

CPR E 281: Digital Logic

(Sections F, G, J, N)

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IOWA STATE UNIVERSITY
Electrical and Computer Engineering

Structure of a Computer

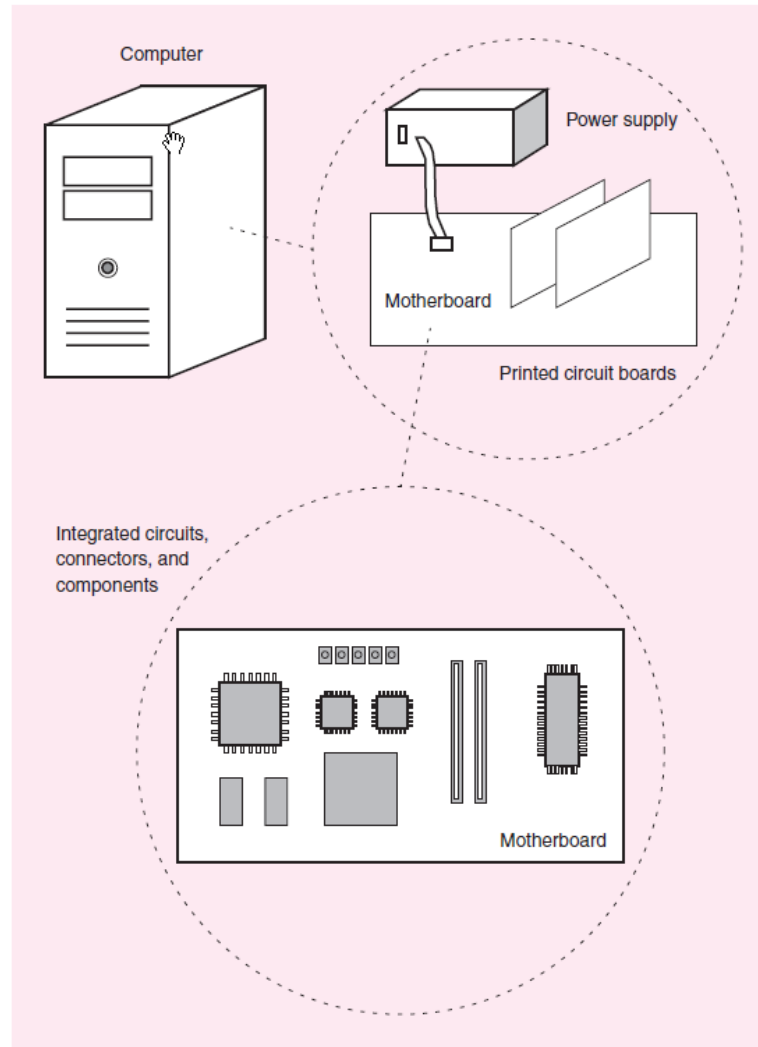


Figure 1.4 A digital hardware system (Part a).

Computer (contd.)

