MY REFLECTIONS ON WHAT TO TEACH IN COMPUTER NETWORKING

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My →20 years of teaching experience

- Undergraduate level
  - A first course on computer networking
- Post-graduate level
  - Internetworking protocols I (proposed in 1994) : TCP/IP fundamentals
  - Internetworking protocols II (proposed in 1999): Advances in TCP/IP
  - Internet Infrastructure Security (proposed in 2004): Security in TCP/IP

My research

- Network-quality measurement and applications
  - Publications and patents
  - Running a live measurement platform for HARNET for almost four years
- Network security and privacy
  - Publications
  - Release CVEs for Android security

My problem statements

- How could the students learn the complex and fast-changing computer networking field effectively?
  - Not necessarily MORE subjects
- The purpose of our curriculum?
  - Career: Technicians, engineers, network operators, network architects, researchers
  - How about beyond career preparation?
    - *What Are Universities for?* by Stefan Collini

Agenda

- Curriculum design
- Objectives and teaching/learning methods
- Conclusions

Curriculum design

A common approach

- “Core/fundamental” subjects
  - Packet switching, layered model, protocol and service, data-link, etc
- “Advanced” subjects
  - Require knowledge in core subjects, e.g., Internet security
  - More recent topics, such wireless/mobile, multimedia networking, etc
  - More in-depth treatment of a subject, e.g., advanced topics in routing

My example

- A first course on computer networking
- Internetworking protocols I: TCP/IP fundamentals
- Internetworking protocols II:
  - IPv6, IP multicast, Mobile IP, IP telephony, and IP security
- Internet Infrastructure Security
  - Security problems when introducing cryptographic primitives to TCP/IP

Another approach: Three Ps

- Product
  - Understand what has already been produced.
  - E.g., how does IP network work?
- Probing
  - Understand beyond what-is and probe into why-is.
  - E.g., why is IP network designed in this way and why not the other way?
- Principle
  - Understand the principles underlying the design and implementation.
  - E.g., what principles were used to guide the design of IP network?

The first P: Product

- Study a finished and well-tested “product.”
  - The selected topics are usually “useful.”
  - Shifting from OSI to TCP/IP
- Challenges: Understand the problems involved and how they are solved in the current “product.”
- My examples:
  - A first course on computer networking
  - Internetworking protocols II: Advances in TCP/IP
  - Internet Infrastructure Security

The second P: Probing

- Understand beyond what-is and probe into why-is and even why-not.
  - The selected topics are not necessarily “useful.”
  - Why is IP router designed to be stateless?
- Challenges: Understand the rationales beyond a certain design/implementation.
- My example:
  - Internetworking protocols I: TCP/IP fundamentals

The third P: Principle

- Understand the principles underlying the design and implementation.
- Challenges: Think outside the box
- My example:
  - Internetworking protocols I: TCP/IP fundamentals (10%)
- References:
  - *Patterns in Network Architecture: A Return to Fundamentals* by John Day
  - *Network Algorithmics* by G. Varghese

