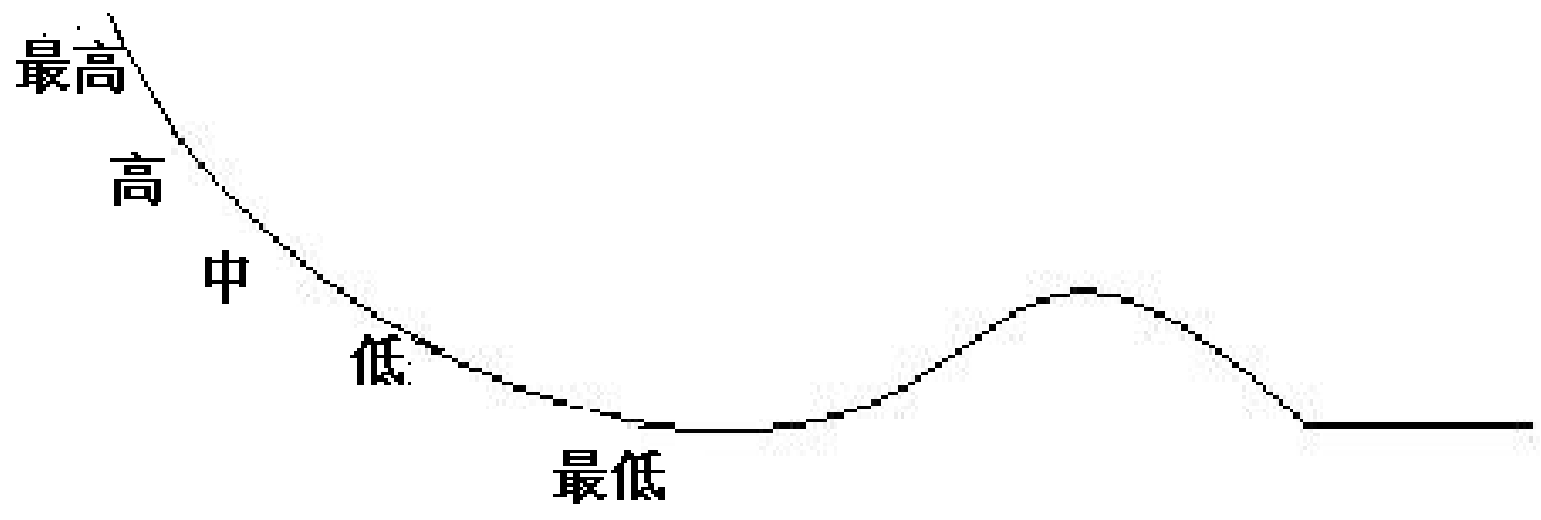
Black-Box Experiment

- A system that we can observe the input and output signal but do not know its inside structure. We analyze the system's function and feature by its output characteristics which is caused by the changes of the input.

Black-Box Experiment (outside)

What is the structure inside?

Black-Box Experiment (inside)



What is

"Constructing Physical Models"?

Constructing Physical Models

- the course that the individual explains and forecasts the things and phenomenon they have observed by constructing mental models of token outside, and construct models which accord with physics models and theory after the interaction of the results.

Why model and modeling are important in scientific inquisition?

Why important?

- How to develop model-based learning has been the new important topic in science education research.
- How to construct Physics Models in the situation of black-box experiment is important for the teachers to create modeling ability, and improve students' character in science.

About the research

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- The research is guided by Modeling Theory
- takes the black-box experiment as a tool
- tests 36 students in Grade 7 and Grade 8 by semi-structured interview

In order to…?

In order to

get know how the students' construction including

- how to study the relationship between the model of observing and characterization of mental models
- the level of modeling ability
- how to treat different models
- how to solve the problem after using the effected models

Part 1

The research's stages

The research is divided into 5 stages:

- model selection
- model construction
- model validity
- model application
- model deployment.

