Teaching a University-wide Programming Laboratory

Managing a C Programming Laboratory for a Large Class with Diverse Interests

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Introduction – continues

- There are now 23 IITs.
- Five of them are called original – Pre 1963
- Guwahati is 6th – Mid 1994
- Rest are called New! – Post 2008
- Some have been converted from existing universities – c. 1847, 1919, 1926)

Motivation for the work

- Given the population of India (~1.3 Billion) that provides students for these IITs (~12000 places) competition is very strong. (Applicants ≈ 130,000)
- Yet at IIT Guwahati in 2017 we had over 130 failing students in a class of ~700 in Programming Laboratory course.
- This large failure rate does not sit well with the admission processes!
- We suggest that it is due to undue haste in teaching these courses.
- ***Can we train students to construct programs in a way that accommodates those who need time as well as those who are quick programmers?***

Agenda for Today's Presentation

- What causes this disappointing pass-rate?
- What we did to address this cause?
- How we did it?
- What were the outcomes?
- What new concerns this caused?
- Seek your comments and questions.

What may be the Cause of Low Progression-rate?

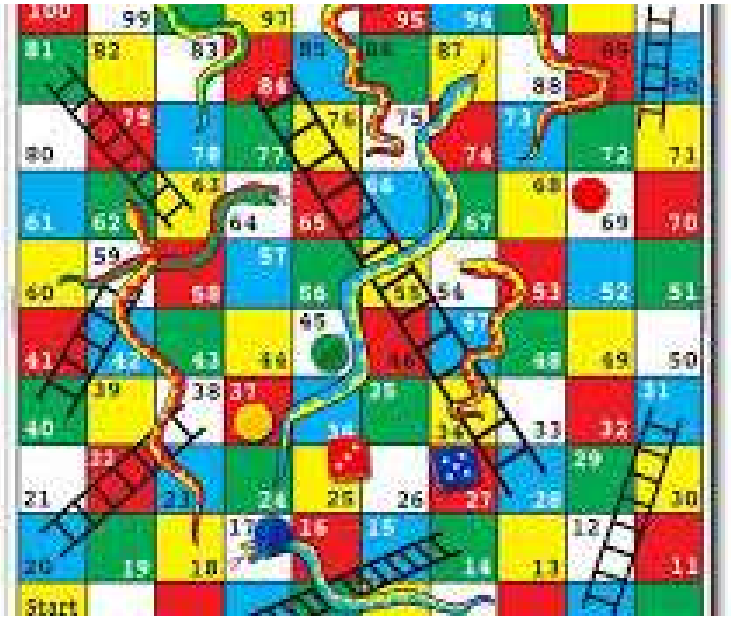
- The reason for disengagement among the students is (an analogy)
  - We train the students to ride push bike for some time.
    - Some learn to ride; others may need more time.
    - We ignore their need for more time.
  - We take all of them to Motorised bike training!
    - Broken bones are our fault!
- ***Students who do not match the pace drop out!***
  - ***Solution: Let each student progress at their own pace.***

Solution: Break Contents into Useful Parts – Modules

- Create useful modules – Each useful module is
  - Made of easily-identified contents and programming skills
  - Examinable unit with meaningful target skills
  - A sequential skills-progression over the previous module
- Four Modules
  1. **Module 1**: Be able to write programs for computations mimicking a session with a calculator. Basic types – `int`, `float`.
  2. **Module 2**: A single function program – `main()` with flow controls
  3. **Module 3**: Programming abstractions – functions, parameters – by value and by reference (pointers), C defined types
  4. **Module 4**: Advanced topics – Pointers, user data-structures, files

Modules, Stages, Drills, Assessments, Examinations

- Module is an examinable unit giving a set final course grade
- Each module has a number of stages to support learning and training.
- Stages in a module are sequential units supporting training/learning
- Each stage has a drill manual and a set of assessment problems



