Experiences of using a Web-based Virtual Shell and Tube Heat Exchanger Experiment by Adult Continuing Learners

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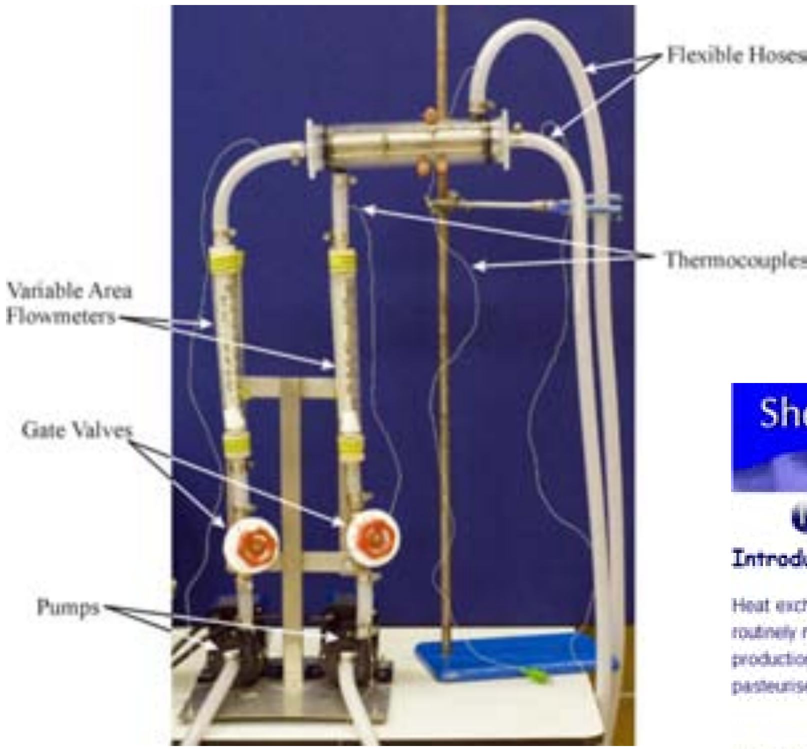
Predates computers…

Edwin Link's 'link trainer' flight simulator from 1928 with pneumatic and electrical instrumentation

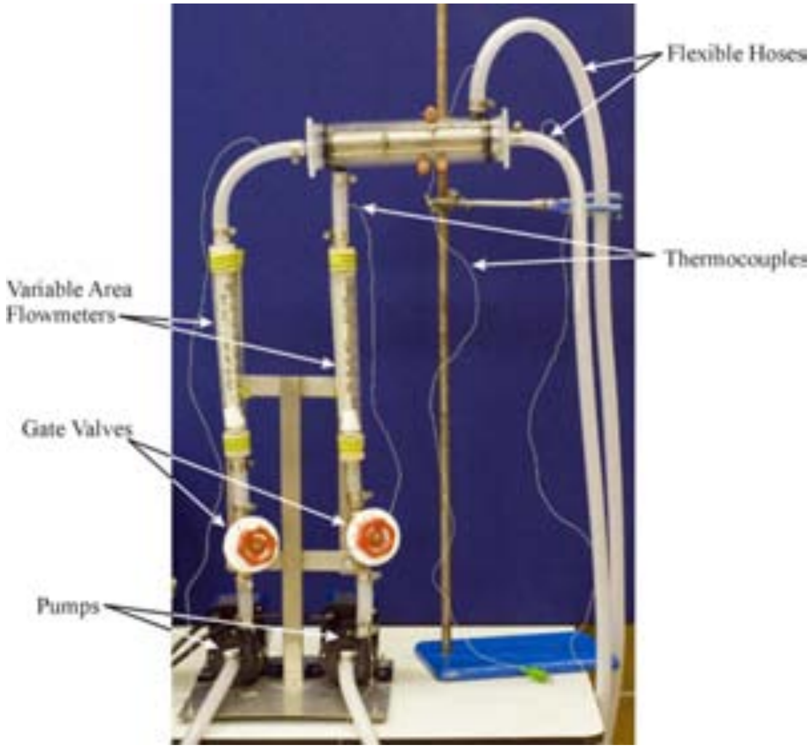
Two stage design of the virtual lab experiment



1. The design, construction, operation (data collection) and modelling of a lab scale model Shell & Tube Heat Exchanger (STHE) (Jiříček)

