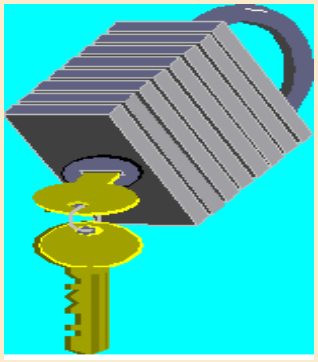
数学建模教学研究



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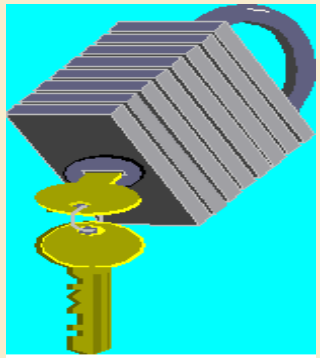
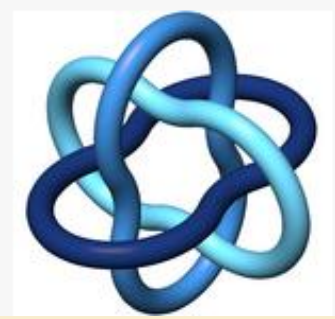


1. ICME和ICTMA简介

2. 数学建模教学研究二例

三大国际数学盛会（4年1届）



国际数学家大会（ICM - International Congress of Mathematicians)　　2002: Beijing

首届：1897，瑞士苏黎世；第二届：1900

IMU - International Mathematical Union

http://www.mathunion.org

国际工业与应用数学大会（ICIAM - International Congress on Industrial and Applied Mathematics)

首届：1987，法国巴黎；2015：Beijing

ICIAM - International Council for Industrial and Applied Mathematics

http://www.iciam.org

三大国际数学盛会（4年1届）

国际数学教育大会（ICME）

International Congress on Mathematical Education

ICME-1: 1969, 法国里昂 (Hans Freudenthal倡导)

ICME-2: 1972, UK；ICME-14: 2020, Shanghai

Organized by ICMI (founded in 1908):

Intl. Commission on Mathematics Instruction,

a commission of the ***IMU*** starting from 1952.

http://www.mathunion.org/icmi

ICMI设立的两个奖项：

Hans Freudenthal奖

Felix Klein奖

（每两年评奖一次，ICME会上授奖）

宗旨：展示数学教育研究的现状和趋势，以及所有层次上的数学教育研究和实践

ICME上每次都有大量关于数学建模教学的专题

ICTMA有两层意思

1. International Community of the Teachers of Mathematical Modelling and Applications

----ASG (Affiliated Study Group) of ICMI

International Study Group for the Teaching of Mathematical Modelling and Applications

2. International Conference on the Teaching of Mathematical Modelling and Applications

---- 1983(英国)开始举办，每两年一届

网址: www.ictma.net

ICTMA-19 (2019, Hong Kong)

国际数学建模教学与应用会议

➔ 国际数学建模与应用教学会议

International Conference on the Teaching of Mathematical Modelling and Applications

充分交流：这个会议的一个特点

展示中国在数学建模教育方面的成果

ICTMA基本情况

- 会议主题(Theme)，如 ICTMA-19：

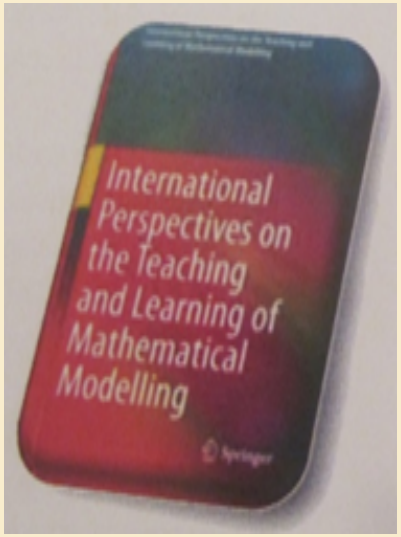
  Mathematical Modelling Education in West and East

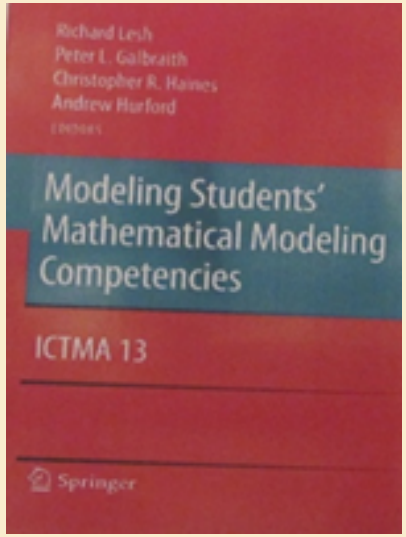
- Day 1: 报到；执委会; 晚（Reception / 开幕）；
- Day 2-5: 会议（0.5-1天：考察；1次晚宴/Dancing）
- Day 6: 上午闭幕 （后半段Business Meeting）