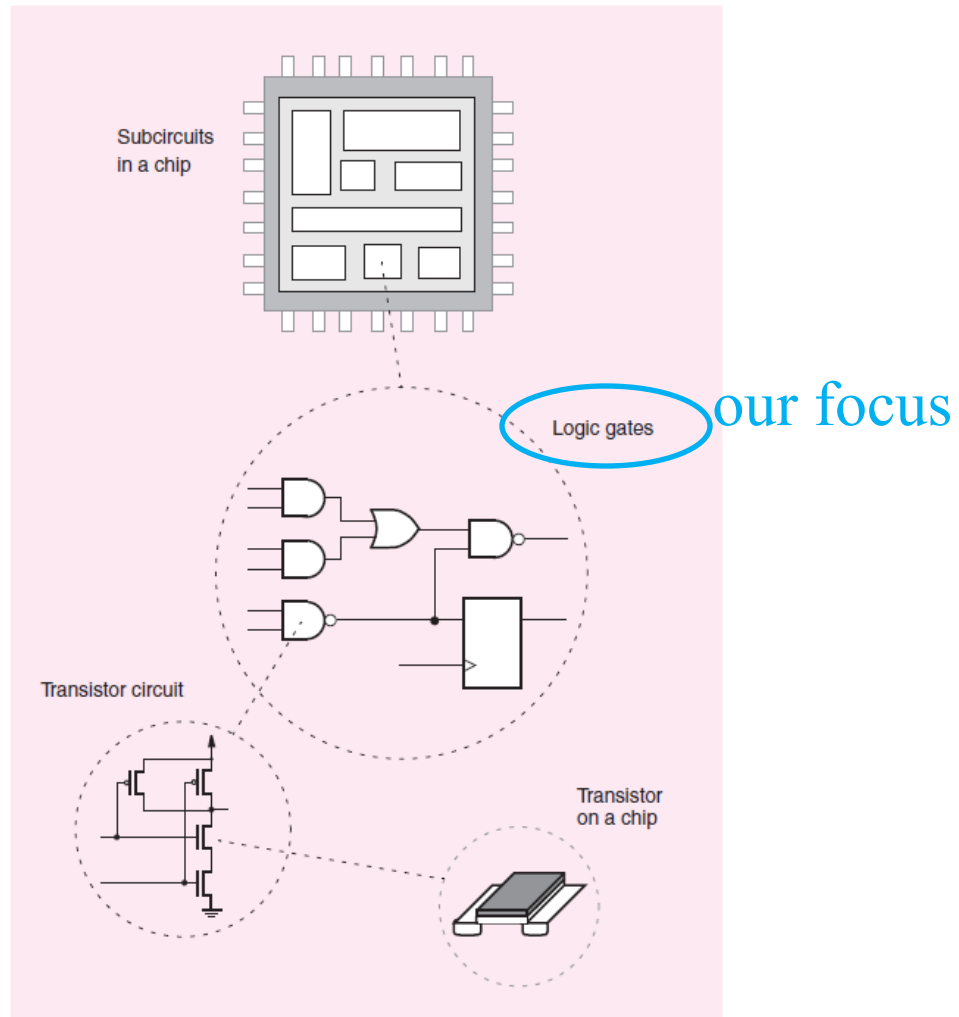


Figure 1.4 A digital hardware system (Part b).

Related Courses

- *Architecture Design*: user's perspective, what does it do?
 - Instruction set, register set, and memory model
 - MIPS, x86, ARM, ...
- *Microarchitecture Design*: how the architecture is partitioned into registers and functional units
 - Single cycle, multi-cycle, pipelined, superscalar?
 - For x86: 386, 486, Pentium, PII, PIII, P4, Celeron, Core, Core 2, Cyrix MII, AMD K5, etc

- *Logic Design*: how are functional blocks constructed
 - Ripple carry, carry lookahead, carry select adders
- *Circuit Design*: how are transistors used to implement logic
 - CMOS etc
- *Physical Design*: chip layout

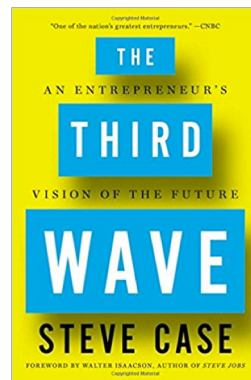
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281

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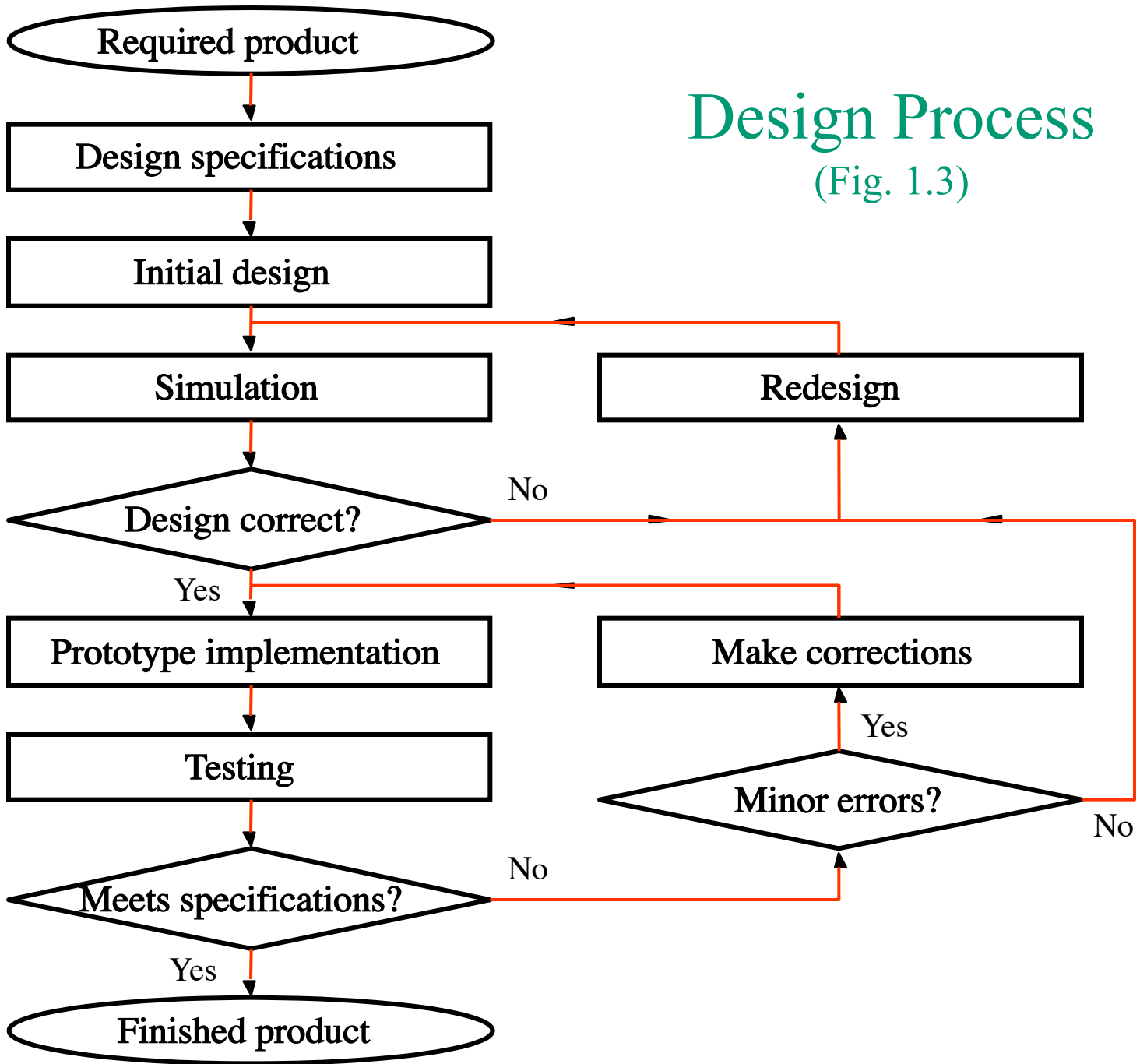
Why Study Digital Logic?

