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Fundamental Pedagogical View

Pedagogical Basis

I believe that the ultimate pedagogical objective at the university level should be to cultivate deep critical thinking and analytical skills in students such that they are not limited by the knowledge given to them in their education, but instead are able to extrapolate beyond it and learn how to acquire the knowledge needed in their professional and personal lives. In other words, we as teachers should not just foster learning, but also meta-learning.
In my view:
- Teaching should be *grounded* on a strong theoretical basis.
- This theoretical grounding should *support* an intuitive practical understanding and application.
- Practical understanding and intuition should help *revise* the theoretical foundation.
- Currently taught theory is not the ultimate truth (which students often accept it for). Instead, it might just be *one of many models* with which to explain or model a given problem. At higher levels of learning, a teacher should foster their students' abilities to draw from other subjects to find alternate explanations for the reality they have constructed.

Based on the above, and in terms of learning paradigms, my view is strongly influenced by cognitive constructivism. However, I believe that a key limitation or failure of teaching practice is that the cognitive constructivist process is not scaffolded sufficiently. Often, although the learner's background, knowledge and stage of development are considered in the design of teaching materials or sessions, we let the student's mental model evolve completely on its own. As such, at less mature levels of development, the learner will at best just accept what is being taught at face value, with little meta-cognitive reflection, leading to "information loss". A more experienced person, however, might reflect on how the teaching relates to their prior knowledge and draw connections in their cognitive model. As teachers, it is not enough to wait for this to eventually happen. Instead, we should propose thought patterns and design activities that facilitate this.

Example: Scaffolding report writing in engineering education

To give an example, a typical complaint of many engineering university teachers is that their students do not write good reports.
One action to address this might be to suggest a report structure that the students may use. This, however, does not address the root of the problem, but just its symptoms. The student might just adopt the structure at face value. In the best of cases, this will result in a better report for the current project. But in a future project, the same structure might not be suited to the communication intent; thus, the problem reoccurs.
Instead, one could provide multiple examples of report structures. Yet, in this case, the student might not know which structure to choose in which context. Indeed, many may be viable for the current project. The student might, in the future, just stick to what worked in the past and forget that alternatives exist.
In both of the above cases, what I believe is wrong from a pedagogical point of view is that the intent behind report writing has not been effectively communicated and the intended meta-analytical skills have not been fostered. The focus should not be on "How should I structure my report?", but "What am I trying to communicate with my report?", "Who is going to read my report and what is their prior knowledge (on both the field, but also the context of the project)?", and "Why does a specific structure support my communicational intent?". This can lead to a dialog with the student on how the problem statement, methodology, experimental design, and conclusions should be tightly knit together and strongly support/depend on each other.

Application to an Engineering Context

In an engineering context, I believe students should – through practical exercises, projects and guidance – develop the skills to apply theoretical knowledge to solve real problems. The challenges they encounter during this practical application should help them revise their understanding of the theory and when it can or cannot be effectively applied. Consequently, I view applied project work (both individual and in groups) as a fundamental component of an engineering education.
Through project work, students can:
- Experience the limitations of theoretical models in a practical use-case.
- Develop a better understanding on why both theory and practice are important.
- Develop complimentary skills, specializing in what they find most interesting.
- Learn how to share knowledge with their colleagues, developing stronger communication skills.
- Intuitively gain meta-learning skills within their field of expertise.

In my supervision practice, I adopt many of the principles outline above and scaffold them to the level of the learning as follows:

- *Bachelor Semester Projects:*
  Focus on working effectively in teams, task breakdown, integration of the concepts learned in the semester courses, and structured technical report writing.
- *Bachelor Theses:*
  Introduction to literature review, focus on strong connection between theory and application, basic experimental design.
- *Master Semester Projects*:
  Focus on literature review, extrapolation of the concepts learned in the semester courses to the wider state of the art, integration, implementation, contextualization, and scientific evaluation and reporting.
- *Master Theses:*
  Focus on formulating scientific problem statements, semi-independent literature review, implementation, strong experimental design, data collection, evaluation, analysis and contextualization of results, longer-term project planning, and some research/ professional independence.

Example: Course design for *Robot Kinematics*

In the design of my *Robot Kinematics* course, I have also tried to apply the concepts above.
Robot kinematics is essentially an application of matrix algebra to modeling of robotic systems and their movements. As such, the course could potentially be approached highly theoretically.
However, as this is currently being taught at the second semester(!) of the BSc./BEng. Robot Technology educations, student retention and motivation is critical.
I have approached this by:
- Making the students aware of how the course connects to other course in their educational program, but also how kinematics is connected to other disciplines within robotics.
- Choosing exercises that make use of real, practical robotics use cases (often from situations arising in industrial robotics), including graphical visualizations, i.e., not just "some random matrices with numbers in them". Additionally, I provide a robotics simulation in MATLAB that the students can input the matrices into and visualize how this affects the resulting robot motion. This simulation initially acts to them as a "magical black box", i.e., they do not understand how it works (more on this below).
- Making the students aware of when a kinematic model is effective, and when it ceases to be so (e.g., in cases where there exist external forces and objects can deform, in which case dynamics must be considered).
- Making the students aware that the approach they learn in the course (transformation matrices) is just one way to model the kinematics of a robot and there exist others (e.g., screw theory/dual quaternions). In other words, "this is one kind of math that solves this problem, and not THE math that solves this problem."; a mathematical model within engineering is just a tool, and can often be replaced.
- Applying pedagogical practices that foster active learning, such as flipped and collaborative learning. Particularly, FL and CL are used in a lecture on building a robot kinematic model in simulation, where at the completion of the module, the students will be able to open up the "magical black box" simulation model I provided earlier (see above), and understand how it is built.

Teaching Experience

I have been main or invited lecturer for the following courses:

Supervision Experience

I have supervised the following semester projects:

In addition to the above, I have supervised a number of Bachelor and Master theses:

Formal Pedagogical Training

Lecturer Training Program, SDU

The Lecturer Training Program is offered to all teachers at Assistant Professor level at the University of Southern Denmark and provides an introduction to different pedagogical frameworks and principles with the objective The program includes the following modules:
- *Module 1 - Inspiration* **-** This module introduces pedagogic theory and practices with a

focus on alignment, feedback, teacher and learner roles, e-learning activities, research-based teaching and designing a project for personal pedagogical development.

- *Module 2 - Coaching* - This module seeks to facilitate a deeper insight into teaching and supervision practice. This is achieved through combination of supervising and being supervised by other peers, as well as by a personal mentor.
- *Module 3 - Development* - This modules takes an outset in the methods and frameworks introduced in all prior modules. Based on this, the teacher is expected to design and conduct their own development project with the aim of improving some aspect of their teaching.
- *Module 4 - Presenting* - This module develops the teacher's competences to present their own pedagogical insights and the results of their own pedagogical research.
- *Module 5 - Future Development* - This module focuses on professional development through description and reflection on personal teaching experiences and competencies. This is formalized in the form of a teaching portfolio and concluding dialog.

MCQ - Construction and quality control of multiple choice items, *Elective Course*

Flipped Learning, *Elective Course*

Supervision – roles and relations, *Elective Course*