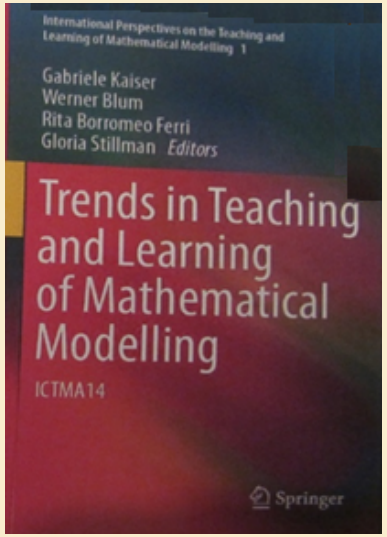
- 5 个左右大会报告(报告 1 小时，评述/提问30分钟)
- 分组报告：40-45分钟，其中提问/讨论15-20分钟
- 1次“Panel Discussion”(1.5 小时): 主题交流研讨
- 若干Workshop （专题研讨，1.5-3小时）
- 其他：如本国特色的项目 - MathFair, Carnival, ……

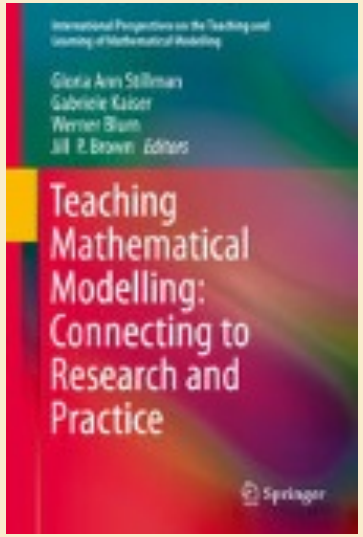
ICTMA基本情况

- 会议规模：一般100-200人（主办国占50%以下）
- 会前投稿（摘要）、审稿：通常在当年2-3月份
- 参会者会后可以投稿、通过审稿的出一本书(Springer)









ICTMA Book Series

- **To be considered for inclusion in the book a chapter needs to be:**

1. **of a high scholarly standard**
2. **original work not being considered for publication elsewhere or previously published**
3. **substantially different from any previously published work**
4. **a good fit with the theme of the book.**

High Scholarly Standard

A **research report** chapter needs:

- a well-referenced situating of the problem in **international literature** including chapters in previous ICTMA books and/or the ICMI studies that are relevant. Show where your work fits – **what is new that it will bring?**
- a **theoretical frame**,
- **study design** with all relevant details (e.g., an empirical study of a Year 5 class (10 yrs old) of 30 students undertaking their third modelling activity) including clearly stated **Research Questions**, data collection **instruments**, analysis techniques
- **Analysis of Results** - understandable to others
- **Discussion** referring back to the literature and theoretical frame as well as to Research Questions
- **Conclusion**

High Scholarly Standard

A **teaching evaluation chapter** needs

- a well-referenced situating of the problem your teaching materials/method is addressing in **international literature** including chapters in previous ICTMA books and/or the ICMI studies that are relevant. Show where your work fits ……
- a **theoretical/ analytical** frame,
- **Details** of the teaching experiment (e.g., who were the participants, how many, what did they do) including any data collection instruments, analysis techniques for evaluation
- **Analysis of Results** – clear and understandable by others
- **Discussion** referring back to the literature & theoretical frame & your approach
- **Conclusion**

High Scholarly Standard

A **polemic （辩论，争论）chapter** needs

• a well-referenced situating of the problem in **international literature** including chapters in previous ICTMA books and/or the ICMI studies that are relevant. Show where your opinion fits – **how does this chapter add to work in the international field inside and outside ICTMA / A & MM?**

• Its **style is less rigid** but there should be

– **Scholarly Analysis of Points raised** – clear and understandable by others

– **Discussion** referring back to the literature, analytical/theoretical frame & your approach

– **Conclusion** which comes from the points made in this chapter

•[See Galbraith in Stillman, Blum & Biembengut, 2015]

Modelling or Application Examples
(less common in recent books)

- Please remember there needs to be some sort of background.
- **Literature** could be about the problem itself or the pedagogical purpose of the task.
- Do not give too much tedious mathematical detail.
- You do need to bring some **reflections on the use of the example for teaching / learning** – another opportunity to bring in literature.
- **Conclusion** relating back to the purposes outlines at the beginning
- [See Orey & Rosa in Stillman, Blum & Biembengut, 2015]

