Innovative Methods for Teaching of Computer Science Courses

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Teaching/Learning Approaches

Inductive v/s deductive:

- The "best" method of teaching at UG is **induction**, whether it be called problem-based learning, discovery learning, inquiry learning, or some variation on those themes.

  Examples: double the voltage across a resistance, the current also doubles : is inductive
- Traditional college teaching method is deduction, starting with "fundamentals" and proceeding to applications
- example: the flow of charge carrier is proportional to the potential difference, and charge carrier flow rate is current: $(\therefore I \propto V,)$ is deduction.
- Problem with inductive presentation:

  It is not concise and prescriptive - you have to take an appropriate example or a collection of observations or data and try to make sense of it.
- Many or most students would say that they prefer deductive presentation

Change of the visual/auditory dimension to the visual/verbal dimension

- "Visual" information clearly includes Pictures, diagrams, charts, plots, animations, etc.,
- "auditory" information clearly includes spoken words and other sounds.
- Information transmission that is not clear ? (written prose).
- The written text is perceived visually. Hence, cannot be categorized as auditory !!
- Cognitive scientists have established that our brains generally convert written words into their spoken equivalents
- To a visual learner, a picture is truly worth a thousand words,
- Making the learning style pair the visual and verbal solves this

Learning and Teaching Methods

Students learn in many ways - by

- seeing and hearing;
- reflecting and acting;
- reasoning logically and intuitively;
- memorizing and visualizing and drawing analogies and
- building mathematical models

Teaching methods also vary:

- Some instructors lecture,
- others demonstrate or discuss;
- some focus on principles and others on applications;
- some emphasize memory and others understanding.

- How much a given student learns in a class is governed in part by that student's native ability and prior preparation but also by the compatibility of his or her learning style and the instructor's teaching style.

Learning and Teaching Methods ..

- Mismatches exist between common learning styles of engineering students and traditional teaching styles of engineering professors. In consequence, students become bored and inattentive in class, do poorly on tests,

- Professors, confronted by low test grades, unresponsive or hostile classes, poor attendance and dropouts, think something is not working;

Learning and Teaching Styles ..

We will explore:

1. Which aspects of learning style are particularly significant
2. Which learning styles are preferred by most students ?
3. What can be done?

Dimensions of Learning Style

- Learning in a structured educational setting is a two-step process: 1. Reception, 2. Processing of information (learning).
- A learning-style model classifies students according to where they fit on a number of scales pertaining to the ways they receive and process information.

Models of Learning

Learning style is defined by answers to five questions:

1. Type of information a student prefer to perceive: sensory - sights, sounds, physical sensations, or intuitive
2. Channel from it is effectively perceived : visual - pictures, diagrams, graphs, demonstrations, or auditory - words, sounds
3. With what "information organization" one is comfortable : facts and observations are given, principles are inferred inductive, or principles are given, consequences and applications are inferred deductive
4. Way he/she prefer to process the information : actively - through engagement in physical activity or discussion, or reflectively /passively - through introspection
5. Progress toward understanding is effective : sequentially - in continual steps, or globally - in large jumps, holistically

Teaching Styles

Teaching style is defined in terms of answers to five questions:

1. Wat type of information is emphasized by instructor? concrete - factual, or abstract - conceptual, theoretical.
2. What is mode of presentation ? visual - pictures, diagrams, films, demonstrations, or verbal - lectures, readings, discussions.
3. What is Organization of presentation ? inductively - phenomena leading to principles, or deductively - principles leading to phenomena?
4. What is presentation induced student participation? active - students talk, move, reflect, or passive - students watch and listen.
5. What type of perspective is used in the presentation? sequential - step-by-step progression (the trees), or global - context and relevance
6. Thus, teaching styles are: concrete, . . . , global

Models of Learning & Teaching Styles...

The hypothesis: Engineering instructors who adapt their teaching style to include both poles of each teaching style are popular teachers !

1. Visual and Auditory Learners: As the name suggests.

   A study carried out by the Socony-Vacuum Oil Company:

   - students retain 10 percent of what they read,
   - 26 percent of what they hear,
   - 30 percent of what they see,
   - 50 percent of what they see and hear,
   - 70 percent of what they say (table learning), and
   - 90 percent of what they say as they do something.

