



**Overview of Research Projects
in Mathematics and Computer Science**

Hon Wai Leong
 School of Computing
 National University of Singapore
 Email, MSN, FB: leonghw@comp.nus.edu.sg
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Tips for a first-class research project

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Mathematics (and CS) Projects

What is a mathematics/CS project?

❖ **Project ranges widely...**

Simple demonstration of mathematical problems, techniques or principles

Applications of these mathematical results, or Re-discovery of these results

Exciting discoveries of new concepts or theorems or Exciting discovery of new methods of solution

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Projects from 2009 (NYGH)

Study and Demo

Continued Fractions
Voting Theory
Nature's Law & Fibonacci Numbers
Around Asia in 80 Days
Rainbow (Snell's Law)
Impossible Figures

Game Analysis

The Mummy Maze
Blokus
Nim & "The Nim"
Quixo
Frogs and Toads

Investigate & Appl

2009002 Flip
Ellipses and Astroids
Tarzan, the Monkey Man
Josephus Problem in 3-D Space
Letter Pairs and Keyboard

**I worked with
2 groups...**

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Objectives [KohKM]

- 1) Stretch students' *intellectual thinking* in mathematics and problem solving
- 2) Stimulate and *promote interest* in Math-CS
- 3) Encourage *reading* in Math-CS
- 4) Opportunity for student to do *independent work* (either individually or as a team)
- 5) Learn how to collate relevant data and information from various sources

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Objectives [KohKM]

- 6) Sharpen students' *problem solving skills*
- 7) Gain "*new*" knowledge not contained in syllabus
- 8) *Taste* what 'research' is like.
- 9) Learn how to *organize* the relevant materials and to *compile, edit* and *write* the report.
- 10) Experience how to *present* the findings, and to *answer queries* and *respond* to comments from others.

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Criteria (for Math-CS Projects)

- Problems are not too difficult to understand and do not require too much theory.
- Do require thinking and problem-solving heuristics.
- Interesting motivation or historical background.
- Relevance and applications.

OTHERS:
multi-disciplinary, no solution is known, or those reaching research frontiers.

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Stages in a Project

- 1) Preparation of project topics. **Teachers**
also students
- 2) Selection of projects by students. **Students**
- 3) Guidance during research period. **Students & Teachers**
- 4) Submission of written reports. **Students**
- 5) Presentation of project **Students**
- 6) Evaluation of presentation and report. **Teachers**

Typical Stages in CS Projects

- ❖ Idea/ Problem
- ❖ Requirements
- ❖ Review of State-of-the-Art
- ❖ Solution Proposals
- ❖ Solution Design
- ❖ Implementation
- ❖ Documentation
- ❖ Presentation

This is included for comparison purposes only.

Note:
Some of the steps are not applicable to your projects.

Timeline for UROP Research in NUS

© Milestones:

- ❑ Nov -- Start of Project
- ❑ Jan -- Interim UROP Report
- ❑ Apr -- Solution Proposal + Impl Plan
- ❑ May -- completed implementation
- ❑ July -- NURP Paper (all) + UROP Report (CS2288)
- ❑ Aug -- Evaluation (for CS2288)
- ❑ Sept -- NURP Congress
- ❑ Oct -- CS3288 Evaluation

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Note:
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My Own 10-Steps Project Methodology

1. Overall Project Plan (presentation)
2. Rapid Prototype
3. Literature Research
4. Solution Proposal
5. Design, Implementation, Testing
6. Evaluation and Evolution
7. GUI Dev & Software Doc
8. Project Report Writeup
9. Project Presentation
10. Project Cleanup & CD Archive

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Note:
Some of the steps are not applicable to your projects.

Doing the Project -- Learning Process

- ❑ **When learning new concept or techniques,**
 - * try out the concepts with your own examples,
 - * examples are the best way to learn,
 - * work through *all the individual steps*,
 - * ask yourself questions as you go along
- ❑ **Learn notations.**
 - * every term has a precise meaning (no more, no less)
- ❑ **Try to explain your notation to a friend.**
 - * in precise and concise language
- ❑ **Know/Figure out your preferred learning style.**
 - * take advantage of your strengths,
 - * also work on improving your weaknesses,

Guidance (by Mentors)

- 1) Weekly or bi-weekly meetings with mentor.
- 2) Set a target.
- 3) Search for materials.
- 4) Study and discussion.
- 5) Selection of relevant materials.
- 6) Preparation of a draft.
- 7) Final report.
- 8) Project presentation.