Other Forms of Acceptable Chapters

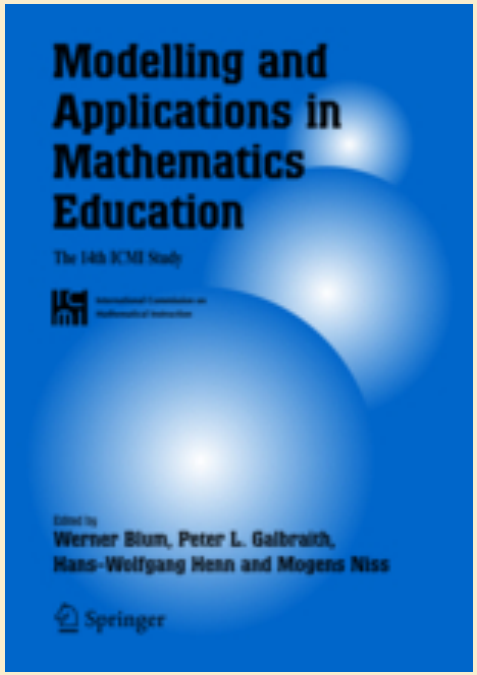
- These chapter forms that we have highlighted do not exclude other forms of acceptable research reports etc but cover the majority of chapters that have been submitted for recent books.

- Others forms could include:
  - An historical document analysis
  - A literature review bringing a new idea for research or development

其他审稿要求

- Empirical studies have to properly reported
- Chapters that are purely problem solving or teaching mathematical content, no matter how well written, are not in keeping with a book in this series
- Connection to real world aspects needs to be explicit
- There has to be a connection, fully argued, to the current international discussion and debate in modelling and applications and a clear statement as to how your chapter relate to current issues and debates.

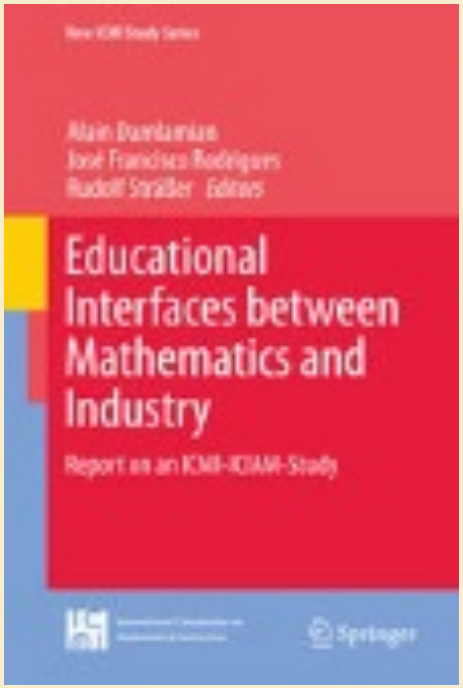
建模教育的两本重要参考书



The 14th ICMI Study

Blum W., Galbraith P., Henn H.-W., & Niss, M. (Eds.)

2007, 524p.



The 20th ICMI Study (with ICIAM)

Damlamian A., Rodrigues J. F., & Strasser, R. (Eds.)

2013, 466p.

一点感受：中外对比

- 外：多数人来自大学的数学教育系（教师/研究生）
  -- 不太关注大学数学，更关注中小学数学教育
  中：非教育系、大学数学教育为主

- 外：多从教育学、心理学、认知科学等角度研究
  -- 注重定量研究，或定量与定性研究相结合
  -- 注重方法论研究(规范的研究方法)
  -- 注重实证研究 (实验对比；问题要具体)
  中：定性、经验为主

森林←→树木？

中医←→西医？

一点感受：借鉴与改进

- 研究问题越具体越好，不求大而全

  切忌写成年终报告、成绩总结、……

  （领导保障，教师关键，学生主体 ➔

  课程设置与教学，竞赛组织和成绩）

- 更深入细致、规范的教学研究，例如：

  如何衡量某种教学法比另一种好？（指标、实验）

  学生建模时难点在哪？原因何在？（认知过程）

  如何设计教学案例/过程？教师作用？（教学法）

一点感受：教学案例

- 对于建模应用方面的研究（实际建模问题）
  - -- 注重问题来源是否真的实际
  - -- 注重文献综述（目前相关研究的现状）
  - -- 注重结果的分析 / 检验
  - -- 注重实际解决问题的效果
  - -- 注重能否在课堂教学中使用、如何使用的建议

【注】这类文章在ICTMA会上越来越不太受欢迎！

一些期刊

数学建模及其应用

数学的实践与认识

中国大学教学

中国高教研究

高等理科教育

职业教育研究

中等职业教育

……

Teaching Mathematics and its Applications

ZDM; J. Math Didakt

J. of Math. Modeling and Application

Educational Studies in Mathematics

Research in Mathematics Education

Int. J. of Computers for Math. Learning

Int. J. of Math. Education in Sci. & Tech.

