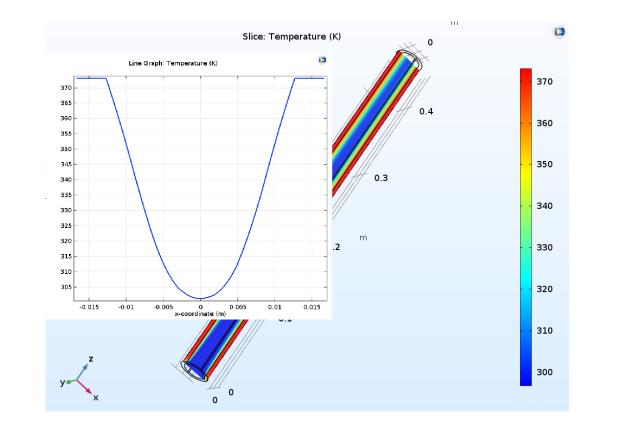
# Simulation Apps for Teaching Engineering Delivered via COMSOL Server<sup>TM</sup>

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**INTRODUCTION**: Apps were developed and delivered via COMSOL Server<sup>TM</sup> for use in an undergraduate chemical engineering laboratory class. Before experimental runs, 66 students used the apps to review heat transfer fundamentals and used pre-built COMSOL<sup>®</sup> models and detailed tutorials to review fluid flow fundamentals.



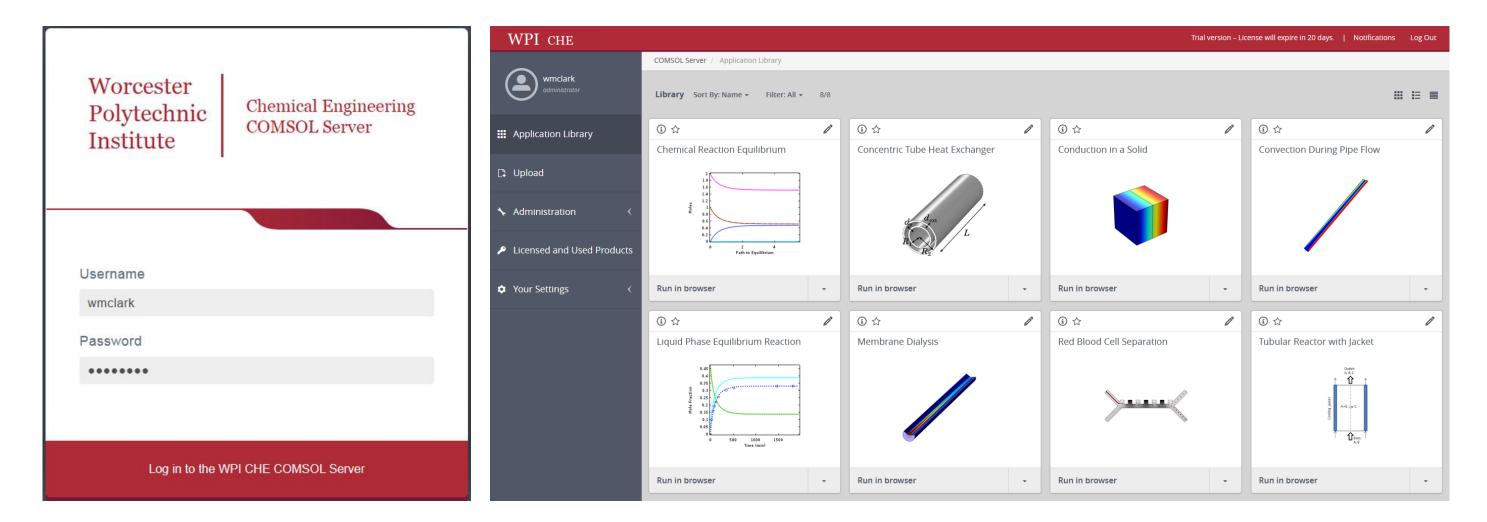


**ASSESSMENT**: Students completed:

- pre and post diagnostic tests on knowledge of fluid flow and heat transfer
- survey on satisfaction with using COMSOL<sup>®</sup> for reviewing fundamentals
- survey on preference for using apps compared with manipulating .mph files following tutorials

(b) (a) **Figure 1**. Heat exchanger: (a) experiment, (b) simulation.

