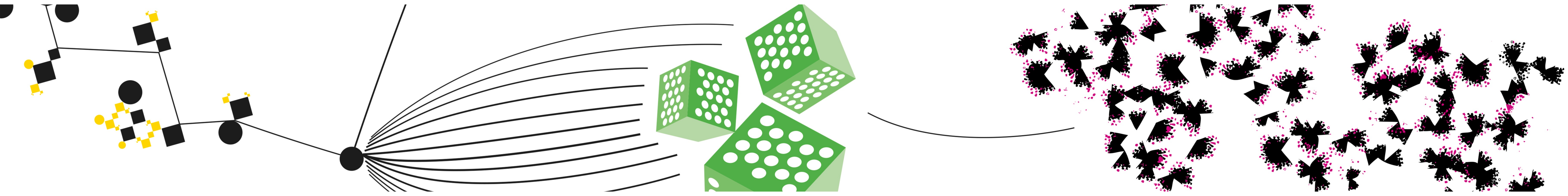


# How to Solve it?

"Systematic Approach to Problem Solving, Treshold Learning Concepts, Decoding the Discipline and Student as Partner"

C.H. Venner

## 1. Introduction

Educational institutes have to educate a new generation of engineers that will develop low impact, clean, low noise, minimum energy use, flexible new technology for a resilient society. Engineers solve problems. They analyse, combine insight and information into a suitable model, design a strategy leading to a solution, obtain it, and verify the result. The result should be realistic within an operational envelope. Each step is essential. Misconception, errors in design or calculation, in real applications can be catastrophic. How to teach students the engineering problem solving approach ? This question has been subject of many studies, but, in the present "digital" society where they are exposed to an overload of (often not reliable) information and constant media distraction causing a reduced span of concentration, it is more difficult to answer. Teacher centred methods (classic lectures and exercise classes) appear out of date. Problem (Project) based learning is widely introduced but also criticized [1]. This project is about the redesign of a convective heat transfer course to improve actual ***problem solving ability*** and ***learning experience*** by emphasizing systematic problem analysis (SAP) and using recent educational developments as threshold learning concepts (TLC) , Decoding the Discipline (DtD) and student as partner (StAP).


Figure 1: Todays learner in transformation to engineer for resillient society

## 2. Educational Context

The Twente Educational Model (TEM) is a modular BSc program. Module 7 (year 2) in Mechanical Engineering "Thermal Fluid Engineering" contains courses "Fluid Mechanics" and "Heat Transfer" and Project Based Learning (PBL) using a practically relevant complex design involving fluid mechanics and heat transfer. The courses are evaluated by classic solving problem exams. Teaching is by lectures and supervised exercise practicing classes. Only 20% of the students attend these exercise classes, whereas solving problems is exactly what is needed to pass the exam. Most student (groups) pass the oral project exam, and deliver acceptable project reports. The course exam scores are much lower. In this project the effect of partial redesign of the heat transfer course on the individual problem solving skill shown at the exam is investigated. The project is carried out as part of the Senior Teaching Qualification project. Implementation first done in february-may 2017.