- Logic circuits as integral parts of modern world
 - Computers
 - *Consumer electronics*: smart phones, digital watches, cameras, electronic games, TVs, music and video players, printers, household appliances (microwave, oven, refrigerator), etc
 - *Society infrastructures*: Internet & telecommunication networks, television broadcast systems, *digital & precision ag systems, industrial control systems, power grid, medical instruments etc*
- Ample opportunities of developing new logic circuits today
 - Software-defined radios in 5G wireless networks
 - High-performance, energy-efficient embedded systems
 - Connected and automated vehicles, smart ag, industrial IoT, smart grid etc
- Interesting intellectual subject
 - Logic, Boolean Algebra etc
- Foundation for advanced EECS subjects



Design Process

(Fig. 1.3)

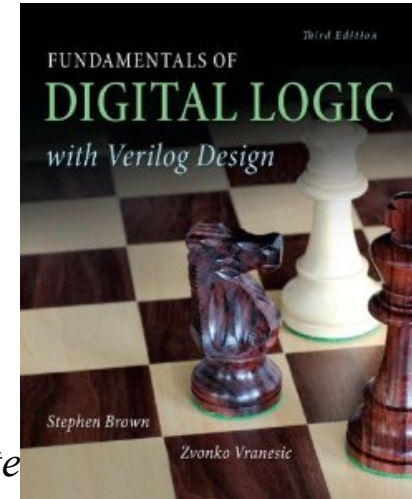


Required Textbook

- “Fundamentals of Digital Logic with Verilog Design”
 - By Stephen Brown and Zvonko Vranesic
 - 3rd Edition, 2013; ISBN: 978-0073380544
 - McGraw Hill
 - *ISU bookstore also sells an abbreviated version that includes only Chapters 1-6 (the only chapters covered in this class, except for the Appendices). Books can also be rented through ISU bookstore and Amazon.*
- Topics to be Covered:
 - Module #0: Design process (Ch. 1)
 - Module #1: Logic design (Ch. 2)
 - Module #2: Circuit implementation (Ch.2, App. A, App. B)
 - Module #3: Logic minimization (Ch. 2)

 - Module #4: Number representation and Arithmetic circuits (Ch. 3)
 - Module #5: Combinational building blocks (Ch. 4)

 - Module #6: Memory devices (Ch. 5)
 - Module #7: Basic design techniques for synchronous sequential circuits (Ch. 6)
 - Module #8: Digital system design (Ch. 7 & 6)
 - Module #9: Advanced synchronous sequential circuit design (Ch. 6)



What is the Meaning of “Digital”?