Int. J. of Science and Math. Education

Journal of Mathematical Behavior

……

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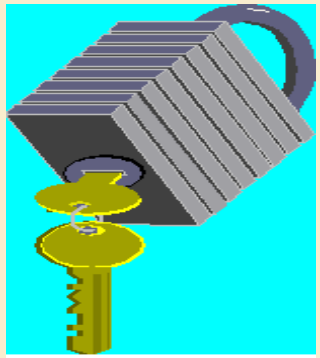

1. ICME和ICTMA简介

2. 数学建模教学研究二例

Mathematical modelling skills and creative thinking levels: An experimental study in a China university

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jxie@math.tsinghua.eud.cn

Co-work with
Qi Dan, *Logistics Engineering College, Chongqing 400016, China;*
danqi31@163.com

ICTMA-14, Hamburg University, 27/07/2009

Outline

- Introduction
- Mathematical modeling vs. creativity thinking
- Mathematical modeling vs. other mathematical courses
- Analytical approach vs. constructive approach
- Summary

Higher Education in China

- **~100 years ago: Universities founded in China**
  - The history is short compared with long history of China, and with long history of universities in Europe
  - Before 1952, there are only very few universities (and thus, students) compared with the large population of China
- **1952: # of universities increased dramatically in China**
  - Follows (former) Soviet Union style
  - Focusing on teaching the students "knowledge and skills"
- **1978: China opened up to the world ("reforming")**
  - Economics: grows quickly
  - Universities: concerns more about creative thinking and practice ability of the students

Creative Thinking: Current Situation

- **1999: A survey sponsored by China National Ministry of Education & China Youth League**
  - **19,000 students (from both high schools and universities) in 31 provinces of Mainland China**
  - **Only 4.7% students consider themselves to have curiosity, confidence, perseverance and imagination**
  - **Only 14.9% students want to cultivate their ability of exploration of new things, information collection, and imagination**
  - **Only 33% students participated in practice activities**
  - **When a student raises an objection to the teacher in the class, 48.1% students think that most students would keep silent, and 16.5% students even think that most students would criticize the objector.**

Mathematical modelling (MM)

- **Mathematical modelling courses attract more and more interests in China in recent years**
  - **Focusing on students' ability of problem solving, and acquiring new knowledge, rather than only "knowledge and skills"**
  - **Regarded as a breakthrough of "quality education", especially in mathematical education**

- **But up to now, in China,**
  - **most studies on education (or teaching) are "qualitative"**
  - **Quantitative (especially experimental) studies are sparse**

Motivation of this study: An experimental study in China

- How to assess China students' modelling skills?
- What's the relationship between students' modelling skills and creative thinking?
- What's the relationship between students' modelling skills and their performance in other mathematical courses?
- What's the best approaches to teach modelling courses?

Outline

- Introduction
- Mathematical modeling vs. creativity thinking
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- Summary

Basic information of experiments

- **33 Students in class 2005171 (sophomore with major in automation), Logistics Engineering College, China**
  - **Engineering students from an college of "average" level**
- **Test on mathematical modelling skills** (TMMS)
  - **Test instruments developed in the past years (Izard et al., 2003) : 22 questions (2 points for each) within 40 minutes**
  - **Difficulty coefficient = scores / total score =0.71**
  - **Evaluation**
    - **Strong (30+ points); Poor (20- Points)**

Question Examples of TMMS

- Which one of the following options most closely models the height of a sunflower while it is growing (in terms of time t)?

A. $1-e^{-t}$ B. $(1-t)^2$ C. t D. $t-t^2$ E. $1/(1+e^{-t})$

Question Examples of TMMS

3. Consider the real world problem (do **not** try to solve it!):

A pedestrian crossing is being considered for a busy road. Assume that the road is a straight one-way single carriageway.

Which **one** of the following assumptions do you consider the **least** important in formulating a simple mathematical model which would determine whether the crossing was needed?