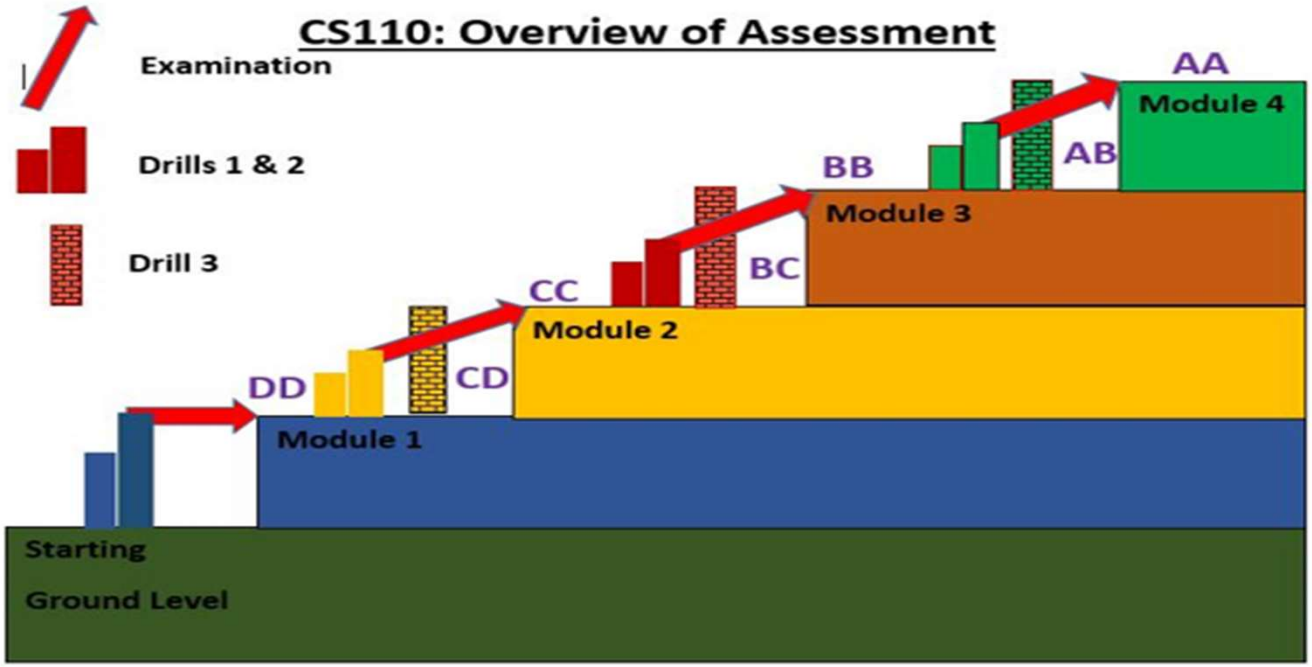
Solution – Modules are trained through stages

Module	Stage	Drill topics
Module 1	Stage 1	Basic UNIX commands
	Stage 2	Imperative statements
Module 2	Stage 1	Numerical values and their input-output
	Stage 2	Conditional control flow, **`assert()`**
	Stage 3	Loops, operators with side-effects
Module 3	Stage 1	Non-recursive functions
	Stage 2	Arrays, **`struct`**s, strings
	Stage 3	Recursive functions, Call by reference
Module 4	Stage 1	
	Stage 2	Data structures (linked list, stack), object orientation, header (.h) files
	Stage 3	Files and long-term data storage

Stage: Training Routine

- Stage: *Maximum* amount of work for a laboratory session
- Students complete a drill lesson for a stage with support from the tutor(s)
- Students demonstrate (stage) learning by completing a randomly chosen assessment problem.
- If a student cannot demonstrate learning, student stays at the stage till stage is learned.
- Module Examinations scheduled at the set dates – Module examination administered if at least 2 stages completed.
- Success at a module examination delivers the module specific grade

