Learning Scientific Reasoning with Multiple Representations: Experience of CMI Students Learning Genetics in English

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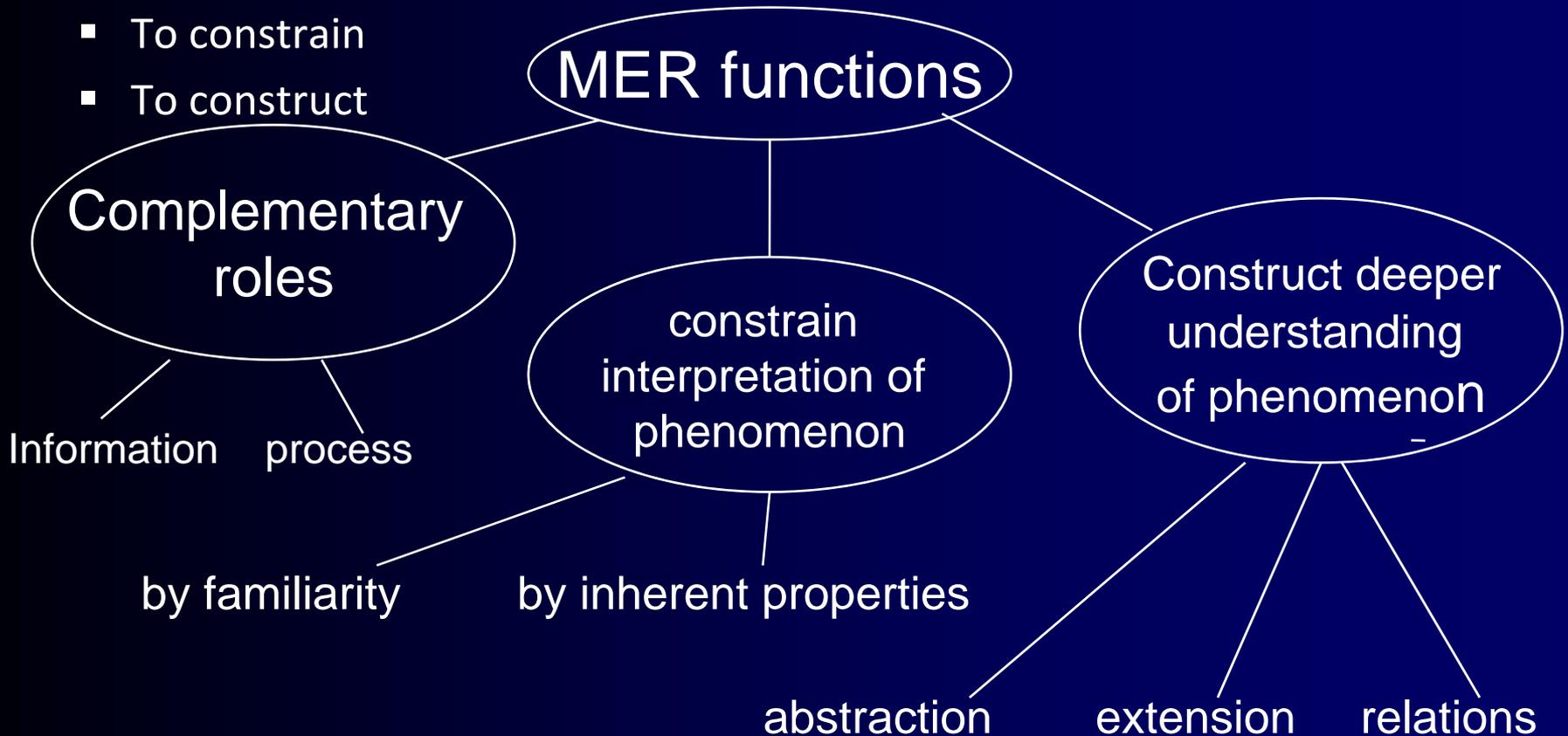
Po Leung Kuk Yao Ling Sun College

Purpose of Study

➢ To study CMI Secondary 3 students learning scientific reasoning with interactive computer-based multiple representation in English in terms of :

- their learning outcomes: genetics reasoning and constructed understanding of genetics in writing

- their new experience of learning genetics in English and learning English through genetics

➢ To use the findings and their implications to inform practice in the school (to help some Secondary 3 CMI students to switch to EMI in Secondary 4 year)

Theoretical Framework (1)

➢ Learning with multiple external representations (MERs): language, graphics, tables, images, gestures, actions, etc.