- Digital:
 - Information is represented as *discrete* symbols (e.g., integers)
- Analog
 - Information is represented as *continuous* values (e.g., real numbers)

What is “Verilog”?

- A language used in designing digital circuits/hardware
- Two commonly used language for hardware design
 - Verilog
 - Verilog Hardware Description Language
 - Verilog HDL
 - VHDL
 - Very High Speed Integrated Circuit Hardware Description Language
 - VHSIC Hardware Description Language

Expected Student Learning Outcomes

- Understanding of *number systems, and digital representation of data*
- Understanding of the *general concepts* in digital logic design, including logic elements, and their *applications* in combinational and sequential logic circuit design
- Familiarity with *CAD tools*
- Familiarity with *programmable logic devices*
- Capability of *working in teams* in learning and problem solving

Teaching Approach: Team-Based Learning (TBL)

- Focus on *applying* knowledge, in addition to knowledge *acquisition*
- Focus on both individual-work and team-work
- Flipped classroom
 - Focus instructor's in-class-time more on knowledge application than on basic knowledge acquisition
 - E.g., focus on learning activities (e.g., application activities of different depth and breadth) where students may benefit more from a mentor/coach/instructor
 - Use class time for advanced/deeper-level learning activities instead of lecturing on materials that students can read by themselves

Values of TBL

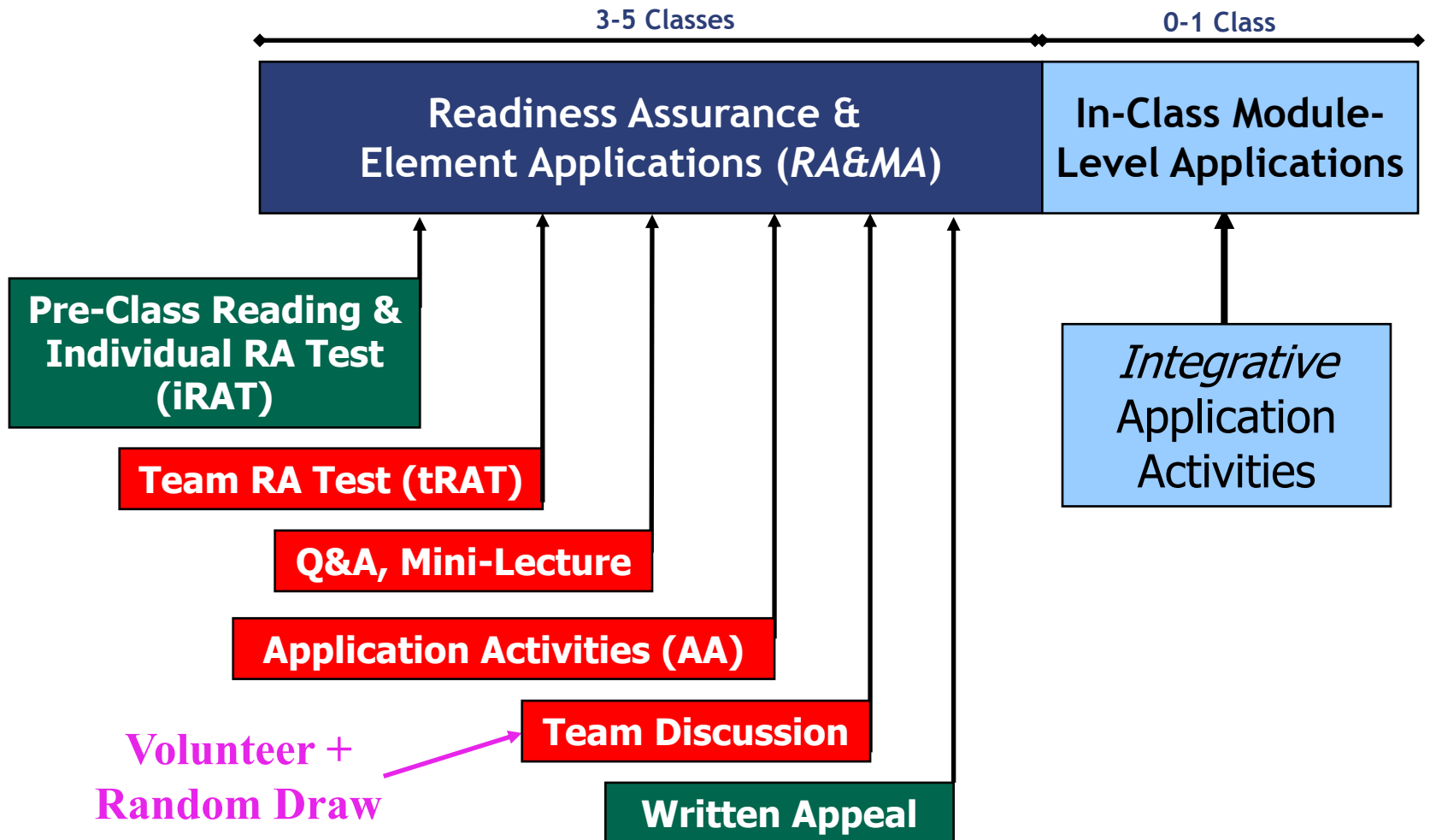
- Quantitative benefit: students' grade
 - Students perform better in final and standardized exams
 - Teams outperform best members
 - Based on 20 years of results, Larry Michaelsen found that 99.95% of teams outperformed their best member by an average of 14%
 - *TBL for CPRE 281: ~14% improve in student exam grade too!*
- Qualitative benefits
 - Higher level of student learning in TBL classes/classrooms
 - Train students to become a *self-learner* in a *collaborative team-based setting* that also encourages independent thinking and that mimics how they would learn new things in the real-world after graduation
 - Develop *learning communities* among students
 - Train students in *non-technical skills* such as technical presentation, social interaction, leadership, etc
 - “... top of the list in just about every survey of what employers value are the so called “*soft skills*” of teamwork, communication skills, leadership, etc ...”