Training and Progression over Modules & Stages



Training Routine: Keller Plans

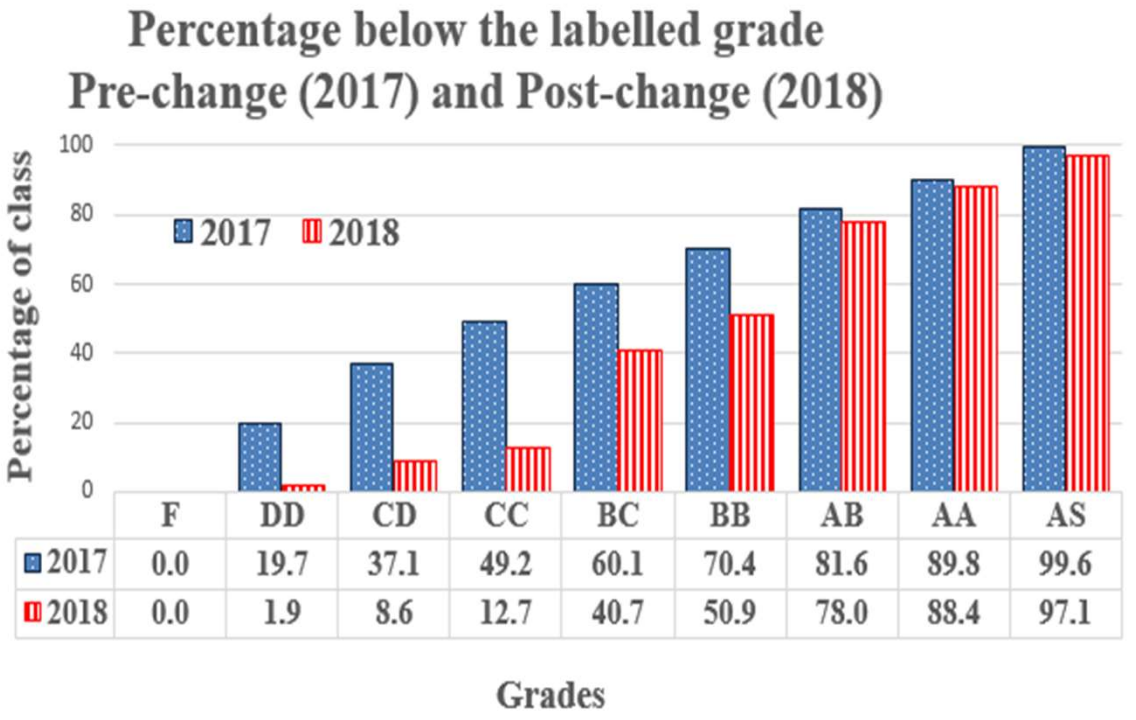
- Failure at a Module examination (Snake bite)
  - Repeat the module training

- Classical approach to teaching: *same pace, different learning*
- Keller plans: *different pace, same learning*

- Our approach: *different pace, different learning, different grades*
  - No more than one stage can be completed in a weekly laboratory session

Outcomes: Benefits of the Changed Arrangements

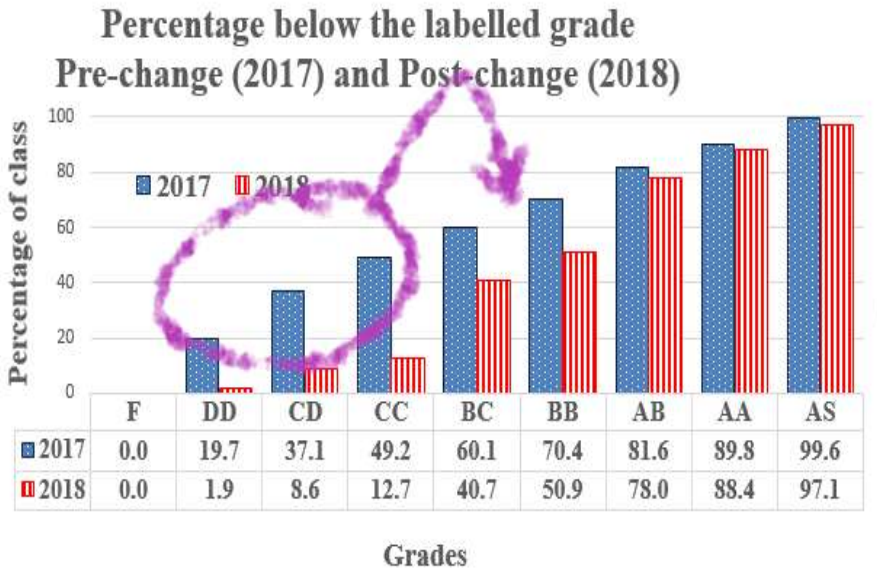
- Big reduction in the failed student count
- Shift from the lower grades to the middle grades
- Students have clear view of their options



	F	DD	CD	CC	BC	BB	AB	AA	AS
2017	0.0	19.7	37.1	49.2	60.1	70.4	81.6	89.8	99.6
2018	0.0	1.9	8.6	12.7	40.7	50.9	78.0	88.4	97.1

Effect of the Changed Practice: Wrong Training Avoided

- Students at grades below CC have moved up. Because,
  - Better support and more time to learn basic topics.
  - Examinations/assessments appropriate to the preparedness.
- Students at the top grades see little change in their ways and achievements