When meeting mentors

- ❑ **Come prepared**
 - * with progress reports
- ❑ **Bring your own examples**
 - * carefully (neatly) worked out examples
 - * listing out the key steps
- ❑ **Prepare list of questions and doubts**
 - * things you don't understand, don't know, cannot find,
 - * prepare suggestion for tackling them

Keep a log book of project related stuff

- * write down things learned, examples, comments, suggestions, questions, web-sites, etc

Teamwork (collaboration)

- ❑ **Collaboration very important in research**
 - ❖ **Good Collaboration: $1 + 1 > 2!$**
 - ❖ **Bad teamwork is worse than working alone**
- ❑ **Get organized**
 - ❖ **Choose a team leader**
 - ❖ **Exchange contacts and set up meeting schedules**
 - ❖ **Assign roles (who does what; can swap later)**
- ❑ **Divide up the work**
 - ❖ **Some work – everyone must do**
 - ❖ **Some work can be divided and delegated**

Teamwork (Collaboration)

- ❑ **Working as a Team**
 - ❖ **Set milestones**
 - ❖ **Everyone must do their part,**
 - ❖ **If cannot finish your part, get help EARLY**
- ❑ **Discuss ideas/methods with everyone**
 - ❖ **Each member report on their part**
 - ❖ **Discuss ideas, clear up misunderstandings**
 - ❖ **Learn to present within the team**

Your Written Report

- 1) Title (precise and concise)
- 2) Introduction and motivation.
- 3) Statement of the Problem (notation and terminology).
- 4) Examples, Results, Proofs, Remarks, Significances, and Applications.
- 5) Summary of results and conclusions.
- 6) New problems and directions.
- 7) Appendices.
- 8) Acknowledgement.
- 9) References.

Project Presentation

- ❑ **Rough Organization**
 - ❖ **What is the Problem**
 - ❖ **Give simple examples**
 - ❖ **What is known about this problem**
 - ❖ **What you did in this project**
 - ❖ **Methods and Results**
 - ❖ **Findings and Observations**
 - ❖ **Lessons Learnt**

Some presentation tips

- ❑ **Know your audience**
 - ❖ **What level should you pitch your talk**
- ❑ **Speak to the audience**
 - ❖ **Try not to read from slides, scripts**
- ❑ **Simple examples, more pictures**
 - ❖ **Then only more complicated ones**
- ❑ **Emphasis learning experience**
 - ❖ **Where are the parts you learned something?**
- ❑ **Pause, Recap main points**

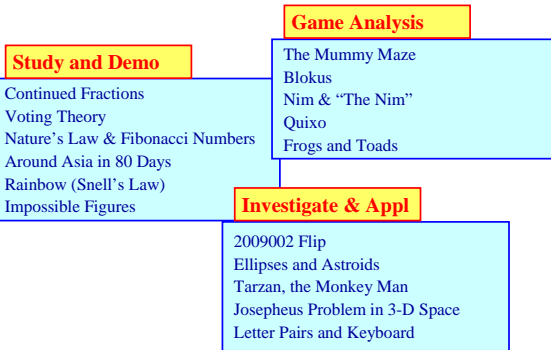
Some advice for supervisors

- 1) Form project groups according to nature of topic.
- 2) Propose and identify suitable projects.
- 3) Be familiar with the problems involved.
- 4) Be aware of the quality and capability of the candidates.
- 5) Help to plan the major project milestones
- 6) Encourage teams to have small, early victories
- 7) Enthuse and inspire.

Sources of Project Topics

- 1) List of previous projects
- 2) Books and pamphlets
- 3) Magazines and periodicals
- 4) Web-site and web materials.
- 5) Professional and Educational Societies

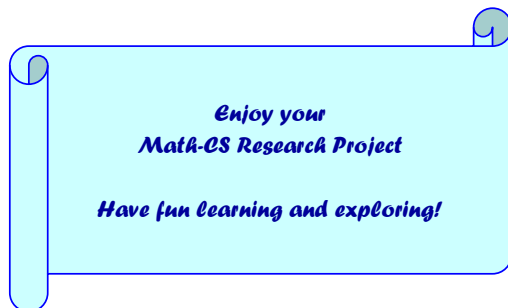
Projects from 2009 (NYGH)



Some Possible Project Topics

- Recursion and Mathematical Induction**
❖ Synergy bet. recursion and mathematical induction
- Who is Singapore's Kevin Bacon?**
❖ Graph theory, breadth-first search
- Chinese Postman Problem**
❖ Graph theory, Euler tour, Matching
- Exam and Job Scheduling**
❖ Graph colouring
- Graph Chromatic Polynomials**

Finally....



Thank you!

*If you want to contact me,
go email, MSN, FB at leongfw@comp.nus.edu.sg*