Objectives and teaching/learning methods

The first course on computer networks

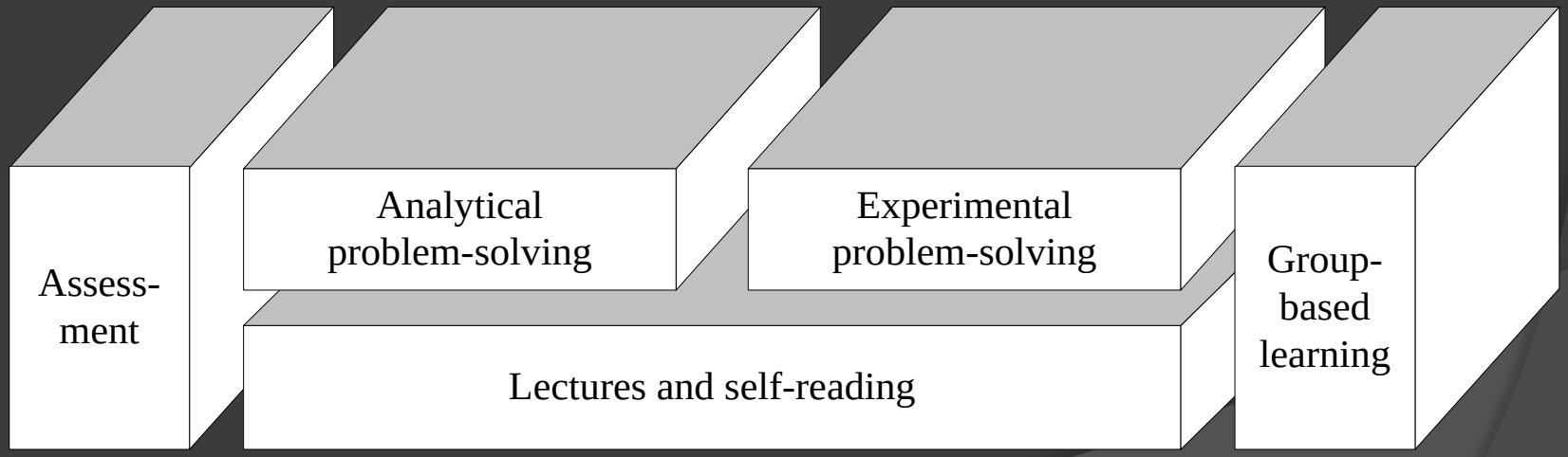
- A “product” course
- Objective:
  - Understand the main topics.
  - Increase their interest in the subject.
- Approach:
  - Identify and remove the obstacles to learning the subject.

What so difficult to learn networking?

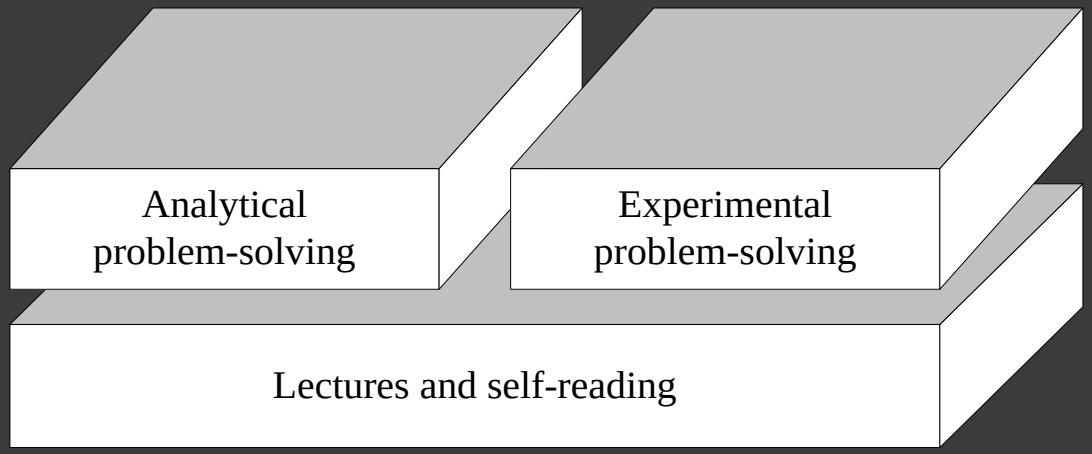
- Rapid development in the field (both in scope and depth)
- Abstract concepts
- Lack of hands-on experience
- Many terminologies and acronyms
- Heterogeneity of students' backgrounds
- Lack of motivation to learn
- Scaling to large class size

An integrative approach

- Three types of integration
  - Teaching and learning activity integration
  - Peer integration
  - Teaching and assessment integration

