College of Computer Sciences & Engineering (CCSE)

Active Learning: ***Techniques for Improved Learning***

(Engineering & Science Perspective)

CCSE Teaching & Learning Committee

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Contents

1. Education Trend

- **Learner – Centered education** (compared to instructor-centered education)
- Not advocating abandonment of lecturing
- Learner should be **actively** involved in the education process → *Active Learning*

2. Why active learning?

- Improved student understanding
- More motivating to students
- Improved feedback to instructors
- Accommodates different learning styles

Shallow learning encouraged by:	**DEEP learning encouraged by:**
• Relatively high class contact hours • Excessive amount of course material • Lack of opportunity to pursue subjects in depth • Lack of choice over subjects and methods of study • Threatening and anxiety provoking assessment system	• Student perception that deep learning is required • Motivational context • Learner activity • Interaction with others • Well-structured knowledge base

3. Definitions

"**Active Learning**" is anything students do *in a classroom other than merely passive listening* to an instructor's lecture.

"**Cooperative learning**" covers the subset of active learning activities which students do as groups of three or more

"**Collaborative learning**" refers to those classroom strategies which have the instructor and the students placed on an equal footing working together in, for example, designing assignments, choosing texts, and presenting material to the class.

4. Active Learning Techniques for Engineering/Science

Following is a set of possible *active learning* techniques that are suitable to use in engineering & science courses:

1. **The "One Minute Paper"**

    - Ask students to take out a blank sheet of paper, pose a question (either specific or open-ended), and give them **one** (or perhaps **two** - but not many more) minute(s) to respond.
    - Sample questions include: "Write the main points/outline of topics discussed today", “what is the difference between a latch and a Flip Flop” "What is the activation energy for a chemical reaction?", "Write a method to exchange values of the parameters t and v”

2. **Muddiest (or Clearest) Point**

    - At the end of a class period, *or at a natural break* in the presentation have students answer the following question "What was the "muddiest point" in today's lecture?" or,
    - Ask more specific questions, for example: "What (if anything) do you find unclear about the concept of “asynchronous pipelines”, “class inheritance”, etc.

3. **Lesson/Subject Summaries**

    - Students are requested to summarize (*may be as a homework or part of class activity*) a given topic and share this summary with other colleagues
    - Summaries can be in the form of:
        - **Textual summary**

- **Mind maps (**involve writing down a central idea and thinking up new and related ideas which radiate out from the centre. By focusing on key ideas written down in your own words, and then looking for branches out and connections between the ideas, you are mapping knowledge in a manner which will help you understand and remember new information.**)**
- **Concept mapping** is a technique for representing knowledge in graphs. *Knowledge graphs* are networks of concepts. Networks consist of nodes and links. Nodes represent concepts and links represent the relations between concepts. Concepts and sometimes links are labeled. Links can be non-, uni- or bi-directional. Concepts and links may be categorized, they can be simply associative, specified or divided in categories such as causal or temporal relations. Concept mapping can be done to generate ideas, to design a complex structure (long texts, hypermedia, large web sites, etc.), to communicate complex ideas, to aid learning by explicitly integrating new and old knowledge, or to assess understanding or diagnose misunderstanding.
- **Visual lists / webs** are concept maps that may also contain images, different ways of visually constructing relationships (such as Venn diagrams instead of points and lines), and explanatory textual material.
- **Cognitive analogies** Students are encouraged to imagine multiple ways in which an idea, fact, explanation, procedure, etc. could be understood. How, for example, might a painter represent Darwin's ideas about kin selection? Or, how might Oedipal conflicts serve to represent the confinement of negative electrical charge to specific nuclear orbits?
- **Student-created charts, matrices, flowcharts, models** Students are encouraged to build charts, matrices, flowcharts, and models as contexts for extending their understanding of key course-specific concepts. This sort of exercise encourages students to ask: What would a good model look like? How should the model actually be constructed? What are the strengths and weaknesses of the model? Computers provide an excellent resource for this sort of work (SimCity is a nice example of a commercial product that enables multi-level modeling of techno-socio-political problems, ideas, issues, etc.).
- **Student-prepared case study, mini-case study, illustrative example(s)** An analysis of a particular case or situation, either real or constructed, that is used as a basis for the application of knowledge and/or drawing conclusions in similar situations.

