Addressing module challenges with online resources

Faculty of Engineering | Department of Process Engineering

Modules: Chemical Engineering 344
Lecturers: Dr TM Louw tmlouw@sun.ac.za & Dr Lidia Auret lauret@sun.ac.za
Blended Learning Coordinator: Dr Moira Bladergroen mbladergroen@sun.ac.za

Learning activity:
Online learning opportunities

Learning technology:
Videos & quizzes

Context

Background

The third-year module of Chemical Engineering 344 has always been presented in a traditional lecture and tutorial environment. The class size for Chemical Engineering 344 was 61 students in 2015.

Subject area

Chemical Engineering 344 focuses on the derivation and application of mathematical models from process information provided and process knowledge from previous undergraduate modules. The application of mathematical models includes the use of specialised software.

Intended learning outcomes

After completion of the module, students are expected to:

- master the modelling and simulation of integrated process units through steady and unsteady state mass and energy balances;
- master process integration methodologies for optimal heat recovery; and
- master the development and solution of numerical optimisation problems in a chemical engineering context.

Established practice

Before the blended learning intervention, the module consisted of three traditional lectures (in the form of chalk-and-talk with PowerPoint slides) per week and one tutorial session per week. The tutorial session focused on a specific paper tutorial handed out beforehand. The lecturers and student assistants were present during the tutorial session to assist the students. Afterwards, the student assistants marked the tutorials but, because of the large student numbers, the students received minimal feedback (in the form of only a mark). This limited feedback was usually available a few weeks after the completion of the tutorial session.

The challenge

Three main challenges were experienced in the module that motivated the lecturers to adapt their existing teaching practices.

The first challenge was the gap that existed between the actual complexity of the topic material and the perceived complexity (by the students) of the topic material. Typically, the students became aware of the gap offline (i.e. not during the lectures or tutorials) and then required assistance to bridge the gap. To address this gap, the students needed to engage in active learning (i.e. they needed to attempt the problems actively instead of just following the monologues by the lecturers).

The second challenge was that formative and summative assessments needed to be feasible in terms of the resources required for setting and marking the assessments. The then current model of hardcopy tutorial setting, hardcopy tutorial submission and offline (manual) marking was consuming resources that could have been spent elsewhere. Addressing this problem would allow the module to scale with (potential) increasing class sizes.

The third challenge was the fact that teaching the use of software tools was not optimal combined with traditional teaching methods, i.e. the lecturers talked and demonstrated and the students listened. The students easily became lost and could not explore the software interface. Another approach was the lecturers and students engaging in the software at the same time, the lecturers guiding the entire class step by step. This approach was time consuming and inefficient, since different students have different learning rates.

Advantages associated with the integration of technology

Technology was integrated into the module to address the specific challenges (complex concepts, assessment and software demonstration). With regard to the complex concepts, videos of theory application examples were made containing question and answer stops. Having the videos available ensured that the students could access the explanations and the built-in knowledge test any time that they needed to. The lecturers saved time by not presenting such theory application examples during traditional lecture times and by reusing the same videos every year.

With regard to the assessments, the use of automated assessments saved time and energy. Tutorials were created online with a question bank allowing for a large number of questions with easy extension of questions

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through changing numerical parameters in each. The online tutorials provided immediate feedback for the formative assessments and allowed for the automatic marking of the summative assessments.

With regard to the software demonstrations, videos were made that the students could access any time that they needed to and pause and proceed as they required while mastering the software themselves. The lecturers saved time by not presenting the software usage during the traditional lectures and by reusing the videos.

Student overview
A total of 61 third-year Chemical Engineering students was enrolled in the module. The students had limited competence in the specialised software required and had access to the software only in the computer user areas on campus.

Other relevant role-players
The student assistants still played a role after the integration of the technology. They were available to answer student questions during tutorial times and to assist with the marking of tutorials and tutorial tests when needed.

Learning and assessment activities

Educational approach
The blended learning strategy was evaluated in the light of two theoretical frameworks: the transactional distance theory (Moore, 1993) and the four approaches to learning in the engineering context (Case & Marshall, 2007). The transactional distance theory was used to analyse the students' engagement with the online resources and to identify opportunities and threats to learning, which could include mobility, structure and dialogue. The potential for online resources to shift student learning, as defined by Case and Marshall (2007), was also investigated.

Learning and assessment activities
The students were provided with two sets of instructional videos. The first set contained videos with worked-out examples and question stops. The second set contained videos with software demonstrations. Online quizzes provided the students with hints and immediate feedback. Four of these online tutorials were available to the students on SUNLearn.