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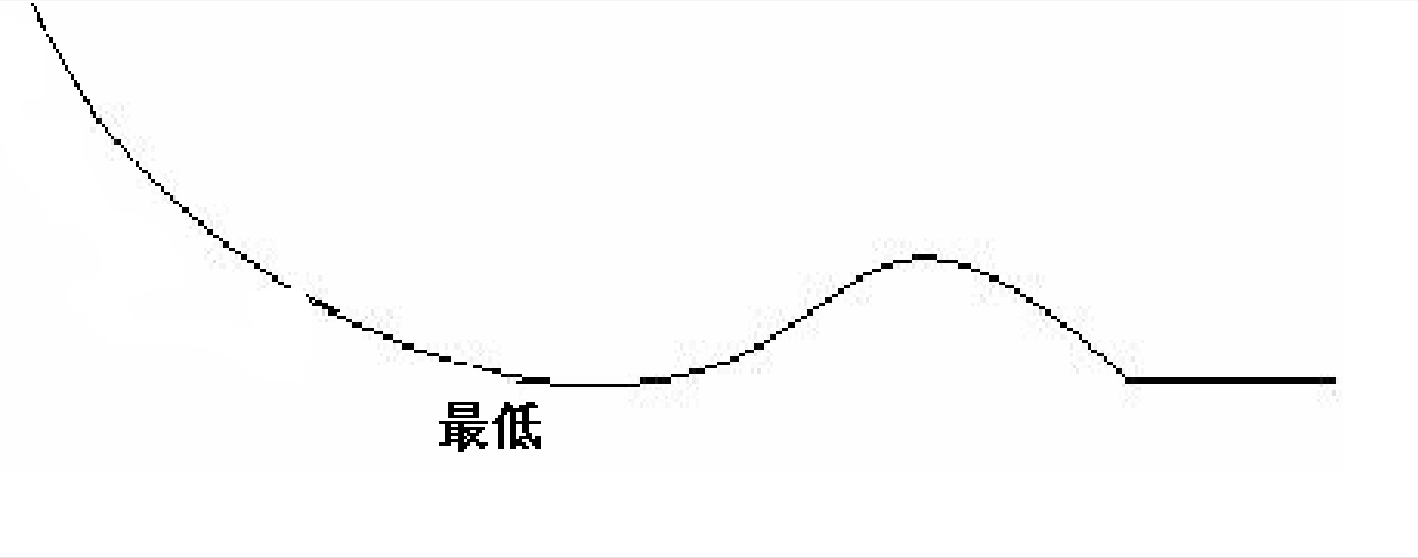
model selection