Examples of Teaching methods in CS

- Successful and Unsuccessful Problem Solving Approaches of Novice Programmers
  - Many studies have shown that learning to program is difficult for many students
  - Pair programming transforms a traditionally solitary activity into a collaborative one,
  - One partner, typically referred to as the *driver*, sits at the keyboard
  - While pairing, the partners switch roles regularly,
  - Comment: pairs are more likely to refer to the textbook
  - Comment: Students who did not use the compiler tended to do poorly

IMPLICATIONS FOR TEACHING

- A challenge for educators is to help students learn the beneficial behaviors and avoid the ineffective ones.
  - Try to get students to think about the problem before jumping in. Encourage students to ask themselves, "What order should I do this in?"
  - Teach students to compile frequently. If you program in front of your students, model this behavior for students to emulate. Discuss why you are doing so. Take "baby steps".
  - Teach students how to use a debugger.
  - Stress effective testing techniques.
  - Stress to read the API documentation carefully.
  - Highlight areas of (Java) that lead to student confusion.

Examples of Teaching methods in CS

- PI (Peer-Instructions), Mazur (prof of Physics,MIT), PCI (Force Concept Inventory), Active Learning, Socratic Teaching / Learning, test for why worn?
- 2D games programming for learning programming and Programming languages
- Introduction to Special Issue on Alternatives to Lecture in CS class room

  Active learning

  Evidence-based instructional practices

  Collaborative learning

  Studio-based instruction.
- Active Learning: Active learning is characterized by student activity and engagement in the learning process.
- With collaborative learning, students interact with each other to achieve a common learning goal. Good for introduction to programming course.

Examples of Teaching methods:

- PEER INSTRUCTION:
  - Peer Instruction (PI) is an active pedagogy pioneered in Physics education in which most lecture time is replaced with students answering carefully designed multiple-choice
  - Responses are provided using hand held devices informally called "clickers".
  - (CROUCH, C. AND MAZUR, E. 2001. Peer instruction: Ten years of experience. Amer. J. Phys. 69, 9, 970-977.)
  - http://peerinstruction4cs.org http://peerinstruction4cs.org
- STUDIO-BASED LEARNING
  - The fields of Architecture and Fine Arts promote student collaboration in Studio-Based Learning (SBL).
  - SBL has been promoted in computer science. The approach is particularly well suited for human-computer interaction courses
  - Peer Code Review (PCR) is an SBL approach adapted from code reviews performed in the software engineering profession.
  - Conclusion: Evidence-based instructional practices that are shown effective alternatives to lecture.

Examples of Teaching methods:

- STUDY DESIGN (for SBL) includes
  - Plan the inspection of a specific piece of code.
  - Hold a kick-off meeting with an inspection team to distribute the code to be inspected
  - Have members of the inspection team inspect the code for defects on their own time.
  - Hold a moderated inspection meeting to log issues found
  - Edit the code to address the issues

Talking about Code: Integrating Pedagogical Code Reviews (PCRs) into Early Computing Courses

- "soft skills," including communication, collaboration, and teamwork, are becoming increasingly coveted in the software profession{BARKER, P. 2011. Soft skills important for IT job candidates. Montreal Gazette. http://www2.canada.com/montrealgazette/ news/archives/story.html?id=a90c9d79- 48ac-4890-b505- 89fd4c0cc706.}
- Inspired by the code inspection process used in the software industry, a PCR is a collaborative activity in which a small team of students, led by a trained moderator:
  - walk through segments of each other's programming solutions,
  - check the code against a list of best coding practices, and
  - discuss and log issues that arise.

GINI: A User-Level Toolkit for Creating Micro Internets for Teaching & Learning Computer Networking

- GINI (GINI Is Not Internet) is an open-source toolkit for creating virtual micro Internets for teaching and learning computer networking.
- It provides lightweight virtual elements for machines, routers, switches, and wireless devices
- The virtual elements run as unprivileged user-level processes.
- The GINI provides a user-friendly GUI-based tool for designing, starting,

GINI: A User-Level Toolkit for Creating Micro Internets for Teaching & Learning Computer Networking

- GINI, an entirely software-based approach containing many of the features found in more expensive laboratory-based solutions.
- The GINI provides lightweight but IP compatible virtual elements for machines, routers, switches, wireless access points, and mobile devices.
- The virtual elements can be interconnected to create virtual networks for experimentation purposes.
- The GINI provides a tool with a GUI (graphical user interface) called gBuilder to design, start, inspect, and stop virtual networks.
- The processes that are created as part of the elements of a virtual network such as virtual machines can all run within a single machine or be distributed across multiple machines.
- The GINI is designed such that it can install and run without special privileges (e.g., super user access).
- This allows students to use GINI toolkit on machines provided in university computing centers or on their personal computers.

GINI