On Teaching Critical Thinking to Engineering Students

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Critical thinking in the Portuguese curricula

- The teaching of critical thinking skills in Portugal is rare in science and engineering programmes. To our knowledge, there is no specific Critical Thinking (CT) course in Higher Education, in any field. The one reported here is first of its kind.

- The course takes place at Universidade Nova de Lisboa, and began in September 2006. Detailed information, including slides and other documentation in English, can be found on the web page http://ssdi.di.fct.unl.pt/lei/pc/
Critical thinking in the Portuguese curricula

- CT was introduced as a compulsory course in the 3rd semester of Informatics Engineering, formatted according to a 3-year Bologna 1st cycle, as part of its recommendations for more soft skills in higher education. 97 students enrolled.

- This CT course is preceded by a generalist and mandatory “Expression and Communication” course in their 1st year, and is followed, in the 2nd cycle (for those who continue) by an obligatory course on “Scientific and Technical Communication”.
**The relevance of CT for engineering education**

- Though our CT course follows a fairly standard approach, it is innovative in emphasizing the stance of the specialized producer of scientific and technical information, not just that of the layman information consumer.

- CT skills are essential for good and apt decision making and the understanding of problematic issues.

- It is most important for engineering professionals, expected to make decisions, solve technical problems, face ethical balances, employ best practices, report and document findings and products, and act in a consultant capacity.
The relevance of CT for engineering education

- A deeper understanding of the epistemological, philosophical, and methodological foundations of science is also important. And not just for those intending to pursue a research or teaching career.
- Ironically, engineering and science training can discourage CT by presenting the student only with well established theories, received wisdom, and best practices, not necessarily inviting a critical attitude.
- This may leave them unprepared to face real life situations, where uncertain, fuzzy, unreliable, or even misleading information can affect the decision process.
The relevance of CT for engineering education

- Though students are prepared in their scientific field, they are hesitant and have difficulty in criticizing non-scientific claims in their daily lives.

- In practical sessions of this CT course, students are asked to discuss subjects such as astrology, miracles, or spirit communication. Many initially argue in favour of these beliefs, simply based on the absence of negative evidence.

- While no engineering student would argue in favour of a technical claim in their field based on such weak reasons, they seem unaware of the importance of positive evidence to support a claim, outside their area of expertise.
The relevance of CT for engineering education

- CT is essential for effective scientific and technical communication. In addition to skills to assess claims and data, it is important for engineering students to develop the skills to criticise their own assumptions and inferences, and how they communicate and argue their own knowledge.

- These important skills for the engineering professional are rarely part of the regular technical courses, where the students are graded rather by their performance. The examinations focus on the application of technical knowledge, not on its actual communication.
The relevance of CT for engineering education

- Thus our focus on two aspects of CT:
  - As consumers of information, requiring the skills to assess claims and inferences critically;
  - As producers of technical information, with specific training to question assumptions, to put checks on reasoning, and to avoid fallacies.

- We designed the course with two major goals in mind:
  - To improve the student’s ability to analyse claims and information critically;
  - To teach students to present results and technical information in a correct manner.
The Critical Thinking course

- The course is taught by alternating 2-hour lectures presenting the subject matter to all students, with 2-hour practical sessions where a smaller number of students (approx. 30) have the opportunity to discuss subjects and practice with exercises.

- Students are expected to spend an additional 6 hours per week on individual study and practical exercises.

- All sessions are recorded on digital audio files made available in the course’s web site, so students can review the sessions and hear their own contributions to discussions.
The Critical Thinking course

- Evaluation is split into theoretical and practical components. The practical one consists of 4 exercises and 2 essays, all individual. Exercises are up to 1K characters, each focusing on a specific aspect of CT, such as building an argument, analysing a scientific theory, or making a decision under uncertainty.

- The essays are at most 5K characters, and each covers a broader part of the course. The first is on some objective issue, requiring students to build an argument, analyse competing hypotheses, and assess the reliability of sources. Last time it was an analysis of conspiracy theories about the fall of the Twin Towers in NY.
The Critical Thinking course

- The final essay is on decisions involving both objective data and subjective values. Students can choose the theme for the second essay, with recommended subjects like environmental policies, immigration, abortion, copyright laws, and such.

- The goal is to have the student make a policy decision in the face of uncertainty, distinguish objective aspects from the value judgements, and present and defend such decision in a structured argument.
The Critical Thinking course

- Active participation in the practical sessions is taken into account for evaluation purposes. The practical component accounts for 40% of the overall grade.

- The theoretical component of the evaluation is a 2-hour long written exam, requiring a broad view of CT, where each student will choose 2 out of 4 topics provided, form an opinion, and present it as a written argument. It accounts for 60% of the grade.
The CT curriculum

- The curriculum can be divided into 2 stages. The first focuses on the analysis of objective issues, and the second addresses matters involving decision and value judgements.

- The first stage covers, in order, the structure and logic of arguments, abduction and the formulation of explanations, properties of good explanations, designing experiments to test alternatives, the analysis of scientific models, and epistemological issues.
The CT curriculum

- The second stage covers the assessment of statistical data, decision as satisfaction and optimisation, the consideration of consequences, alternatives and opportunity costs, and finding omitted information.

- There is also an introduction to ethical concepts, as they play an important role in decision making, but the focus is on the objective aspects of decision.
Results

- This course has shown that students start poorly prepared for creating sound arguments, with most resorting to rhetorical tricks and arguments from personal opinion, instead of correctly identifying the important aspects of the problem.

- However, our experience so far indicates that students quickly grasp the important aspects, and the utmost relevance of critical thinking. There is a noticeable improvement along the semester in students’ capacity to analyse different subjects.
Results

- Student reaction has been positive, with most students showing they are interested in the subject, and many participating in the discussions.

- Also, a few students for whom this course is not available have been coming to the discussion classes, even though they are not enrolled. This suggests a potential for the expansion of this course to students outside Informatics Engineering.
References