- Show students (subjects) 4 phenomena one by one

model selection

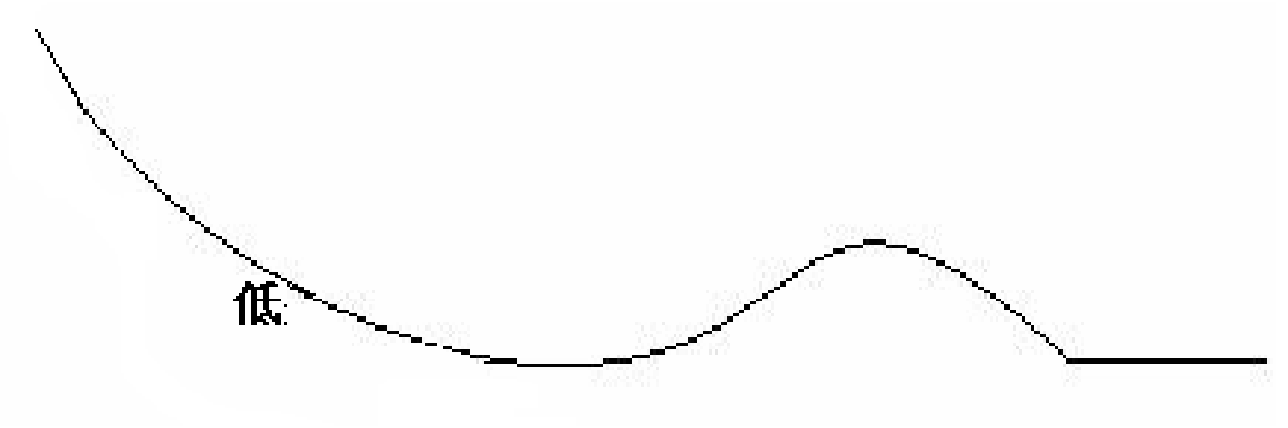
- Phenomena 1: lowest, no ball inside



output

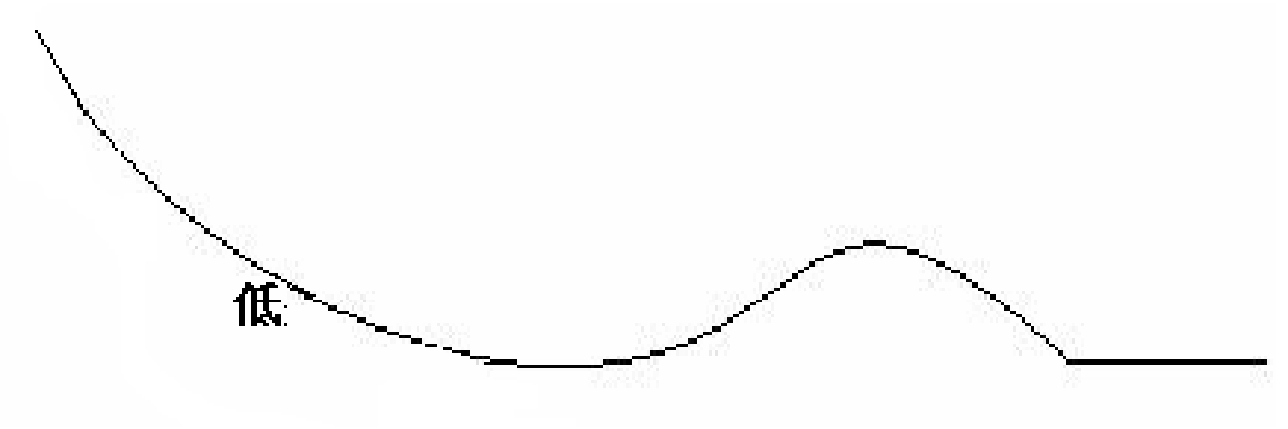
model selection

- Phenomena ||: low, glass ball, ball inside



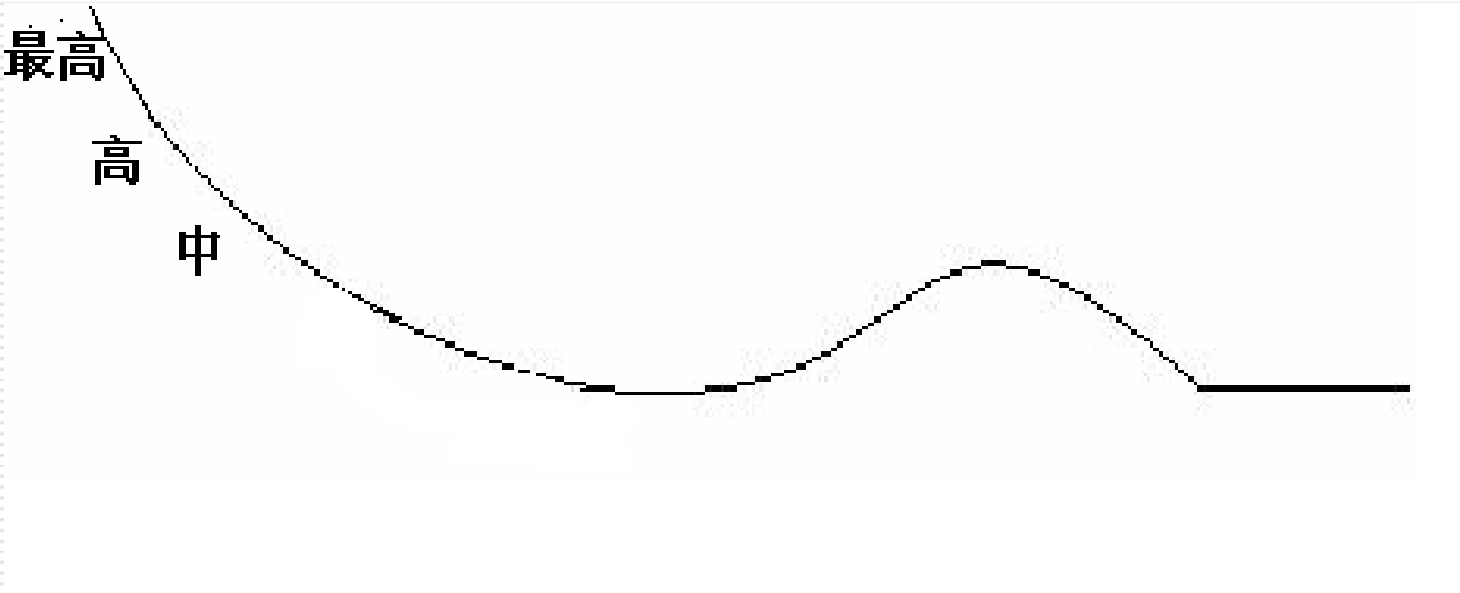
output

- The ball inside is not knocked out



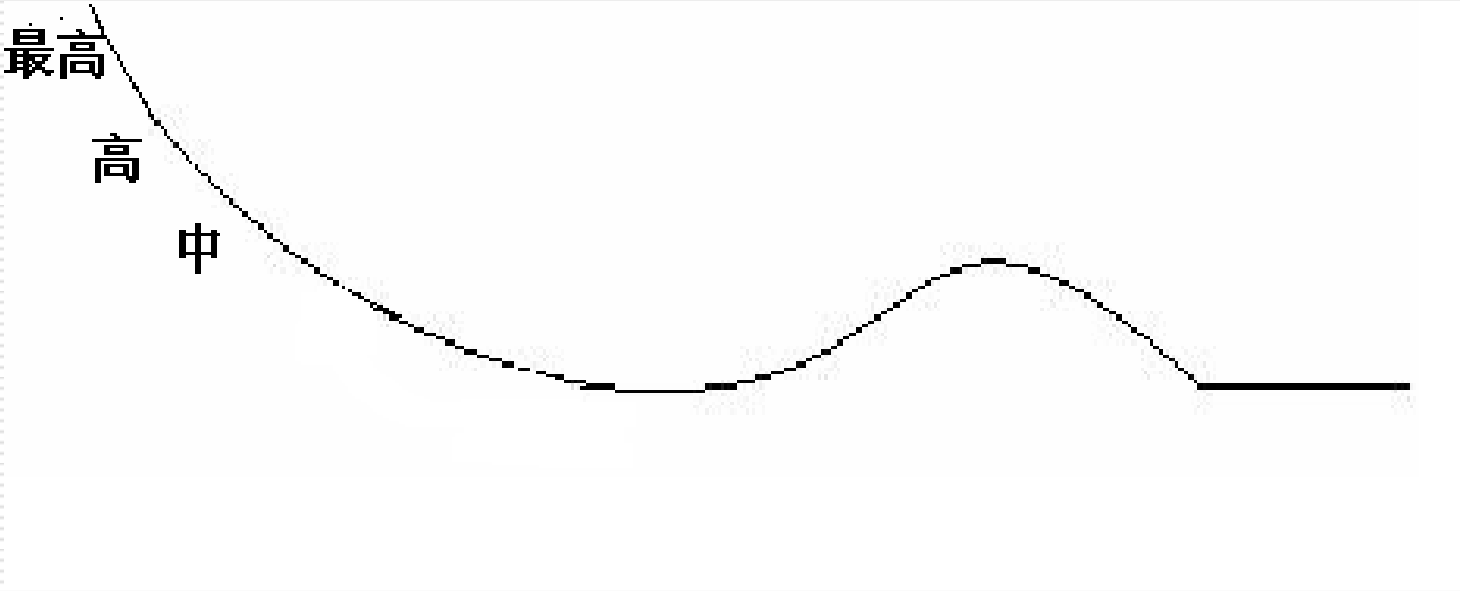
model selection

- Phenomena Ⅲ: intermediary, high, highest. glass ball. ball inside



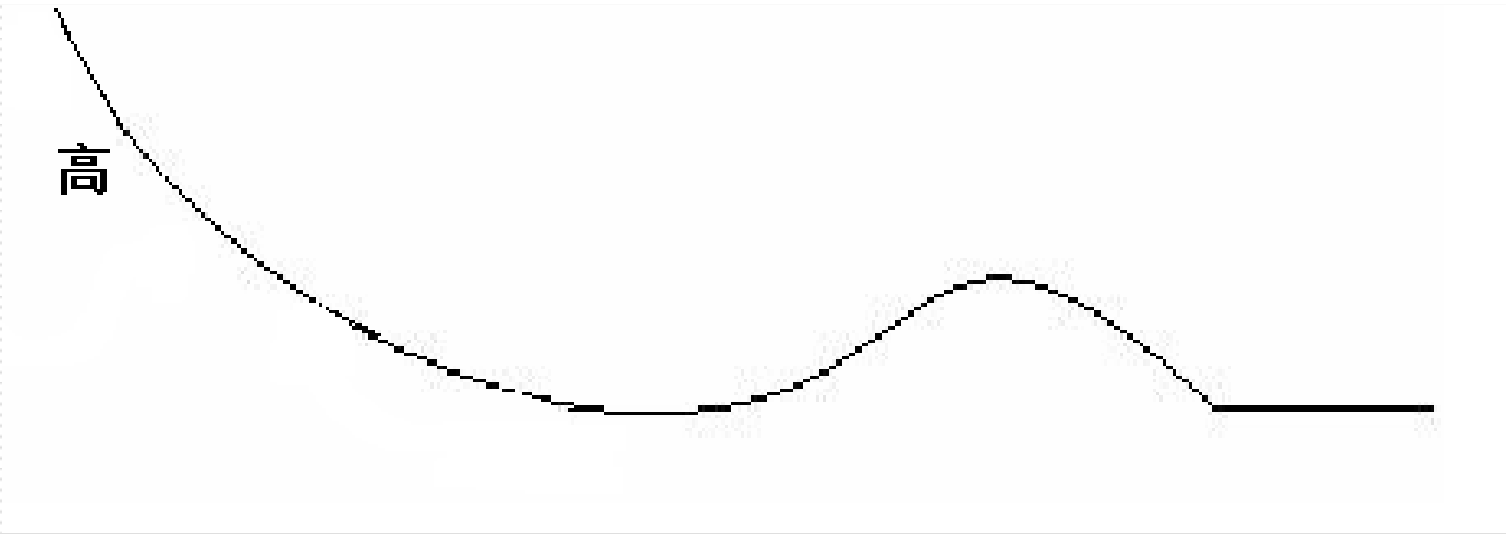
output

The ball inside is knocked out



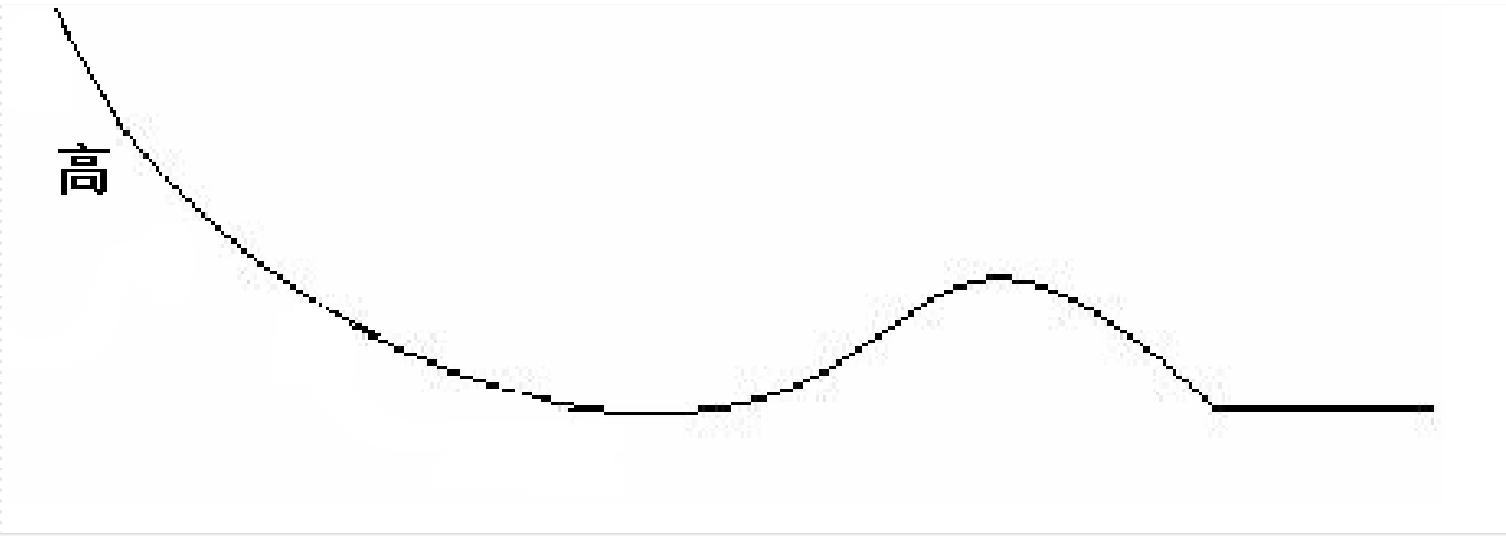
model selection

- Phenomena Ⅳ: high, 2 glass balls & 1 iron ball



output