4. **Reading Quiz**

    - Students are assigned some reading material on which they are quizzed.

5. **Clarification Pauses** This is a simple technique aimed at fostering "*active listening*".

    - After stating an important point or defining a key concept, *stop, let it sink in*, and then (after waiting a bit!) ask if anyone needs to have it clarified. You can also circulate around the room during these pauses to look at student notes, answer questions, etc. Students who would never ask a question in front of the whole class will ask questions during a clarification pause as you move about the room.

6. **The "Socratic Method"**
    - The instructor chooses a particular student,
    - Asks this student a question,
    - If the "selected" student cannot answer, another is selected repeatedly till the desired answer is received.
    - Students may be given marks based on their preparedness/attention.
    - This method has come under criticism, based on claims that it singles out students (potentially embarrassing them), and/or that it favors only a small segment of the class (i.e., that small percentage of the class who can answer any question thrown at them). In addition, once a student has answered a question they may not pay much attention as it will be a long time before the teacher returns to them for a second question. In spite of these criticisms, the Socratic Method is an important and useful one; the following techniques suggest variations which enhance this method, avoiding some of these pitfalls.

7. **Wait Time** - Rather than choosing the student who will answer the question presented, this variation has the instructor ***WAITING*** before calling on someone to answer it. The wait time will generally be short (15 seconds or so) - but it may seem interminable in the classroom. **It is important to insist that no one raise his hand (or shout out the answer) before you give the OK**, in order to discourage the typical scenario in which the five students in the front row all immediately volunteer to answer the question, and everyone else sighs in relief. Waiting forces every student to think about the question, rather than passively relying on those students who are fastest out of the gate to answer every question. When the wait time is up, the instructor asks for volunteers or randomly picks a student to answer the question. Once students are in the habit of waiting after questions are asked, more will get involved in the process.

8. **Student Summary of Another Student's Answer**

- After one student has volunteered an answer to your question, ask another student to summarize the first student's response. Many students hear little of what their classmates have to say, waiting instead for the instructor to either correct or repeat the answer. Having students summarize or repeat each others' contributions to the course both fosters active participation by all students and promotes the idea that *learning is a shared enterprise*. Given the possibility of being asked to repeat a classmates' comments, most students will *listen more attentively to each other*.

9. **Student-Prepared HW, Quiz, or Test Questions**

- Students are asked to become *actively involved in* coming up with questions for HWs, quizzes and tests. This encourages students to think more deeply about the course material and to explore major themes, comparison of views presented, applications, and other higher-order thinking skills.
- The instructor may use any/some of the collected questions as the ***basis*** of HW assignments, review sessions, quizzes exams.
- Students might be asked to discuss aspects of two different questions on the same material including degree of difficulty, effectiveness in assessing their learning, proper scope of questions, and so forth.

10. **Share/Pair**

Grouping students in pairs allows many of the advantages of group work students have the opportunity to state their own views, to hear from others, to hone their argumentative skills, and so forth without the administrative "costs" of group work (time spent assigning people to groups, class time used just for "getting in groups", and so on). Further, pairs make it virtually impossible for students to avoid participating thus making each person accountable.

11. **Evaluation of Another Student's Work**

- Students are asked to complete an individual homework assignment or short paper.
- Students submit one copy to the instructor to be graded and one copy to their partner. Partners may be assigned per HW assignment, or students may be assigned partners to work with throughout the term. Each student then takes their partner's work and grades it giving critical feedback, corrects mistakes, and so forth. This is a particularly effective way to improve student writing.

12. **Cooperative Groups in Quizzes**

- Quiz is posted on screen
- Cooperative groups discuss answers
- After an appropriate time, students are asked to individually submit the solutions.

13. **Work at the Blackboard** - In many problem solving courses (e.g., logic or critical thinking), instructors tend to review homework or teach problem solving techniques by solving the problems themselves. Because students learn more by doing, rather than watching, this is probably not the optimal scenario. Rather than illustrating problem solving, have students work out the problems themselves, by asking them to go to the blackboard in small groups to solve problems. If there is insufficient blackboard space, students can still work out problems as a group, using paper and pencil or computers if appropriate software is available.

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