2. The development of an online virtual laboratory software interface (Barrett)

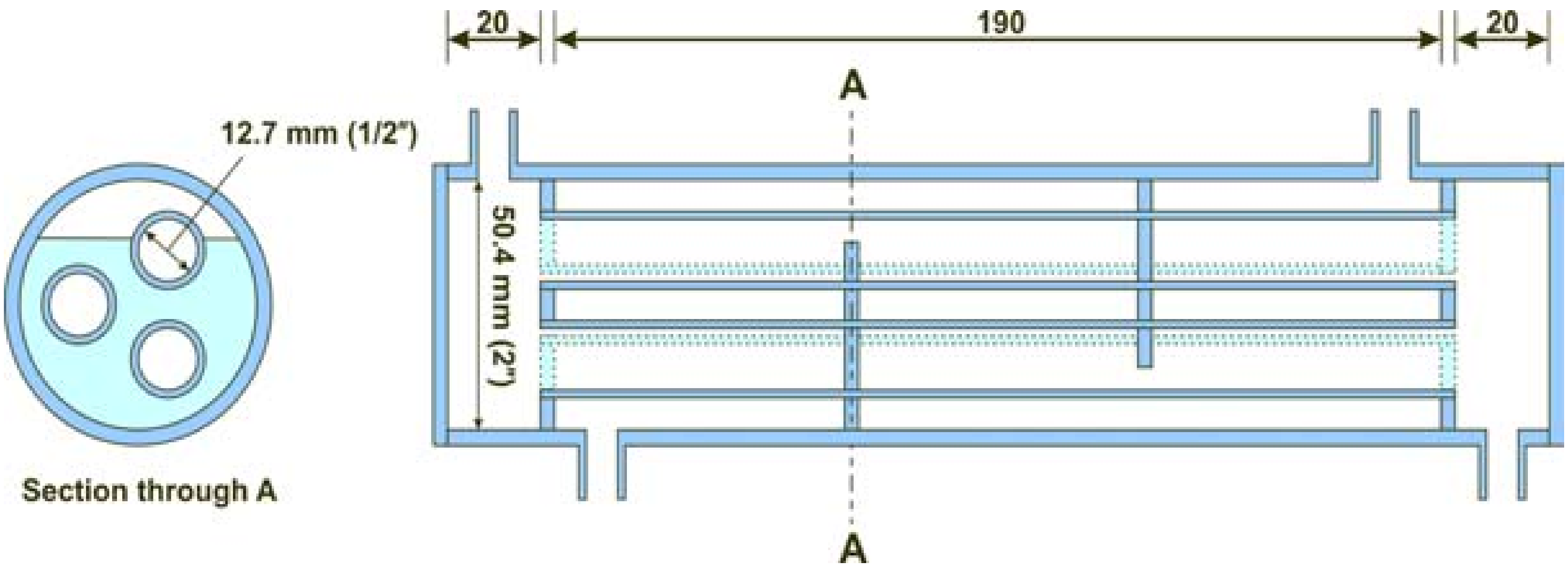
Two stage design of the virtual lab experiment



1. The design, construction, operation (data collection) and modelling of a lab scale model Shell & Tube Heat Exchanger (STHE) (Jiříček)