- The number of the ball inside which is knocked out is no less than 2.



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model construction

- Subjects do the experiment to confirm or modify the conjecture in the stage of model selection

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- **Subjects' task 1: draw the model of black-box's inside structure**
- **Subjects' task 2: describe the course that the ball is in the black-box**
- **Subjects' task 3: explain the reason that what they have observed**

model construction

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model validity

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- **Experimenter: record subjects' appearance when they give the prediction before the interference experiment and their coordination with mental model and proof after the interference experiment**

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model application

- Subject: answer the question__“ What will happen when a iron ball in the low position rolls into the black-box and please explain it.”

- Experimenter: record

The research is divided into 5 stages:

- model selection
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- model validity
- model application
- **model deployment**

model deployment

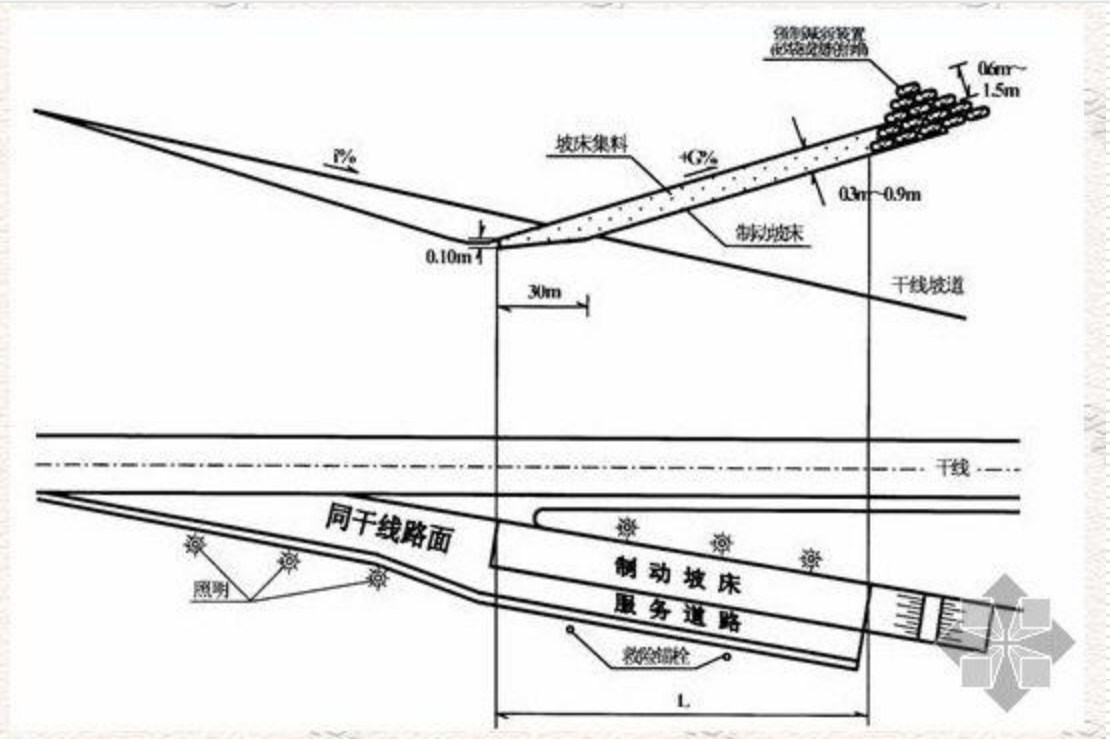
- new context：Hedge Drive

model deployment

- context context：Hedge Drive

model deployment

- Problem context：Hedge Drive



model deployment

- Section of Beijing-Zhuhai Expressway has an accident-prone road sections and the downhill (descending) section is 13 km long where the cars' brakes often go out of control and then car end collisions occur.
- To solve this problem, this highway built the Hedge Drive, which has uphill (ascending) sections.
- One day, a truck loaded with sand rushed into hedge Drive, lost control, burst into hedge lanes and did not stop, but rushed into the hedge drive at the end of the wall.
- If you are a highway management department staff, what will you do to reduce the accident?