➢ Functions supporting learning (Ainsworth, 1999)

- ▪ To complement
- ▪ To constrain
- ▪ To construct

MER functions

Complementary roles

Information   process

constrain interpretation of phenomenon

Construct deeper understanding of phenomenon

by familiarity   by inherent properties

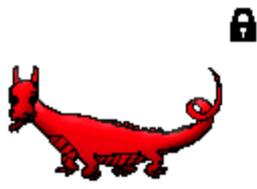abstraction   extension   relations

Theoretical Framework (2)

➢ Vygotsky's (1986, 1978) developmental and sociocultural ideas about learning

▪ Language (or computer) as thinking tool mediating learning

- language as the logical and analytical thinking-tool

- thoughts expressed in words and come into being through words

▪ role of social interactions in learning

- Internalisation and reconstruction of initial external activities

- transformation from inter- to intra-personal psychological processes

▪ zone of proximal development

- the area between the tasks a student can do without assistance and those that require help

BioLogica: An interactive computer program with dynamically linked MERs

➢ Linked Multiple External Representations (MERs) of genetics at different levels of organisation for users to explore the phenomenon of genetics

➢ Organism → Cell → chromosome → DNA→ gene

➢ A change at one level ←→ a change at another level

➢ (Interactions constrained by Mendel's two laws of genetics and molecular model of the DNA/gene)

Dynamically Linked MERs in *BioLogica*
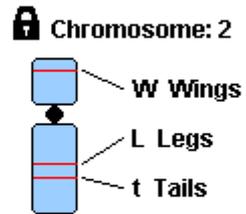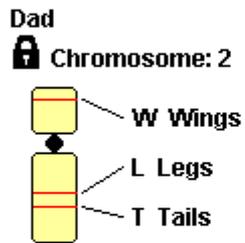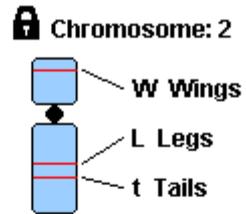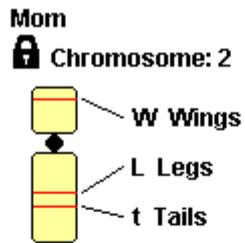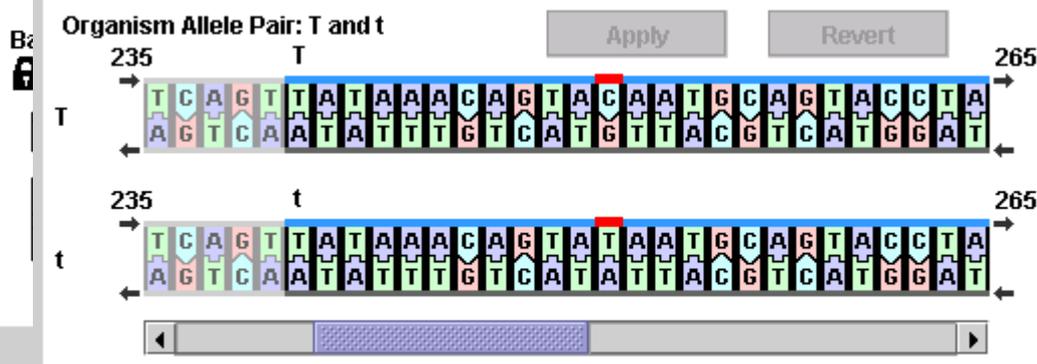
Predict-Observe-Explain (White & Gunstone, 1992) Task with MERs

Research Design

➢ An action research project using qualitative case-based design with multiple data sources: computer log files, pretest and posttests 1 and 2 (paper-and-pencil tests) , classroom observations and group interviews