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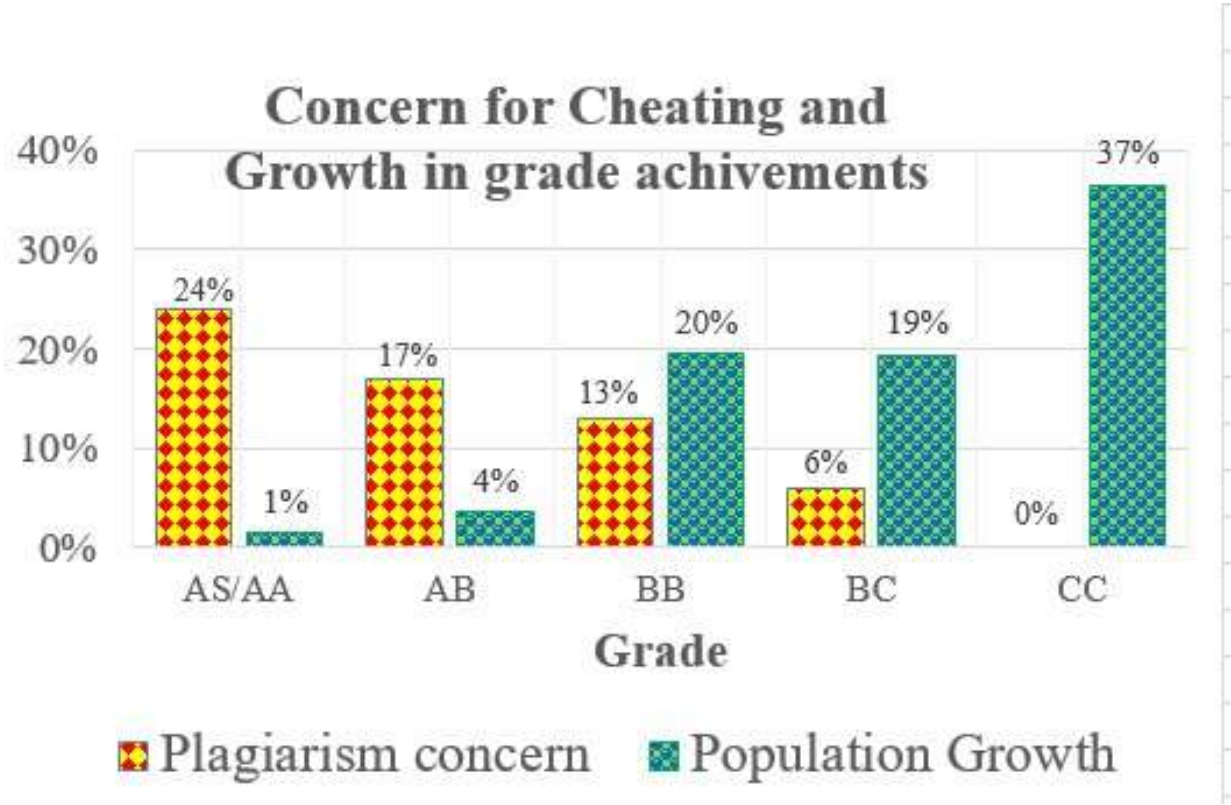
When the Students Completed each Module?

Module	Mid-Sem Exams		End-Sem Exams		Total (%age)
	Part 1	Part 2	Week 1	Week 2	
Module 1	682 (93.0%)	7 (0.9%)	28 (3.8%)	6 (0.8%)	723 (98.6%)
Module 2		474 (64.7%)	108 (14.7%)	62 (8.5%)	644 (87.9%)
Module 3			176 (24.0%)	164 (22.4%)	340 (46.4%)
Module 4				85 (11.6%)	85 (11.6%)