A. The crossing will be controlled by buttons pushed by users

B. The density of traffic is constant

C. The speed of traffic is constant and equal to the speed limit

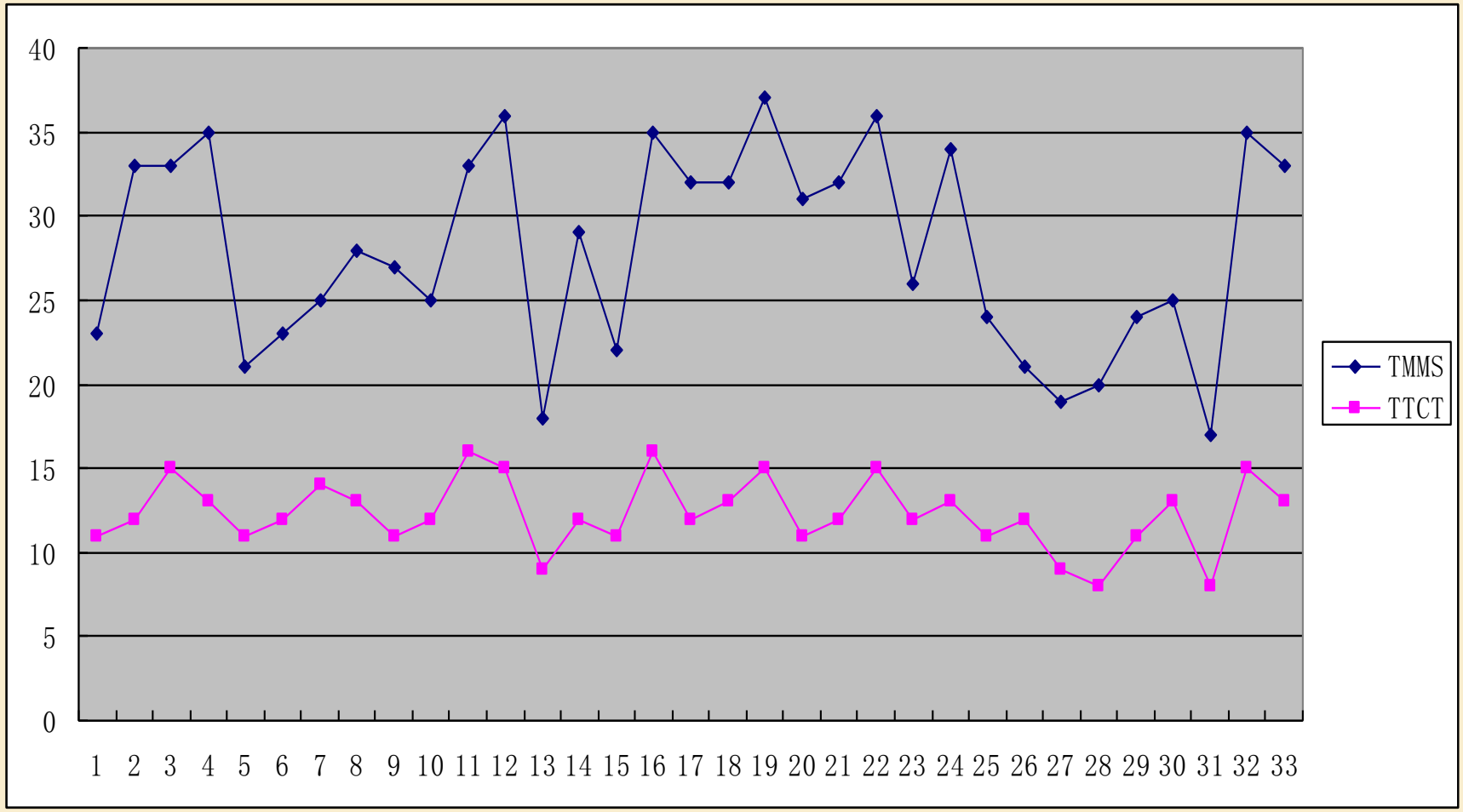
D. Pedestrians cross at a constant rate

E. Pedestrians will not walk long distances to use it

Basic information of experiments

- Test on creative thinking levels
  - TTCT (Torrance Tests of Creative Thinking, 1960‘)
    - Fluency; Flexibility; Originality; Elaboration
  - 20 problems (Li and Zhang, 1999), 1 point for each
  - Plus: 5 points if finished within 15 minutes, 3 points for 20 minutes, 2 points for 25 minutes, must finish in 30 minutes
  - Evaluation
    - 15+ points: strong
    - 10- points: poor
    - Others: medium

Results: TMMS & TTCT



Results: TMMS & TTCT

TMMS

Poor (20-)		Medium		Strong (30+)	
4	12.12%	14	42.42%	15	45.45%

correlation coefficient: 0.815

TTCT

Poor (10-)		Medium		Strong (15+)	
4	12.12%	22	66.67%	7	21.21%

- 15 students get more than 30 points in TMMS, and 7 of them also get more than 15 points in TTCT.
  - Those with strong creativity are also strong in MM ability.
- 4 students get less than 20 points in TMMS, and also they get less than 10 points in TTCT.
  - Those with poor creativity are also poor in MM ability.