Polycarbonate replica model built to produce a 360º rotatable website image

Shell and tube heat exchanger design

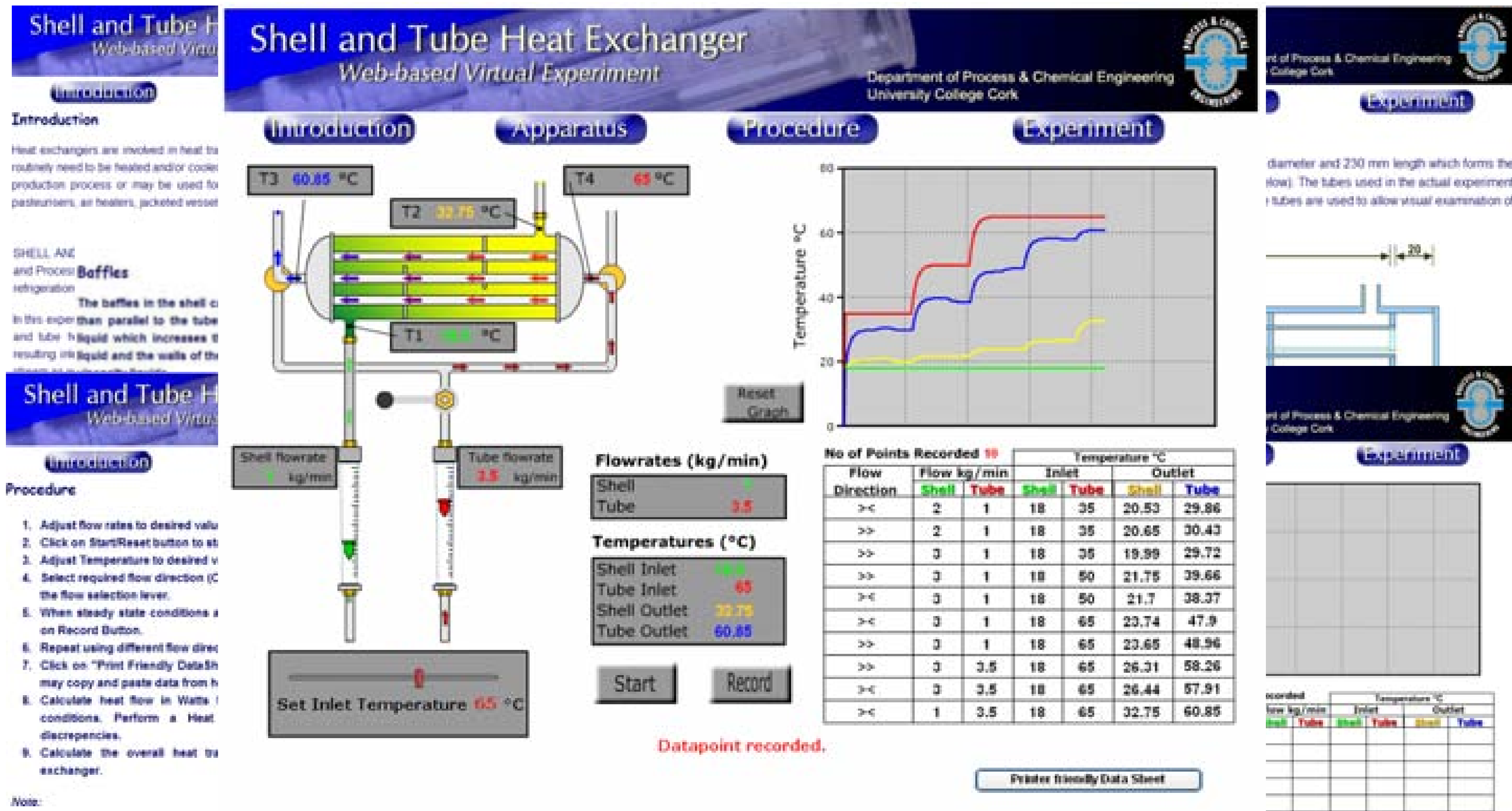


Shell side: transparent polycarbonate
Tubes: stainless steel with helical static mixer elements

Experimental data collection

- Hot (tube side) inlet from heating bath: @ 35°C, 50°C, 65°C, 80°C
- Cold (shell side): mains water @ 18°C
- Flowrates: 1 kg/min - 5 kg/min
- Co-current and counter current configurations
- Data was collected from 360 successful experiments

Online software development



No of Points Recorded 10

Flow Direction	Flow kg/min		Temperature °C Inlet		Temperature °C Outlet	
	Shell	Tube	Shell	Tube	Shell	Tube
>-<	2	1	18	35	20.53	29.86
>>	2	1	18	35	20.65	30.43
>>	3	1	18	35	19.99	29.72
>>	3	1	18	50	21.75	39.66
>-<	3	1	18	50	21.7	38.37
>-<	3	1	18	65	23.74	47.9
>>	3	1	18	65	23.65	48.96
>>	3	3.5	18	65	26.31	58.26
>-<	3	3.5	18	65	26.44	57.91
>-<	1	3.5	18	65	32.75	60.85

Application of online virtual laboratory

- Two year part-time evening **Diploma in Process and Chemical Engineering** @ University College Cork

- Heat Transfer and Applied Thermodynamics Module

- Laboratory complemented students' exposure to STHE design in module
- Virtual and online nature of the laboratory particularly suitable for part-time learners;
  - easily used during night classes (and by a high number of users simultaneously) when real labs and support off limits
  - remote access available online outside of class time
- Students gathered experimental data in class (as with actual experiment), and began to construct speadsheets from which relevant performance plots could be constructed and conclusions/reflections drawn
- Write up completed by the students remotely out of class as part of their continuous assessment *(experimental procedure: see paper)*

Inquiry

Questions on Virtual Laboratory

1. Did participants find the virtual laboratory user-friendly?
2. How did it aid understanding of the principles of heat exchanger design and operation relative to the lectures?
3. How did it aid understanding of the principles of heat exchanger design and operation compared with a real laboratory experiment?
4. Would learners actually prefer the virtual laboratory to a real lab experiment?

- A survey was developed and feedback obtained longitudinally among learners from 2009 to 2012
- Students also invited to provide qualitative feedback

Survey Results

On a scale of 1 to 5 (where **5 is maximum**), please indicate the rating you would propose for each of the following.

With respect to the Heat Exchanger Virtual Lab Experiment, how did you consider the following:	**1**	**2**	**3**	**4**	**5**
User friendliness	-	-	-	17	21
Usefulness in gaining a better understanding of heat exchanger design and operation *compared with lectures alone*	-	-	1	17	20
Usefulness in gaining a better understanding of heat exchanger design and operation *compared with a real laboratory experiment*	-	1	10	19	8
In this module, to what degree would you prefer the HE VLE to a real lab experiment? (3 equals no preference)	-	5	11	13	9

83% response rate (38/46)

Qualitative Feedback

Qualitative feedback very supportive of the vitual lab experience:

- *‘Excellent tool. Gives better understanding of heat exchange.’*
- *‘Very good that the program is online and I was able to finish the assignment at home.’*
- *‘Extremely useful in demonstrating the principles of heat exchangers’*
- *‘Being able to complete the experiment online means you can work on it at your own pace and you have access to it when it suits you. A real experiment may also be of benefit but I would choose the online version if I had to choose.’*

Reflections

While showing impressive support for the online lab, the context (i.e. evening part-time students and associated constraints) should be noted.

The results also appear to reveal a degree of comfort among contemporary (adult) learners with using computers as simulators.

In Conclusion

This project has demonstrated that a well designed virtual laboratory experiment, when used in the right context, can offer significant benefits as a learning tool, even compared with real experiments.

ComLab

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