➢ Learning experience with:

- *BioLogica* – a computer-mediated learning environment in English

- resources from online bilingual dictionaries and glossary;

- teachers' briefing and scaffolding in Cantonese with mixed code, and written feedback on log files in English

➢ Participating students: Group A (S3; n=10); Group B (S3/S4; n=14) (only the results the first group are reported in this presentation)

➢ all S3 students in the sample are CMI students who had been learning through Chinese as the MOI since S1 and had not learned genetics before

Six Types of Genetics Reasoning

(Tsui & Treagust, 2003)
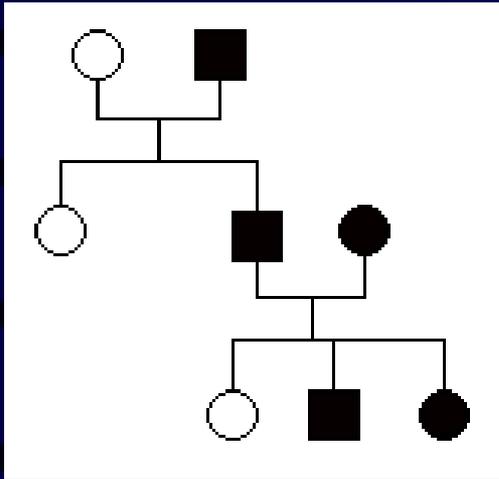
		Domain-general reasoning		
		novice ⟷ expert		
		cause to effect	effect to cause	process reasoning
Domain-specific reasoning: Complex ↕ Simple	between genera-tions	**II**	**IV**	**VI**
	within genera-tion	**I**	**III**	**V**

Two-tier Test (Treagust, 1988) Sample (Tsui, 2008) :
FIRST TIER (Knowledge accuracy)

Which of the following best describes thalassaemia (地中海貧血症), a common genetic disorder in Hong Kong, in the given pedigree (family tree)?
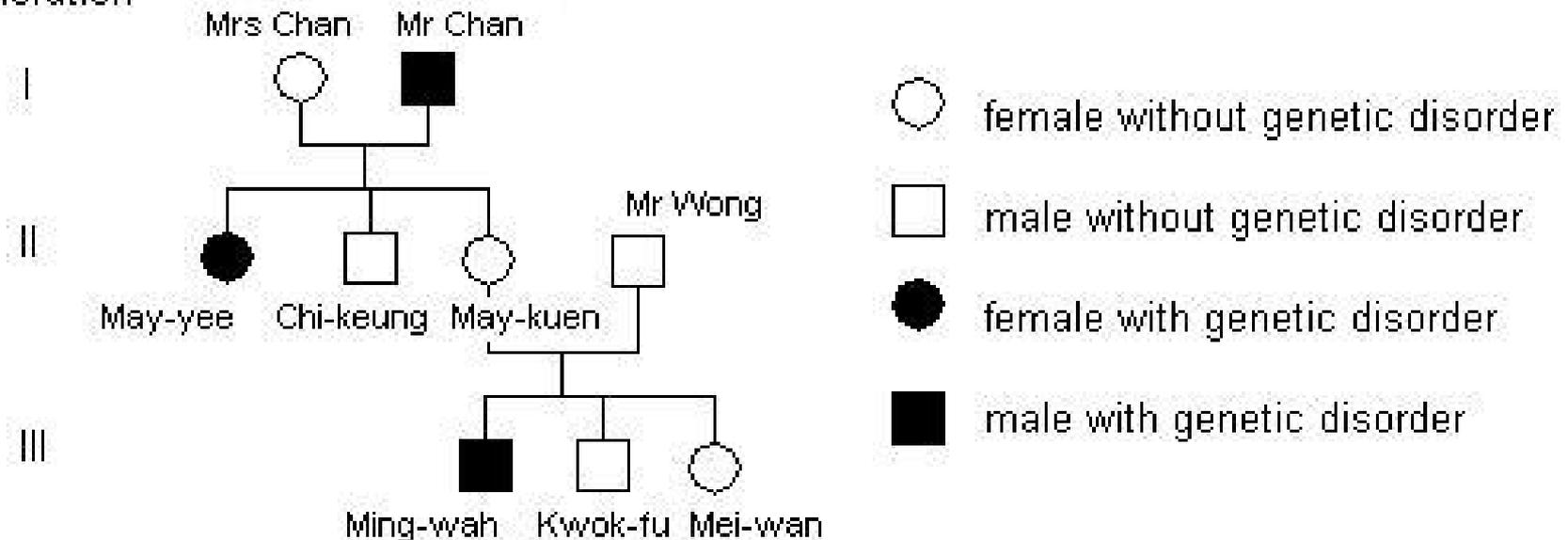
*A. Recessive   B. Dominant   C. Cannot tell

