CACHE DESIGN TASK FORCE UPDATE

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Background

The idea of teaching process and/or product design is often a daunting prospect for faculty members, particularly those outside of the PSE community. While many excellent resources exist for lower level chemical engineering classes, the available material for teaching process/product design is less well-packaged. CACHE maintains a living document entitled *CACHE Guide for Teaching Design using Internet Links*, which provides an overview of various topics. While quite comprehensive in scope, the document does not provide stand-alone modules that a prospective instructor can directly use or adapt. Similarly, a small number of well-developed process design case studies are available, but very little has been added for several years.

During last summer's joint ESCAPE-25 and PSE-2015 conference, we began some initial discussions of potentially starting a new CACHE task force focusing on teaching materials for design. A meeting of a small number of current and future design instructors was organized at the AIChE Annual Meeting in Salt Lake City last November to discuss what resources are available/needed. Below is the list of attendees:

- Thomas Adams II, McMaster University
- Michael Baldea, University of Texas at Austin
- Selen Cremaschi, Auburn University
- Mario Eden, Auburn University
- Scott Guelcher, Vanderbilt University
- Robert Hesketh, Rowan University
- Carl Laird, Purdue University
- Fernando Lima, West Virginia University
- Christos Maravelias, University of Wisconsin
- Ka M. Ng, Hong Kong University of Science and Technology
- Luis Ricardez-Sandoval, University of Waterloo
- Joseph Scott, Clemson University
- Jeffrey Seay, University of Kentucky
- Warren Seider, University of Pennsylvania
- Jeffrey Siirola, Carnegie Mellon University/Purdue University
- Fengqi You, Northwestern University

The CACHE Executive Committee was represented by President Marianthi Ierapetritou (Rutgers University) and Executive Director Tom Edgar (University of Texas at Austin). In addition, a number of people had indicated their interest in participating, but were unable to attend the meeting: Miguel Bagajewicz (University of Oklahoma), Lisa Bullard (North Carolina State University), Russell Dunn (Vanderbilt University), and Troy Vogel (University of Illinois).

Warren Seider opened the meeting with a brief overview of the history of CACHE and its prior activities in developing teaching materials for design. This was followed by a very engaged discussion of not only the apparent gaps in available materials, but more importantly the materials that the attendees have developed/are using when teaching process/product design. It quickly became apparent that this group should focus on 5 initial topics:

1. Materials for teaching Aspen Plus within the context of the senior design sequence
2. Materials for introducing Aspen Plus earlier in the chemical engineering curriculum
3. Updating/restructuring the CACHE Guide for Teaching Design with Internet Links
4. Case studies for product design
5. Strategies and materials for flipping the design course

Materials for Teaching Aspen Plus

There is a lot of material available on this topic, but it is disjointed and needs to be organized to be useful in a teaching environment. For example, the teaching modules developed by AspenTech are helpful for learning about specific models, but in their current form do not provide undergraduate students an easy/structured path to learning the software. The multimedia materials created by the University of Pennsylvania and Technion team are very good for teaching, but the Aspen Plus interface has changed since it was originally developed thus making it much more difficult/cumbersome to use. Updating these materials to incorporate the new user interface is a significant undertaking as it involves recreating several hundred animated screenshots. A quick search on YouTube indicates that there is an abundance of material that other researchers/teachers/students have created to illustrate how to setup and solve a variety of simulation problems in Aspen Plus, however it is a massive undertaking to go through them and assess/verify the quality. Similarly, a number of the attendees at the SLC meeting indicated that they have developed teaching materials for various topics related to design (e.g. process synthesis, solvent selection, heat integration among others). So, material is available, but it needs to be organized into a coherent package/structure that other instructors can use. Thomas Adams shared that he has developed a course package that incorporates many of the above materials. He gave a brief overview of the structure during the SLC meeting and has shared it with the group for feedback. He is revising the structure of the materials during the Spring 2016 semester and CACHE has agreed to support the hiring of an undergraduate researcher to update the screenshots and web links over the coming summer. This should result in a comprehensive package with a clear structure that gives other instructors a strong starting point for teaching this material. The links to e.g. YouTube videos can be substituted at the instructors' discretion of course, but having a formal structure of topics to be covered makes it a lot easier to search for specific materials/tutorials.

A common issue that is often raised is the desire for introducing Aspen Plus earlier in the curriculum to make the students familiar with the software and thereby free up time in the design courses to focus on developing more advanced simulation capabilities. Naturally, it is not possible to teach the students all aspects of the software prior to having had the corresponding traditional courses in separations, reaction engineering, etc. However, the introduction of small simulation modules could be very valuable to instructors teaching mass and energy balances, fluids, thermodynamics, separations, and reaction engineering. Such modules would allow the students to get a better feel for the impact of changing conditions/specifications, e.g. for pumps, compressors, heat exchangers, distillation columns, reactors, etc. The challenge is that in many cases the instructors of these earlier foundational courses are not familiar with Aspen Plus and therefore often resist introducing such software in their courses. Simple, well-developed modules with accompanying instructions would alleviate these concerns to a large extent. Robert Hesketh has experience in developing such modules for incorporating sustainability into lower level courses and will perform the initial survey of what materials are available.

CACHE Guide for Teaching Design with Internet Links

The task force plans to review/revise the links in this living document to include the latest materials available. The purpose of this effort is not to create new materials but to provide links to new materials that would be useful for design instructors. Once completed, this effort could lead to a significant restructuring of the document to possibly include a website for hosting the links. There are tools available that can dynamically keep track of changes to linked pages, which would make it easier to maintain.

Case Studies for Product Design

Many programs have begun including product design into their curricula, and while a few textbooks are currently available, there is a pressing need for case studies to illustrate the material in the classroom. Ka Ng is currently developing a total of 15 product design case studies which aim to let students experience the process of designing a variety of products. The first case studies are planned for completion in early 2016 and will be shared with the task force for review/comments. Also, Luis Ricardez-Sandoval is developing a case study illustrating the use of computational fluid mechanics (e.g., COMSOL) to model drug release kinetics in cancer therapy. His materials (which include an instructional video) provide a tutorial on the use of COMSOL in product design. The materials are currently being reviewed for potential usage as a CACHE product design case study.

Strategies and Materials for Flipping the Design Course

Current tenets in engineering pedagogy include the concepts of active learning and flipping the classroom as means to increase student engagement. The design course often incorporates components of these concepts (depending on how it is taught), through regular team meetings with the instructor to discuss the project etc. There are opportunities for enhancing such activities as certain topics are traditionally only covered in the design course. Danny Lewin at the Technion in Israel teaches a flipped design course and has developed a number of short video lectures that cover a number of the traditional design topics (e.g. heat integration). He has also developed a 14 minute video describing the advantages of a flipped design course and the steps involved in setting it up. Additional videos will become available soon.

Summary

The CACHE design task force is off to a good start. Our initial activities involve identifying the available materials as well as the gaps and attempt to collate them in a cohesive manner. Developing structured course materials for teaching AspenPlus using existing resources will be a valuable tool for current/future design instructors. Providing good systematic case studies for product design will enable more programs to incorporate this topic into their courses/curricula. Strategies and materials for flipping the design course will also be of interest to the community.

WANT TO GET INVOLVED?

Have you developed materials that could be useful for any of the topics discussed above or are you interested in getting involved with the development of teaching modules, please contact us to begin discussions!

If you have materials for us to share with this task force, please send them to both of us.

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