Outline

- Introduction
- Mathematical modeling vs. creativity thinking
- Mathematical modeling vs. other mathematical courses
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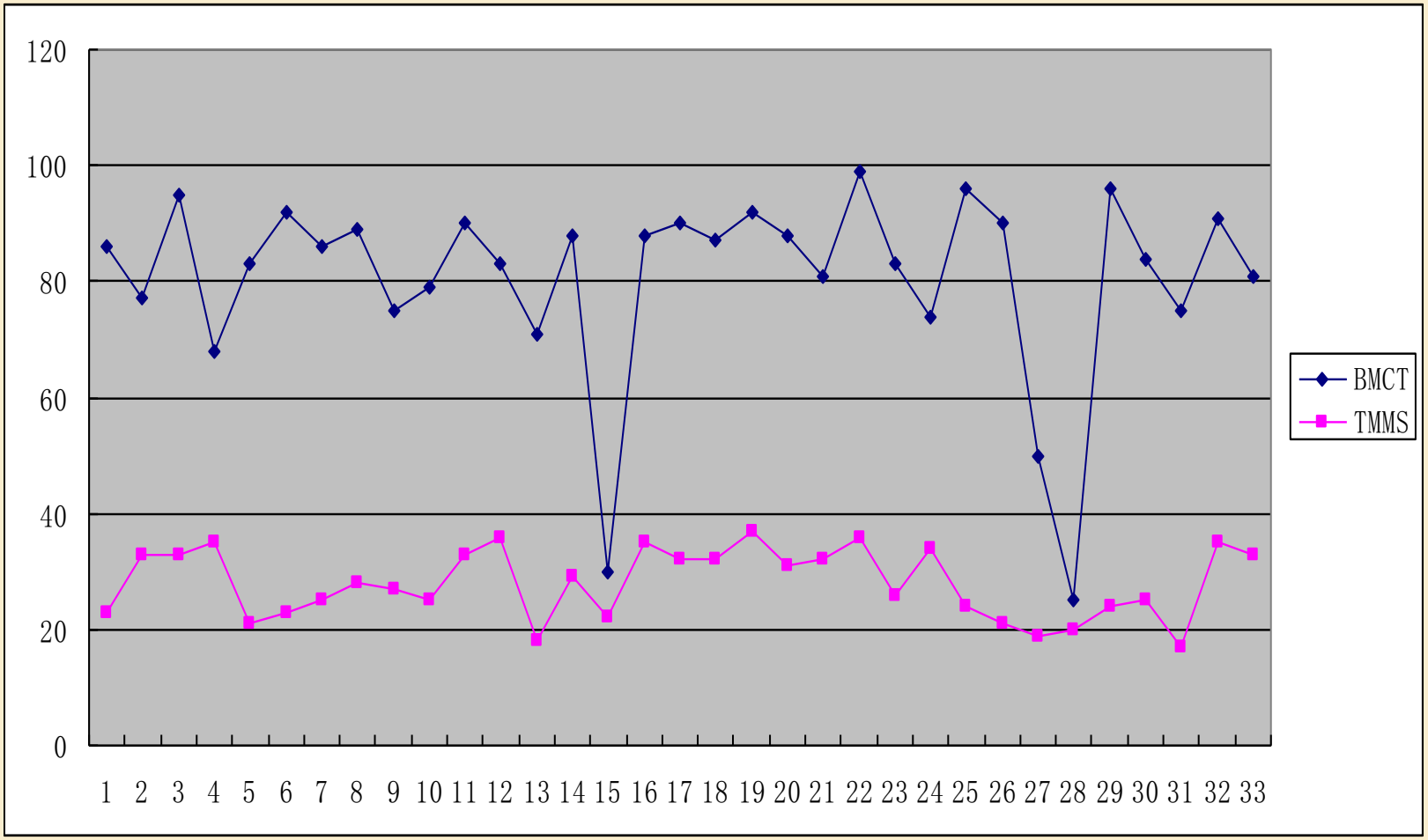
Basic Question

- **Basic knowledge and experience in mathematics is a necessary condition of mathematical modeling**
- **Is it also a sufficient condition?**
  - **Knowledge and experience may also restrict our modeling ideas, because people always like to use familiar method to deal with the new problems and do not consider the difference between new problems and past experience.**
  - **According to this research, students with strong mathematical modeling ability do not always good at mathematics knowledge (the creative thinking and divergent thinking is lacked)**

Basic information of experiments

- Students: same as before
- Scores in other mathematical courses
  - Basic mathematics course test (BMCT): Xi'an Jiaotong University (2003), Time: 2 hours
  - 22 problems of fill-in-the-blank, multiple-choice calculation (in the field of calculus and algebra)
  - The perfect score are 100
  - Evaluation:
    - Students with more than 90 points are excellent
    - Those with less than 60 points are failed