*correct answer   (Genetics Reasoning Type IV)

Reason for the question in the previous slide

A. Only one of the three children in the second generation has the genetic disorder.

B. Both the Mr Chan in the first generation and his daughter have the genetic disorder

*C. Ming-wah in the third generation has the genetic disorder but his parents do not have it.

D. The genetic disorder can be either recessive or dominant.

*Correct answer   (Genetics Reasoning Type IV)

Research Progress Over 9 Weeks
(3 April-28 May 2008)

Weeks	1	2	3	4	5	6	7	8	9

Progressively more challenging

BioLogica
Activities

Introduction
Rules
Meiosis
Inheritance
Monohybrid
Mutations

Paper &
pencil
Tests

Pretest   Posttest1(parallel)   Posttest2(2-tier MC)

Interviews   Group Interviews

Results (1) Meaning-making of Terms
(Pretest and Posttest1: matching/filling-in-blanks questions)

Examples:	Gene (基因)		Allele (等位基因)		Genotype (基因型)		Phenotype (表現型)		Homozygous (純合的)		Trait (特徵)	
PR=pretest PS=posttest1	PR	PS	PR	PS	PR	PS	PR	PS	PR	PS	PR	PS
Peter	X	✔	X	✔	X		X	✔	X	✔	X	X
Amy	X	X	X	✔	X		X	✔	X	X	X	X
Ken	X	✔	X	✔	X	✔	X	✔	X	X	X	X
Betty	X	X	X	✔	X		X	X	X	X	X	X
Mary	X	✔	X	✔	X		X	X	X	X	X	X
Michael	X	X	X		X	✔	X	✔	X	X	X	X

Results (2) Genetics Reasoning
(based on two-tier MC Questions in Posttest2)

Posttest2 consisted of 12 two-tier questions
(2 questions per each reasoning type)
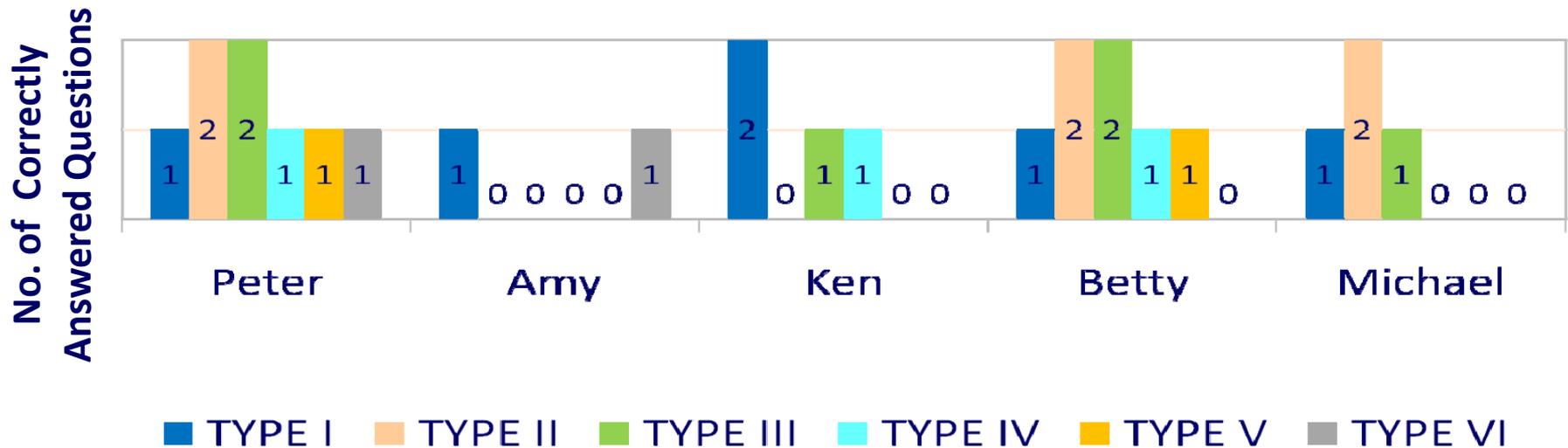
(Mary was absent)