- For high-achieving students who may feel they are slowed down by teammates/team-activities:
 - *The best way to learn is to teach!*
 - Will learn how to value viewpoints brought to the team by others with alternate backgrounds
 - Diverse teams create better products!
 - Practice leadership skills
 - Voice of your fellow student:

“... my learning in general is benefiting from the system because I have to explain concepts and not just know them to lead my team to success ...”

CprE 281 in TBL

- 9 modules, each module spanning about 1-2 weeks
- Structure of a typical module



Learning Activities on a TBL Topic

- Empower students to pursue different levels and aspects of learning in the following order:

Pre-Class Reading & iRATs, *In-Class TBL activities*, Recitation, Lab, Homework, Exam

- An example:

<i>Mon</i>	<i>Tue</i>	<i>Wed</i>	<i>Thu</i>	<i>Fri</i>	<i>Sat</i>	<i>Sun</i>
29 Pre-Class	30 Reading & iRATs	1	2	3	4	5
6 Cls 12	7	8 Cls 13	9	10 Cls 14	11	12
13 Recitation	14 & Lab 5 (related to Cls 12-14)				18 HW#5 due (Cls 12-14)	19
20	21	22	23	24 Finished HW#5 grading	25	26

TBL Execution

- Canvas: <https://canvas.iastate.edu/>
- All TBL activities (i.e., iRAT, tRAT, AA) are open-book
- TBL team formation survey (due: *10pm Jan. 18th*)
 - Comfort in self-learning
 - Prior exposure to topics such as binary numbers, Boolean algebra, logic gate, computer programming, and circuit
 - Major: CE, SE, EE, CS
 - Comfort in championing an idea in team discussions
- TBL grading weights survey (due: *10pm Jan. 18th*)
 - iRAT: 30-50%
 - AA: 30-50%
 - Peer evaluation: 5-20%
 - **Bonus points for tRAT: 1-5 points**
- TBL practice iRAT

How to Study CPR E 281?

- Active learning & do your part!
- Before class
 - Carefully study pre-iRAT reading materials, reflect on the materials read (e.g., assisted by the Learning Guide), and explore potential ways of applying what you have just read (e.g., through the examples in the textbook and, optionally, class slides)
 - Complete the iRAT to the best you can, reflect on the topics that you are not so confident, and study more on those topics before going to class
 - **Prepare questions, if any**, you would like to ask in class
- In class
 - Ask questions, if any
 - Pay attention to mini-lectures to better understand some of the key points that you may have missed
 - Actively participate in the tRAT & AA discussions by sharing your thoughts, listen and understand the viewpoints of your teammates, ask and answer questions, and encourage silent/shy teammates to share their thoughts
- After class
 - Check the tRAT & AA solutions and talk to teammates, TAs, or instructor to make sure you understand every part of the tRAT & AA
 - Work on homeworks, submit homeworks in time, check homework solutions, and talk to teammates, TAs, or instructor to make sure you understand how to correctly solve each homework problem
 - Actively participate in each recitation and lab and make sure you understand every part of it

Reading Materials (optional)

– Teamwork

- “How to Win Friends & Influence People”, by Dale Carnegie

– Belief & action

- “Unleash the Power Within” (audio book), by Tony Robbins
(A related video: <https://www.youtube.com/watch?v=m5DXpNDOHgs>)