Feedback practice
During the online tutorials, the students were provided with multiple hints per question. They received immediate feedback on whether their answers were correct or not. The feedback also contained an explanation of how the final answer could be determined. Immediately after an entire tutorial was completed, the students received feedback on their marks and a second opportunity to take the quiz.

Student self-regulation
During the online tutorials, the students had the opportunity to respond to the feedback received by retrying questions or the entire quiz.

Examples

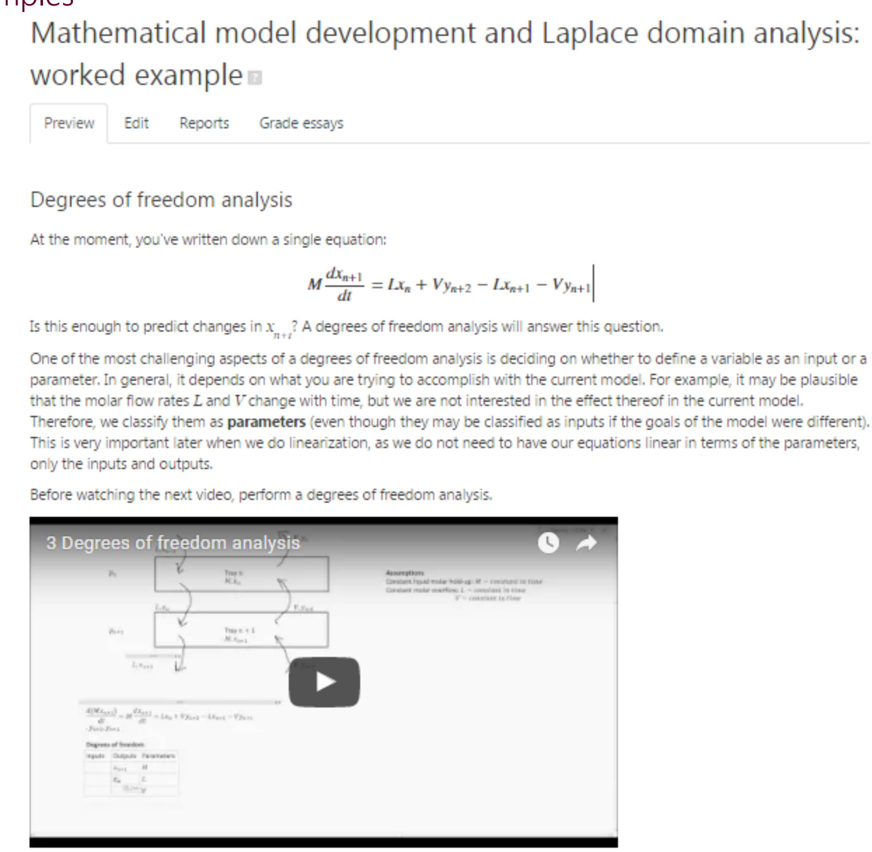

Figure 1: A worked-out example from instructional video set 1

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Simulink for dynamic modelling: Demonstrations

Preview | Edit | Reports | Grade essays

Demo 5: Multiple ODEs

This demonstration considers a more complex dynamic model, with two ODEs.

Simulink aspects covered in this demonstration include:

- Product
- Math function
- MATLAB function

The system under consideration is a CSTR with an inhibitor; read more about the system at the following link:

CSTR with inhibitor

The ODEs for this system are given by:

$$\frac{dC_I}{dt} = \frac{1}{V}(FC_{I0} - FC_I)$$

$$\frac{dC_A}{dt} = \frac{1}{V}\left(FC_{A0} - FC_A - \frac{VkC_A}{1 + k_I C_I^2}\right)$$

The parameters and input conditions can be found in the link above.

Video 1:

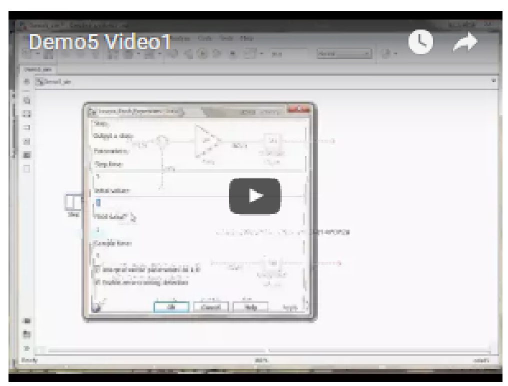


Figure 2: A software demonstration from instructional video set 2

To validate the accuracy of the discrete-time model, you need to create a validation model. In a new Simulink file, create a new Simulink model which contains the $c_{A,in}$ generator and the non-linear model, but with an end time of 300 time units. Using the regression coefficients calculated in part d), determine the predicted $c_{B,m}$. Compare the predicted $c_{B,m}$ with the actual $c_{B,m}$ by calculating the sum of squared errors between predicted and actual $c_{B,m}$. Now determine the optimal coefficients and optimal delay D by repeating the above steps for a range of delays between 0 and 20. You can do this by hand, or create a for-loop in MATLAB. Remember that the regression coefficients need to be re-estimated every time you change the delay!