Results: TMMS & BMCT



Results: TMMS & BMCT

TMMS

Poor (20-)		Medium		Strong (30+)	
4	12.12%	14	42.42%	15	45.45%

correlation coefficient: 0.381

BMCT

Failed (60-)		Medium		Excelent (90+)	
2	6%	21	63.6%	10	30.3%

- **Correlation between math scores and MM ability is weak, but**
  - **Students without high BMCT scores do not have strong MM ability**
    - **The 2 failed students in BMCT get less than 20 points in TMMS**
  - **Students with high BMCT scores may not have strong MM ability**
    - **Only 7 of 10 excellent students in BMCT get 30+ points in TMMS**
  - **Students with strong MM ability may not get excellent BMCT scores**
  - **Students with strong MM ability do have above-average BMCT scores**

Outline

- Introduction
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Basic information of experiments

- **Purpose: Impact of teaching strategies on creativity**
- **Students: Major in civil engineering from Logistics Engineering College, China**
  - **A: Class 20046113 (37 students): Analytical (traditional) approach (Ikeda & Stephens, 2003)**
  - **B: Class 20046114 (42 students): Constructive (discussion) approach (Ikeda & Stephens, 2003)**
- **Test on mathematical modelling skills (TMMS)**
  - **The scores of the two classes in basic mathematics are basically the same**
  - **The instructor of the two classes is the same person (Dan)**

Contents for teaching in the class

- **Mathematical modeling: Bushwalking with Kim**
  - **Bushwalkers travel through different types of country. The denseness of the bush and the ruggedness of the terrain influence the speed of travel. By planning a route to take such factors into consideration, the total time taken to travel from one point to another can be reduced. In calculating estimates of the time for a particular route, a walker uses his/her average speed for each different type of country. Kim is planning to walk from Ardale (A) to Brushwood (B). The direct route, a distance of 14km, will take her entirely through rugged bush country. However, as shown here, there is a large square clearing between the two towns, with side length estimated by Kim to be 7km. Kim assumed that this clearing has one diagonal along the perpendicular bisector of the direct route from A to B and one corner, at the midpoint of the direct route. Further, Kim estimates that she travels at an average speed of 1km/hin the bush and 5km/h through the clearing. Find and describe the route for which her traveling time will be least.**

Research process

The whole process lasts one and a half month, and is divided into 3 stages.

- **Preparation stage: October 2005, collect literature material and scheme stage**
- **Implementation stage: from Nov. 1 2005 to Nov. 14, 2005.**
- **Test stage:**
  - **Former test (Quiz A): two classes' MM ability (six problems in Haines** et al. 2001**, perfect score 12 points).**
  - **Latter test (Quiz B): MM ability difference between the two classes in late November (another six problems in Haines et al. 2001, 12 points)**

Result 1: Analytical vs. Constructive

	Former test	Teaching strategy	Latter test	S: STD
experimental class (B)	6.3	discussion teaching (B)	7.8	1.7
controlling class (A)	6.27	traditional teaching (A)	6.8	2.1

Z-test: Z=2.3>1.96

- **Basically, on average, teaching strategies help students to improve the ability of mathematical modeling**

Result 2: Analytical vs. Constructive

Latter test score	5- points		6-8 points		9+ points	
Experimental class（42 persons）	7	15.7%	23	55.9%	11	28.4%
control class（37 persons）	12	32%	18	50.1%	7	19%

- Constructive (discussion) teaching approach is significantly outperforms the analytical (traditional) teaching approach.

Outline

- Introduction
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Summary

- **Experimental studies in China**
  - **MM ability correlates with creative thinking**
  - **MM ability does not correlates with scores in other mathematical courses**
  - **Teaching method: constructive approach outperforms analytical approach**
- **Further works needed**
  - **Compares with the results in other countries in details**
  - **More experiments**

Thank you for your attendance!

comments / questions?

Outline

- Introduction - Motivation
- Experiment
- Results and comments
- Summary

Motivation

- There are many research focusing on the teaching and learning of mathematical modelling and applications
  - ranging from all education levels including primary, secondary, tertiary and teachers education
- None focuses explicitly on the comparison of mathematical modelling skills between the students at the secondary and the tertiary levels
  - or between students at any lower level and a higher level
- The primary motivation of this study is to investigate whether there are any differences, and what they are if any, between the mathematical modelling skills of the secondary and tertiary students.

Assessment of students' modelling skills

- **The multiple-choice question instrument (Haines et al. 2001, and among others)**

- **Six questions in each test, with full score of 12**
  - to make suitable assumptions on the transition from the real world;
  - to clarify what is to be accomplished by the model;
  - to specify precise parameters for a simulation model;
  - to identify required variables, parameters and constants;
  - to transform real problem into mathematical language;
  - to assess and identify appropriate model with reality.