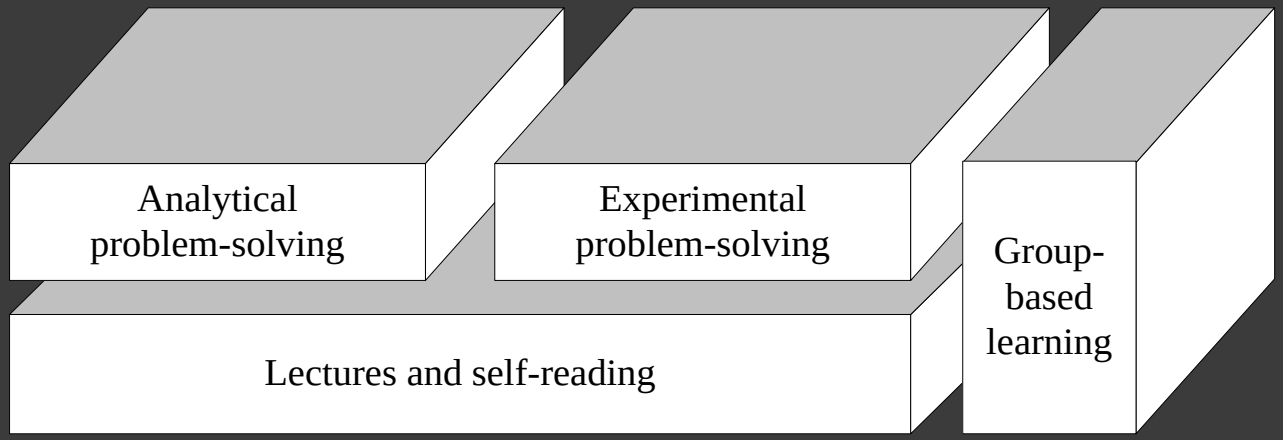


Teaching and learning activity integration



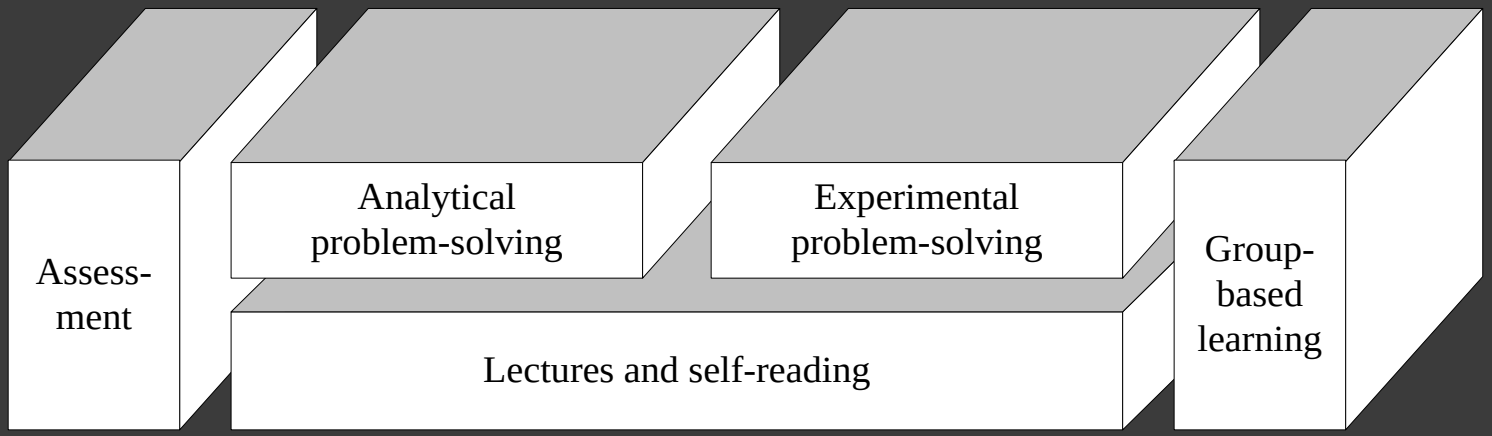
- The main foundation is still based on lectures and self-reading.
- The problem-solving layer intends to deepen the understanding.
  - Cover the important details and reinforce the concepts taught in lectures.
  - Interact with the concepts through experimentation.