Part 2

The value index of the research

The value index of the research is based on

- “scientific theory model” of Henpel, the delaminating of the model put forward by Grosslight

- “modeling ability analytic index” of Zhang Zhi-Kang and Qiu Mei-Hong

Dividing the level and grade

In the method of dividing the level and grade

divides the model class of students into:

- Experience Observe
- Rules of Interpretation
- Theory System

which grade is divided further in order to judge modeling and use ability of students by the level that the students have reached.

Ability level		Reaction	Appearance
Level 1 **Experience Observe**	10	intuition	Did not observe related phenomena, could not answer the relevant and proper factors
	11	entities	Observed the specific phenomenon, but can not answer and correct the factors related
Level 2 **Interpretation**	20	Single factor	Answer **only one** of theory-related factors
	21	Multiple factors	Answer out of **two or more factors** related with the theory, but did not address the relationship between factors
Level 3 **Theory System**	30	interaction	Notes the variety of factors, and also tried to contact the various factors to form a mutual relationship, **but not use the theoretical terms and rules**
	40	Extension	Notes the variety of factors, and also tried to contact the various factors to form a mutual relationship, **and further contact of the Interrelationship of all interactions**
	50	Scientific theory	Notes the variety of factors, and also tried to contact the various factors to form a mutual relationship, **and applied the theory terminology and rules**

Part 3

It discovers that …

It discovers that

- during the stages of selection model and construction model, the ability level of the mental model that the students have constructed related to richness they have observed
- The more they have observed, the higher level of mental models token.
- During the stage, most of the students that in Grade 7 and 8 have reached the Theory System-level.

Among them, …

Among them

- 41.7% reach the level of Interaction
- 33.3% reach the level of Extend Relationship
- no student reach the level of Science Theory
- 5.3% at the stage of the Empirical Observation level
- 10.5% at the stage of Rules of Interpretation-level

What is the characteristics of the students' mental model ?

The students' mental model has the following characteristics:

- be effected by presuppositions during the course of construction
- mental models are generative
- conservative
- uneasy to change
- synthetics.

During the stage of the model validity,
facing complement model,
…

There are 3 kinds of variety circumstance:

- complete approval
- approval
- complement explanation

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- approval
- complement explanation (which is hesitant and need observation to the proof again to draw a conclusion)

84.6% subjects accept the explanation and perhaps take into a fresh explanation while confronting a complement model choice.

While confronting

anti-example of performance,

…

there are 5 kinds of variety circumstance:

- neglecting the anti-example
- brushing-off the anti-example
- giving another explanation
- changing outer circle theories
- changing circle theories

there are 5 kinds of variety circumstance:

1. neglecting the anti-example
2. brushing-off the anti-example
3. giving another explanation
4. changing outer circle theories
5. changing circle theories

- 38.9% subjects change their original models
- 19.4% subjects change their original models by changing outer circle theories

Hence, from the transformational situation when students' confronting 2 different models, it is concluded that ...

It is concluded that …

- it is easier for students to accept the theories which are similar to their own theories
- it is harder to accept the model which are dissimilar to their model

Positive analysis & "prognosticate – experiment" method

- Positive analysis and “prognosticate – experiment” method takes positive place during the course that the intelligence model changing to the physics model

- Through “prognosticate – experiment” method, 60% subjects who hold false mental models while facing counter-examples turn to the right physical models

Reference Suggestions

Reference Suggestions

- black-box experiment on the role of modeling
- the characteristics of students' mental models and modeling-based learning

Thank you

谢谢

Q1:

- Could you introduce such kinds of research in your region?

Q2:

- Could you introduce some material about black-box (biology, chemistry, geography)?