Basic information of experiments

- **193 Students in 2010 Fall class "Introduction to Mathematical Modelling" (freshmen with major in STEM), Tsinghua University, China**
  - 157 are boys and the rest are girls
- **All students finished both tests and both tests were finished within 20 minutes**
  - Test 1 (pre-test) was carried out as the freshmen entered the University and just attended the first lecture of the course
  - Test 2 (post-test) was carried out at the end of the first semester

Basic results

- ***Comparison of the two tests***

Question number	1	2	3	4	5	6	Overall average	Standard deviation
Test 1	1.17	1.35	1.68	1.42	1.91	1.78	9.32	1.86
Test 2	1.69	1.26	1.62	1.47	1.73	1.75	9.53	1.79
Sum	2.87	2.61	3.3	2.89	3.64	3.53	18.84	-

  - Statistical analyses show that there is no significant difference between scores achieved by the students at the two tests.

Some comments

- We should improve our teaching methods in the future, making our teaching more effective.
- The students entering into Tsinghua University already achieved very high score (with an overall average score of 9.32 out of 12) in the pre-test (Test 1), so it's hard to improve further.
- One semester is only a short time. It's difficult to improve the students' modelling skills in such a short time.

Some comments

- ***Most challenging problems: 1, 2, 4***

Question number	1	2	3	4	5	6	Overall average	Standard deviation
Test 1	1.17	1.35	1.68	1.42	1.91	1.78	9.32	1.86
Test 2	1.69	1.26	1.62	1.47	1.73	1.75	9.53	1.79
Sum	2.87	2.61	3.3	2.89	3.64	3.53	18.84	-

  - Q1: making reasonable assumptions for the real world problems
  - Q2: understanding the goals of the modeling work
  - Q4: identifying required parameters and variables

Basic results

- ***Comparison with UK students (***Haines et al. 2001***)***

	Test 1		Test 2		Tests 1 & 2		
	UK	Tsinghua	UK	Tsinghua	UK	Tsinghua	
1	15.8%	12.6%	18.0%	17.9%	17.0%	15.2%	
2	12.0%	14.5%	7.2%	13.2%	9.5%	13.9%	**easy**
3	14.7%	18.1%	22.9%	17.0%	19.1%	17.5%	
4	21.4%	15.2%	19.7%	15.5%	20.5%	15.3%	
5	22.6%	20.5%	20.5%	18.1%	21.4%	19.3%	**difficult**
6	13.5%	19.1%	11.7%	18.3%	12.5%	18.7%	
Sum	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	

  - UK students performed relatively better in Question 4 (assigning parameters, variables and constants)
  - Tsinghua students performed relatively better in Question 6 (assessing and choosing a proper model)

More results

- ***Influences by gender***
  - The boy students got 9.35 in average and the girl students got 9.14 in Test 1. The difference is not statistically significant.
  - But in Test 2, boys got 9.61 and girls got 9.03, which is a relatively more significant outcome.
  - However, we do not think we can conclude that males have better modelling skills than their female peers.
  - More experiments are needed.

More results

- ***Influences by majors***
  - Comparing students form three typical departments: Math and Physics, Electronic Engineering, and Mechanical Engineering
  - Statistical analyses show that there isn't enough evidence to conclude that the students' major influences their modelling skills significantly.
  - In fact, freshmen in Science and Engineering departments at Tsinghua University all take similar courses, so we think the results should be very reasonable.
  - More experiments are needed.

More results

- ***Relationship with basic math courses***
  - Basic math courses: midterm examinations for Calculus and Linear Algebra
  - Correlation coefficients between modelling score and basic math score were less than 0.2
  - Look into more detail:
    - skilled modeller: 12 points in one test; 22+ points in two tests
    - Poor modeller: 6- points in one test; 15- points in two tests

More results

- ***Relationship with basic math courses***

		Number of students	Calculus	Linear Algebra
Test1	12 points	20	89.65	88.13
	6- points	15	87.60	82.00
	P-value	-	0.26	0.07
Test2	12 points	18	87.50	85.61
	6- points	13	83.38	77.88
	P-value	-	0.23	0.08
Tests 1 & 2	22+ points	22	88.23	87.20
	15- points	21	88.76	80.48
	P-value	-	0.43	0.07

Students with strong modelling skills possess skilled knowledge in Linear Algebra.

– **Different from the relationship with the course Calculus**

Summary

- **It is a very interesting area to investigate whether there are any differences in modelling skills between students at different levels.**
  - **But due to the limitations of our experiment, findings from the study are not very stimulating.**

- **Further works needed**
  - **Compares with the results in other countries in details**
  - **More experiments**

Thank you for your attendance!

comments / questions?

一孔之见，欢迎批评指正！

希望和大家共同探索！

谢 谢