Answer:

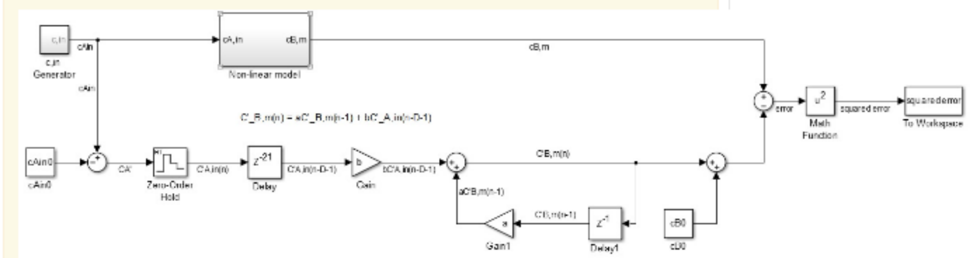
Check

To validate the accuracy of the discrete-time model, you need to create a validation model. In a new Simulink file, create a new Simulink model which contains the $c_{A,in}$ generator and the non-linear model, but with an end time of 300 time units. Using the regression coefficients calculated in part d), determine the predicted $c_{B,m}$. Compare the predicted $c_{B,m}$ with the actual $c_{B,m}$ by calculating the sum of squared errors between predicted and actual $c_{B,m}$. Now determine the optimal coefficients and optimal delay D by repeating the above steps for a range of delays between 0 and 20. You can do this by hand, or create a for-loop in MATLAB. Remember that the regression coefficients need to be re-estimated every time you change the delay!

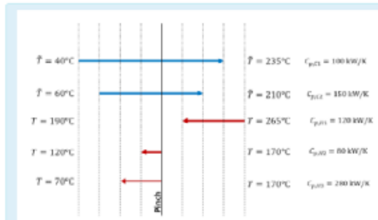
Answer: 5

Check

See below for an example of how a discrete-time dynamic model can be constructed in Simulink. This will be required as part of validating the model.



Try again



Consider the region above the pinch. Which cold streams (and in what order as you move away from the pinch) should stream H1 preferably be matched with?

Select one:
- a. H1-C1 only
- b. H1-C2 only
- c. H1-C1, followed by H1-C2
- d. H1-C2, followed by H1-C1 ✓
- e. H1 shouldn't be matched with any of the cold streams.

Check

Your answer is correct.

Above the pinch, and close to the pinch-point temperature, streams should be matched such that the total heat capacity of the hot stream is smaller than the total heat capacity of the cold stream:

$$C_{p,H} < C_{p,C}$$

Thus, H1 (C_p = 120 kW/K) should first be matched with C2 (C_p = 150 kW/K).

This restriction can be relaxed further away from the pinch, when a larger temperature difference exists between the hot and cold streams. Away from the pinch, it is safe to match H1 with C1 (C_p = 100 kW/K), as long as the temperature of H1 stays greater than the temperature of C1.

The correct answer is: H1-C2, followed by H1-C1

Figure 3: An online tutorial question, a hint and feedback

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LEARNING ENVIRONMENT

Learning setting

Learning took place during traditional lectures, traditional tutorials and online tutorials.

Collaborative setting

No collaborative activities were explicitly designed for this learning activity but the students spontaneously formed groups and tended to work together during tutorials and assignments.

Technology resources

SUNLearn was used as the platform for the online quizzes, videos and all other module content. The videos were recorded with CamStudio and then loaded onto YouTube. The students could view the YouTube videos free of charge when using the campus internet.

The videos were integrated as part of the lesson structures in SUNLearn. This allowed the creation of a step-by-step (page-by-page) presentation of the videos. Each page contained some introductory text along with the video and links to the previous page, the next page and the overall lesson outline.