A sample log file of Peter

```
<log>
    <user> Peter </user>
```
Time Stamp

Scientific explanations (CALP)

```
<question>
    <date> 2008.04.16.16.31.55 04/16/08 | 16:31:55 </date>
    Please explain what chromosomes determine the sex of an organism.
    <answer>
    chromosomes x+Y=malechromosomes x+X=Female
    </answer>
</question>
<question>
    <date> 2008.04.16.16.31.55 04/16/08 | 16:31:55 </date>
    Why are some traits considered sex-linked traits?
    <answer>
    male just have one chromosomes X,so the percentage =1/2Female have
two chromosomes X,so the percentage=1/4meaning if the dragon can
firebreathing ,meaning the sex of the dragon will be  male is higher than female
    </answer>
</question>
```

Ken used mathematical symbols and probability concepts together with the new terms to express his understanding with limited CALP

"One the one hand, we have to be concerned learning genetics knowledge. On

面談(一)

日期: 23-04-2008

Original verbatim transcript in Chinese

Dr. Tsui：首先，經過了這三星期的電腦學習，用新的方法透過電腦以英語學習，你可能已有新的經驗。現在同學可否提供意見怎麼能改善得更好，或者以你的角度，談論一下怎樣做得更好。

Mr. Ng：這樣吧，怎樣做得更好有點抽象，那過程中，你覺得有什麼困難的地方呢？有什麼是很困難的？

Peter：以英語表達吧！

Betty：我也是語言方面的問題，雖然英語教學可以使我們認識更多遺傳學的生字，但是大多數都不是很明白，不過還是可以控制得到的。

Peter：我覺得我們如果在中一剛開始的時候，I.S.是用英語教學的，關於那些科學的名詞，可能我們會比較了解多些，現在就有點馬虎了，可能概念上是清晰的，但卻表達不出來。

Mr. Ng：同學你有什麼想補充嗎？

Ken：我想說的是，一方面要顧及學習遺傳學的知識，另一方面又要學習新的英文名詞，這樣

learning strategy by taking 領會上較為困難

Preliminary findings

➢ Students enjoyed their first-ever experience of learning genetics through English in the multi-mediated learning environment using *BioLogica* software.

➢ Many students were able to develop their understanding and used it reasoning and solving problems in *BioLogica* activities and some displayed good reasoning in the two-tier posttest.

➢ Most students learned some English – basic interpersonal communicative skills (BICS) and cognitive academic language competence (CALP) (Cummins, 1999) but were unable to fully express their understanding in writing.

➢ Dynamically linked multiple representations, social interactions with their peers, bilingual resources, teacher support and feedback all contributed to students' learning.

Implications

➢ Learning with multiple external representations (MERs) or with multimodal approach is a sound way of learning science in Hong Kong schools with rich ICT resources

➢ Students' mother-tongue knowledge and mixed code linguistic resources is one important MER for improving understanding

➢ New but interesting topics in science such as genetics can be useful content-based materials for CMI students to learn English (BICS and CALP) – without interference from prior knowledge of the topic in their first language

➢ Our study has demonstrated that Vygotsky's developmental and sociocultural perspectives can be relevant to learning in Hong Kong classrooms.

Thank You !

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Full paper at http://www.chi-yan.net/Presentations.html