Peer integration



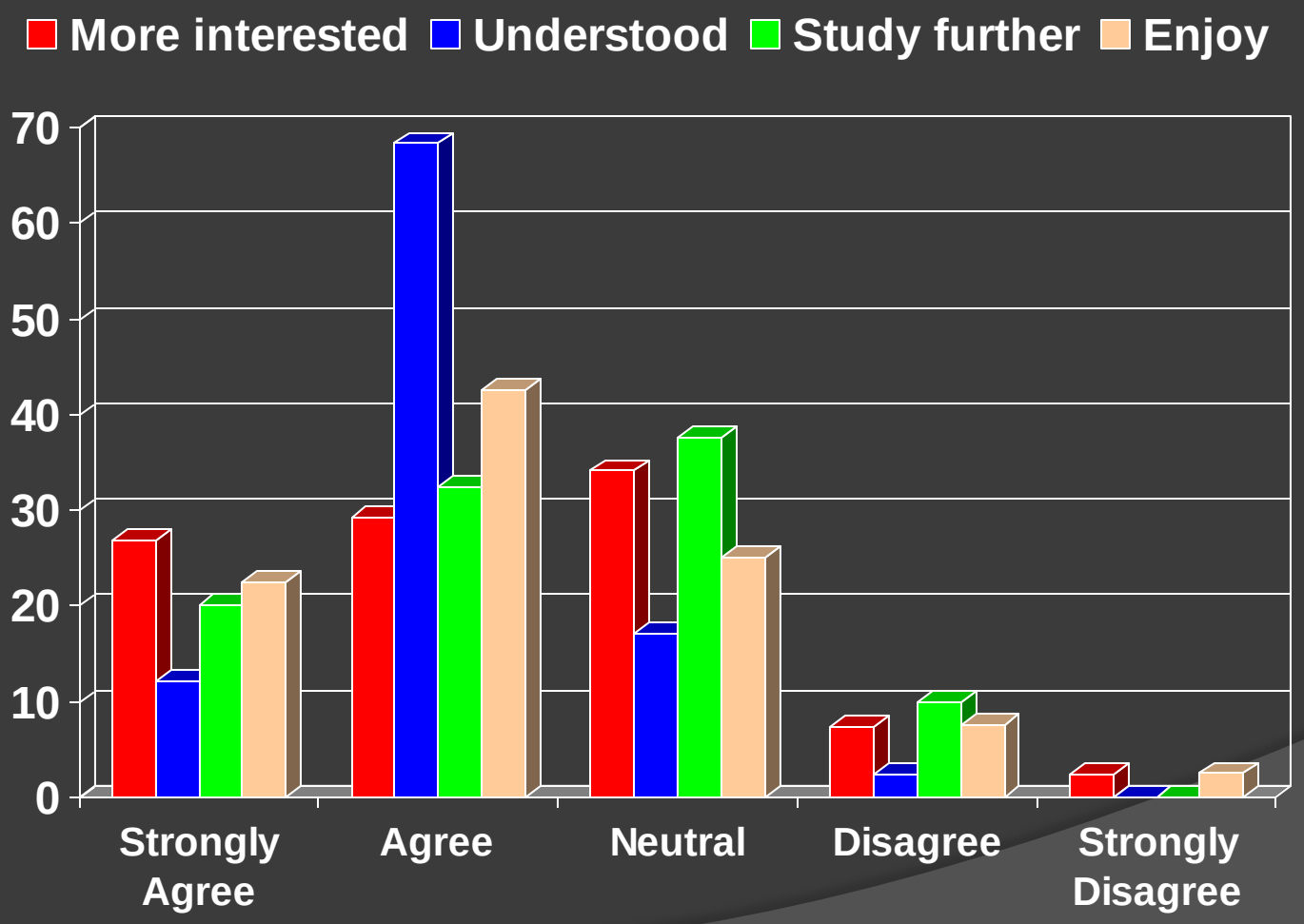
- The best teaching assistants are the students
  - Students know their learning problems.
  - Encouragement, support, and stimulation
- Study groups

Teaching and assessment integration



- Teaching and assessment are nonseparable.
- Meaning and purposes of assessments?
- Imbed assessment in the teaching and learning activities

Assessment


More interested
Understood
Study further
Enjoy
70
60
50
40
30
20
10
0
Strongly Agree
Agree
Neutral
Disagree
Strongly Disagree

A course on TCP/IP networks

- A “probing” course
- Objective:
  - Acquire foundational understanding on the concept of Internetworking in terms of the technologies and techniques that drive Internet.
- Approach:
  - Problem solving (paper and lab)
    - Research papers, RFCs, students’ problems
  - Active engaging the students

Conclusions

Conclusive thoughts

- What is our philosophy of the curriculum on computer networking?
- Need for manpower who is creative and can innovate.
- What is the scalable approach to teaching computer networking?
- The approach based on three Ps: Product, Probing, and Principle
- Broaden the curriculum scope: business model, environmental, humanities, etc