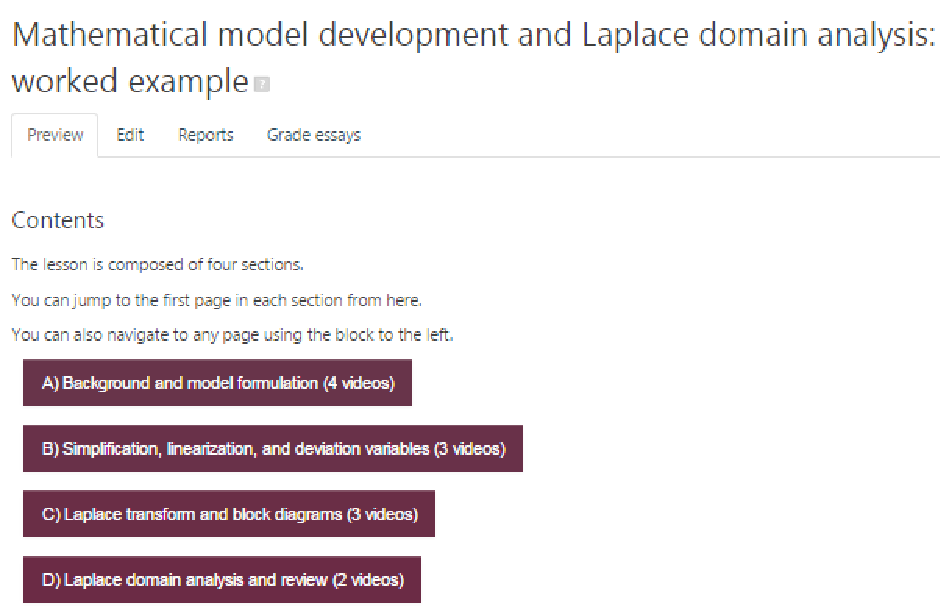

Figure 4: A lesson outline

Support challenges

The specialised software (MATLAB and Simulink) required for this module was available only in the computer user areas. This seriously impeded learning from home.

One challenge experienced with the SUNLearn platform was the inability to create look-up table type numeric quiz questions. The idea behind such a question type is the following: A question is created with one or more variable parameters, e.g. a and b. The parameters can take a range of values, e.g. a in the range of 1 to 5 and b in the range of 3 to 7. When a specific student accesses this question, random values for a and b are presented as part of the question. The student then calculates the answer to the question using her or his unique a and b values and the answer is entered in the quiz. Based on pre-calculated answers, the answer (e.g. a value for y) can then be verified as correct or incorrect. This functionality is available in SUNLearn only if the answer can be written as an explicit formula of a and b, e.g. $y = 4*a + \sin(b)$. However, for more complex problems (as is typical in Chemical Engineering 344), no explicit formula exists. For the ranges of a and b, all y values can be generated. The requirement to present such a question in an online quiz is then some form of look-up table: given the specific a and b, look up the pre-calculated correct answer for y.

The SUNLearn technical team was contacted on numerous occasions and the problem was explained numerous times but no solution was found.

Student experience

Student feedback on the learning experience

The students completed online surveys and engaged in a focus group discussion, during which they were asked for feedback on the theoretical concepts identified by Moore (1993) and Case and Marshall (2007). When asked about the transactional distance of the learning experience, the students stated that engaging online did not create a barrier between them and the lecturers or the content; the videos did, in fact, create a sense of interaction with the lecturers, possibly because the lecturers' voices could be heard and their facial expressions could be seen. The students highlighted the fact that personal interaction remained important. They also felt that the online resources enabled them to equip themselves to solve problems on their own before going to the lecturers to ask for help.

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They were then able to ask fewer but more important questions, therefore actually increasing their level of interaction with the lecturers and student assistants.

When asked about the four approaches, the students felt that the online tutorials assisted them in understanding concepts and procedures. One student stated the following:

"*It did not necessarily increase the amount I learned, but the quality of that learning . . .*"

The students felt that the online tutorials enabled them to identify problem areas quickly when learning new concepts before engaging in the procedures. The videos and online tutorials were generally very well received by the students.

General

Opportunities

The online tutorials optimised student-to-student and student-to-lecturer interaction. After engaging in the online tutorials, the students asked the right questions, which were often those not covered by the hint system built into the online tutorial quizzes. The immediate feedback saved time and built the students' confidence. The videos and quizzes (with the hint system) exemplified a thought system that helped to build conceptual and procedural understanding.

Challenges

Although the integration of online tutorials significantly decreased time spent marking and loading marks onto the system, the lecturers did experience an increase in preparation time. Creating the videos and online tutorials took a lot of time but there was the opportunity to reuse the material on a year-on-year basis or, at least, simply to update the material.

Advice

Effective use should be made of the assistants' time. The lecturers could easily prepare offline document tutorials (or have them already available), which the assistants could then translate to online tutorials. Online tutorials are an effective summative assessment tool that saves a lot of time on marking. Demi hours could be leveraged in terms of the online tutorials.

Reference list

Case, J. & Marshall, D. 2007. Between deep and surface: Procedural approaches to learning in engineering education contexts. *Studies in Higher Education*, 29(5):605–615.

Moore, M.G. 1993. Theory of transactional distance, in Keegan D. (ed.). *Theoretical principles of distance education*. New York: Routledge.