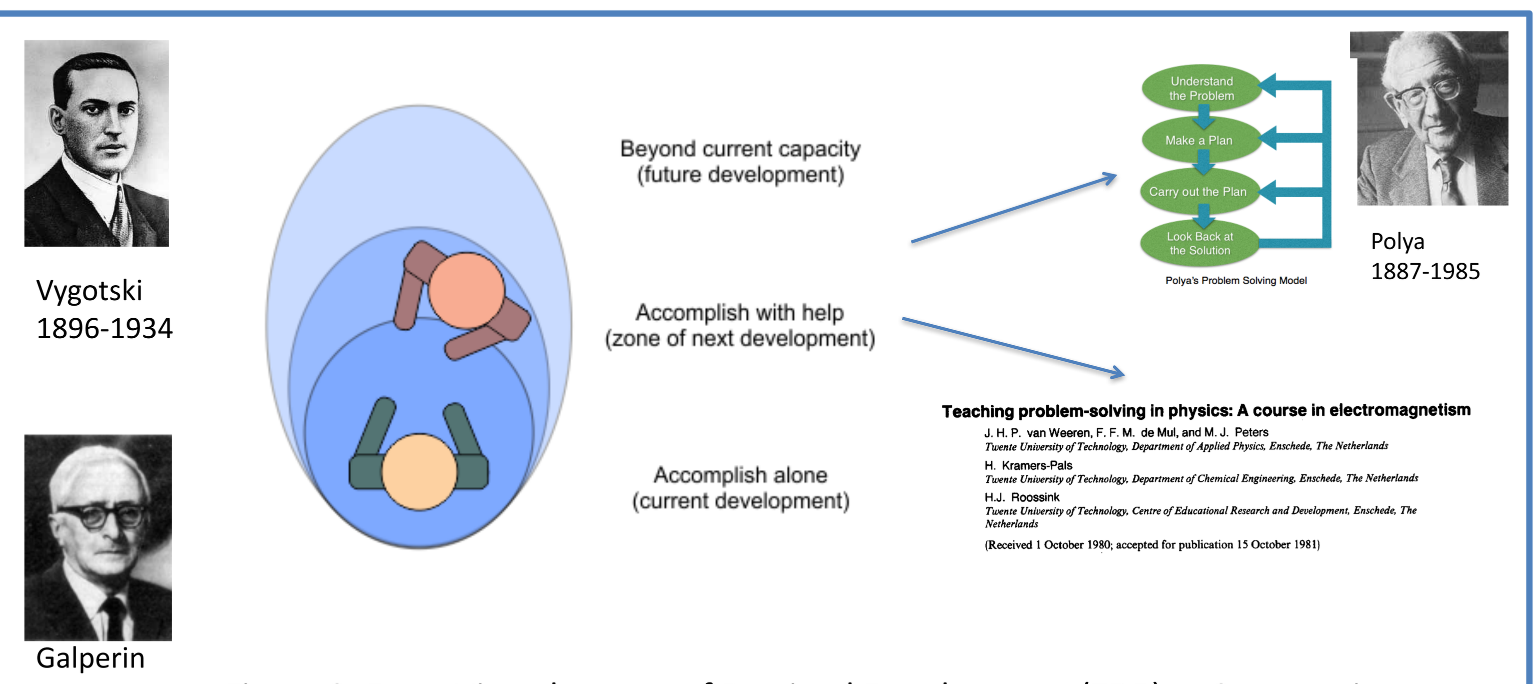



Figure 2: From Vigotsky, zone of Proximal Development (ZDP) to Systematic problem solving (4 step approach Polya [3], and SAP [4,5]).

## 3. Problem solving and theory of learning

Learning is cognitive development in social contact (Vigotsky/Galperin) [2]. Students learn optimal in Zone of Proximal Development (ZPD) with more knowledgeable other (MKO) e.g. teacher. Essential element to arrive "in" ZDP is motivation. Scaffolding towards internalization via guided repetition, and evaluation. Polya [3] introduced a 4 step approach problem solving method widely used. A very similar Systematic Approach to Problem solving (SAP/SPA) [4,5]) was successfully used in teaching in the 1980's at the University of Twente but attention has faded in the past decades.

## 4. Redesign/Intervention Convective Heat Transfer

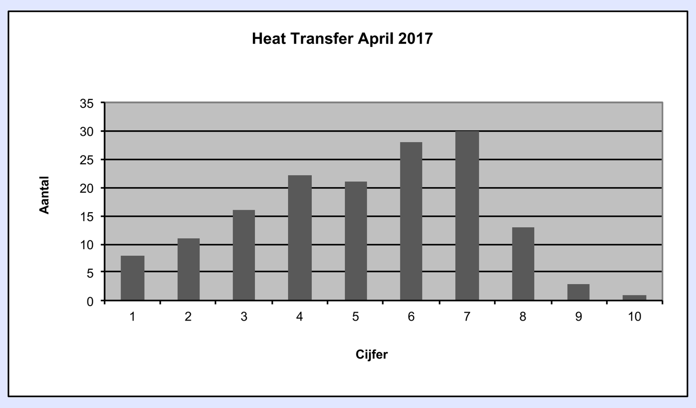
- MSc Student as partners in redesign and execution.
- Threshold Learning Concepts identified (heat transfer coefficient, dimensionless numbers and scaling).
- Student interaction in lectures.
- SAP manual introduced.
- Decoding the Discipline: Convection problem roadmap "specialists work systematically" but also "go back and forth" and look for specific forms of results.
- Exercise class transformed to active "How to Solve it" session.
- Pre-class digital inquiry form with questions from "daily life all around" to enhance motivation and insight in relevance. Results discussed in class.
- SAP analysis specific problem in each session in groups (hand in)
- Bonus score for exam "earned" by presence, inquiry form, and SAP analysis.

## 5. Results (preliminary)

Results of "intervention" measured in exam score. Student evaluation and teacher/assistant evaluation. 99 % attendance of working classes

**Exam scores**

After "bonus" correction marginally improved results. Overall still too low. Pass 51 %




**Student, student assistent, teacher evaluation**

Positive feedback on "How to solve it sessions" , good atmosphere, and learning experience. Students scoring high seeking more challenge. Students scoring extremely low have been interviewed separately. No specific clear new TLC observed. Student assistant and teacher evaluation positive. Teacher experiencing major transformation.

## 6. Conclusion & Continuation

Student learning experience has significantly been improved. Better problem solving ability measured by exam not (yet) seen in preliminary result. Possible cause is that the improvement is obscured by the fact that convection heat transfer is only part of the course and exam. Student feedback provides motivation for repeating the research in the next student generation (february 2018). Study will be continued. SPA part further intensified using specific forms for exercises. Reader of exam and exercise problem with analysis will be written.

## 7. References

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