**Going digital changes the game – teaching fundamental chemical engineering for the digital age**

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**Highlights**

* going digital requires a rethinking of education
* basic units have to be linked to show dependencies
* arrangement of knowledge and documentation of thoughts have to be dealt with

**1. Introduction**

Industrial settings change over time due to economic and environmental demands or new products. Today we find ourselves in a situation where data-sets and their interpretation is focused upon. The goal is to optimize process behavior as to stability of quality, maintenance and in case of multi-purpose-plants to switch the production process automatically. All this sounds familiar, although the working environment has changed. Modern software packages allow to simulate models, calculate statistics and look up data to manage the production on an everyday basis. This changes the speed of decision making and the kind and amount of knowledge which is needed to perform. On viewing this my colleagues and I decided to adapt the bachelor and master study courses accordingly. What followed was a turmoil of changes and a new concept of the courses which development is still in progress, since process engineering is on its way to create a digital twin.

**2. Methods**

In the former courses the topics were presented via static sheets, for each topic a problem was solved using a pocket calculator. Optimizations or variations of the problem were roughly estimated, some of the solutions were shown on slides or using an excel-worksheet. Graphs were drawn to show dependencies or to construct thermal stages. Handling of the pocket calculator, drawing the graphs and documenting the solution took more than 50% of the time. This led to a demonstration of idealized problems (only one basic unit in its clear definition). The students were in a receptive partly passive state and rarely interacted in a discussion. Yet, the lack of understanding was not clearly visible, routinely done calculations with some luck in guessing advanced questions was enough to pass the course. This dissatisfying situation was contradicted by experiences in supervising bachelor / master-thesis as well as lab-courses. Students worked in interdisciplinary teams, were interested in models and discussed their problems. A conceptual change was more than necessary.

For a deeper understanding of the theoretical background it is necessary to build a theoretical classification before working on an exemplary problem, otherwise a selective search for information or solutions would be hindered in future times [1]. Research on causes of study termination show that the main reasons are pressure to perform, dominance of formulas, irrelevance of topics and lacking supervision [2]. Countries with high scores in the TIMSS-study 2015 teach mathematics and sciences by showing how the solution is achieved and allowing students time to try for themselves followed by a discussion and subsequent variations of the problem [3].

The idea was to create a course where the models can be used in a more creative way, this should lead to a way of technical thinking and posing the right questions. An independent working group found the same concept for a future work environment and called it “Funky Prototype” [4]. The idea to calculate with Excel-Worksheets was abandoned, although stage construction was quite comprehensive, because easy to use predefined functions and interdependence of worksheets was hard or impossible to handle. This would set a focus on programming skills not on mechanical and thermal engineering. The software used is MATLAB or for training at home the comparable freeware-tools OCTAVE and SCILAB. The models are held simple but can be used in a modular way, because they are included in predefined functions. Basic programming skills and commands to call for functions, graphs or other in- and output are taught in an introductory lecture. The first two solutions are explained in detail, then the way to solve the problem is briefly outlined before the students start on their own. The outcome is discussed and later an optimization or a different setting is explored.

**3. Results and discussion**

Most students are eager to follow and start to develop own questions and approaches while communicating more intensely with me and with each other. Insecure students need more support while interested students excel. The sensitivity of parameters is visible more easily and the problems later in the course resemble case studies. Surprisingly almost everything, including the presentation of the theory, had to be changed. Instead of bothering with an idealized approach, approximations are applied where thinking about a meaningful threshold value is important. Optimization and interpretation of the graphs is focused upon, which shows very clearly who understands the model and the concept. Usage of model-functions (e.g. thermal equilibrium, distributions of particles) is discussed in contrast with using experimental data.

**4. Conclusions**

The complexity of the problems is higher, which should to be handled with care. Control of basic units and consecutive units can be integrated in the future. The idea to create a learning environment like at starship “Enterprise” in the Star Trek series, where modular solutions are recommended by a board-computer and selected by an engineer who is solely responsible for arranging the information in a meaningful way, is enchanting. Questions as to how the decision is documented, data is treated and exams are to be taken are still discussed. Students need to acquire basic digital key competences as soon as possible but not later as during their Bachelor courses.

**References**

1. Alfred Riedl, Andreas Schelten in R. Bader, P.F.E.Sloane, Lernen in Lernfeldern Theoretische Analysen und Gestaltungsansätze zum Lernfeldkonzept, Markt Schwaben: Eusl 2000, pp. 155-164
2. Wibke Derhoven, Gabriele Winkler, „Tausend Formeln und dahinter keine Welt“. Eine geschlechtersensitive Studie zum Studienabbruch in Ingenieurswissenschaften in Beiträge zur Hochschulforschung, 32. Jahrgang 1/2010
3. http://timssandpirls.bc.edu/timss2015/international-results/timss-2015/science/student-achievement/distribution-of-science-achievement/ from the 23.3.2019
4. Norbert Kockmann, Chem. Ing. Tech. 2018,90, No.00,1-8