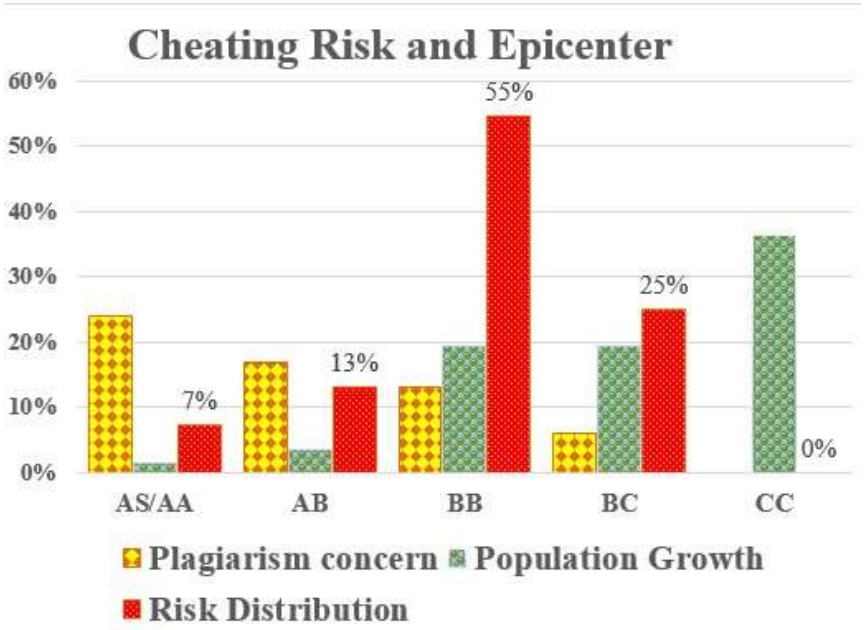
Students' Say

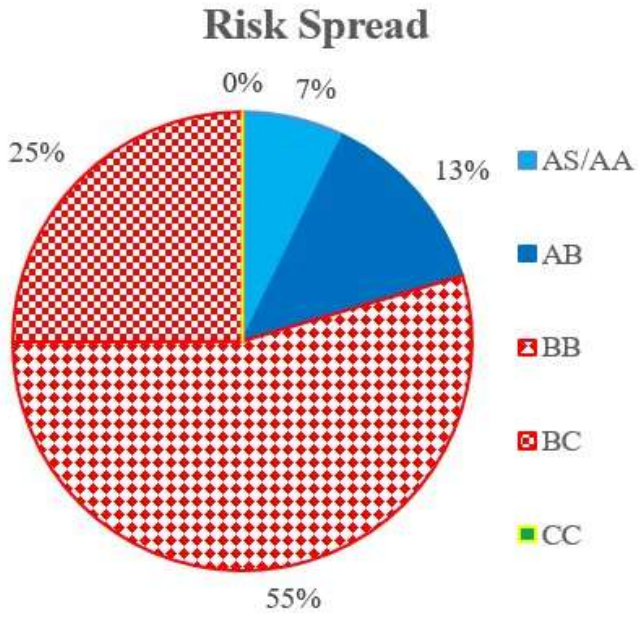
- It is a nice method for conducting lab classes. Drills and module concept is fare.
- The Grading system is very confusing to understand in the first go. Evaluation (in both labs sessions and exams) by the TAs was really biased for some lab groups.
- From a learning point of perspective, the course was simply flawless. Practicing 10-15 questions each week and some being very challenging at the first glance was really amazing and I really learned a lot. So, I guess pre-disclosure of the assessments for the lab should be continued.

New Concerns: Plagiarism and Cheating?



Cheating Risk and its Epicenter
Or *Did They Over-practice*?





Summary: What has been Achieved

- Clear identification of the modules and module contents sets clear plan to define training needs.
- Assessment and training processes are better understood and managed.
- Students had clear idea of where they stand and had good control over their time utilisation across their courses
- Unexpected good benefits to the success-rate
  - Included challenging skills (Backtracking) during the semester .

Motivated students were not affected by those who seek more time.

And, the faster students not hurry those needing time and support.

Thanks for your presence and attention

I welcome your comments

and

would like to answer questions

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A Drill lesson and a related set of assessment exercises are here: Training Lessons for Minimum Pass Standards in a University-wide Undergraduate C Programming Laboratory. https://doi.org/10.13140/rg.2.2.22673.89441

Typical Methods Used to Cheat – Sorry Skipping ☺

- Smuggled solutions
  - Assessment exercises were available for the students to practice.
- Unclear boundary to define cheating!
  - Bringing paper or electronic copy is wrong
  - Is memorising a solution cheating or not?
    - It is definitely wrong if the solution was created by a different person.
  - If the student prepared the solution and memorised?
    - Do not have a firm opinion.

Another Way Used to Cheat

- `printf()` correct answer
- Kept a compiled version ready to demonstrate to the tutor at the end when there is time pressure.
- Tutors failed to verify *Does the program run correctly* check.

		Student	Tutor
1	Is the program appropriately commented? And, do the comments help in understanding the program code?		
2	Is the amount of comments in the program appropriate? That is, the amount of comments is neither too little nor too much.		
3	Is the name of the programmer and date of creation included in the demonstrated program?		
4	Are all constants included in the program code from the exercise statement? The program output should only be computed from the program inputs and constants listed in the problem description.		
5	Are the identifiers used as variables helpful and describe the variable use correctly?		
6	All pointer variables must have an easily understandable part in the variable name to distinguish it from non-pointer variables.		
7	Are the variable type declarations appropriate?		
8	Is the program correctly indented and it is easy to read and understand?		
9	Student's code should have at least two useful `assert ()` declarations.		
10	Does the program run correctly?		

Solutions to cheating Issue?

- Reduce the number of examinations to 3
  - Each of 2 hours + 1 hour for checking status
- Collect programs in a per-problem repository and use similarity checks to catch cheating cliques.
  - Automatic tools may give too many false positives for novice, short programs.
- Drill completion interviews before stage-level assessments
  - Time consuming and labour intensive.