**COMSOL SERVER<sup>TM</sup> AND APPS**: Screenshots below show some of the features of our app implementation.



## **RESULTS**: Instructor observations:

- apps took slightly longer to produce than the original models with associated detailed tutorials
- apps with built-in quizzes were convenient selfcontained learning modules deliverable to any browser

Student learning:

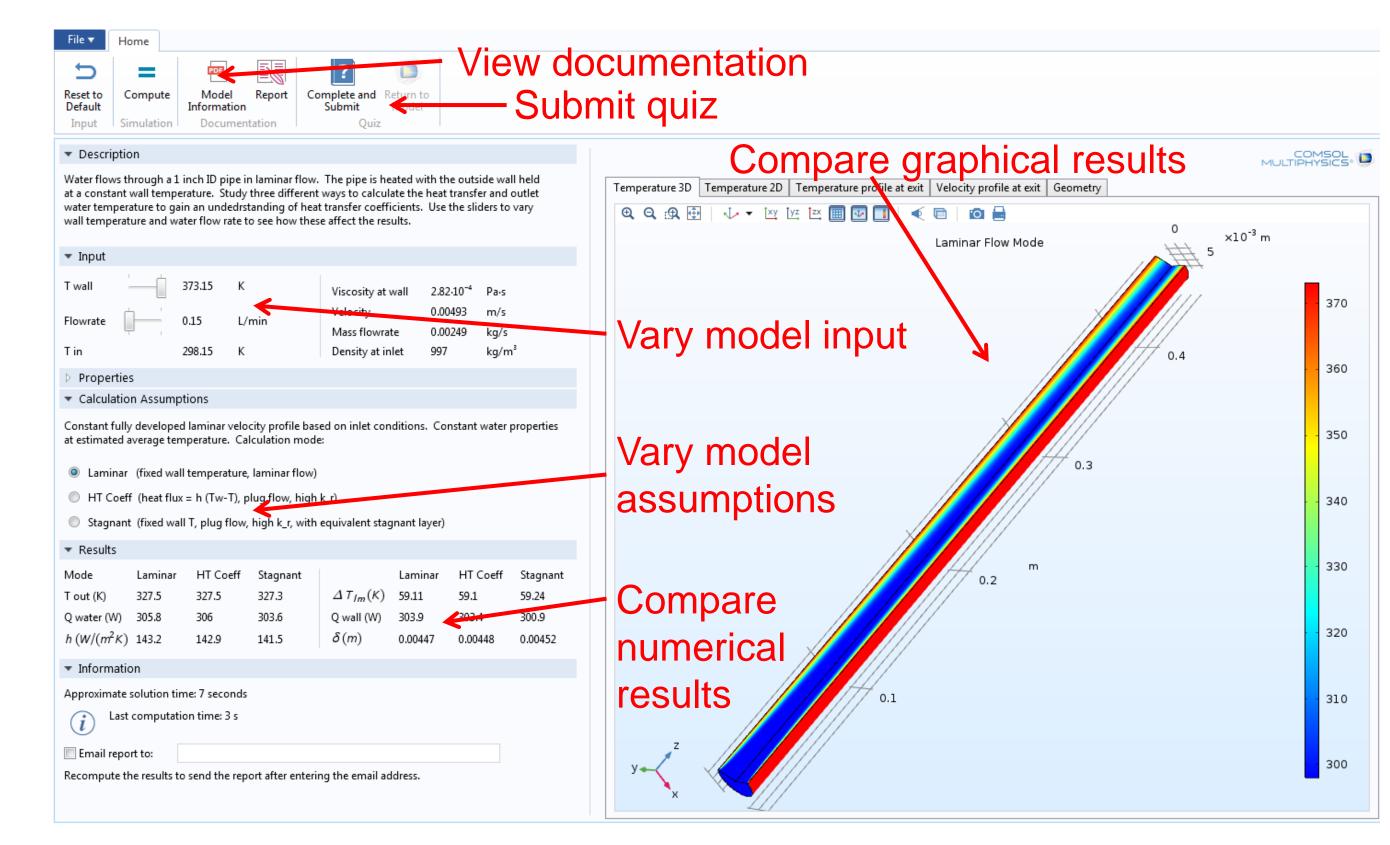
**Table 1**. Class average on diagnostic tests.

Test	Pre	Post
Fluids (tutorials)	74	100
Heatx (apps)	66	98

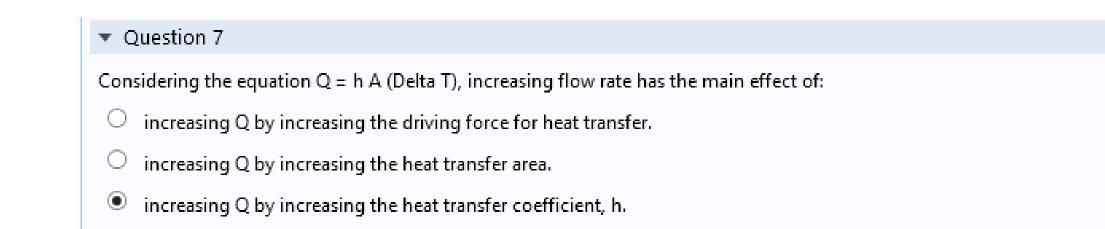
### Student satisfaction:

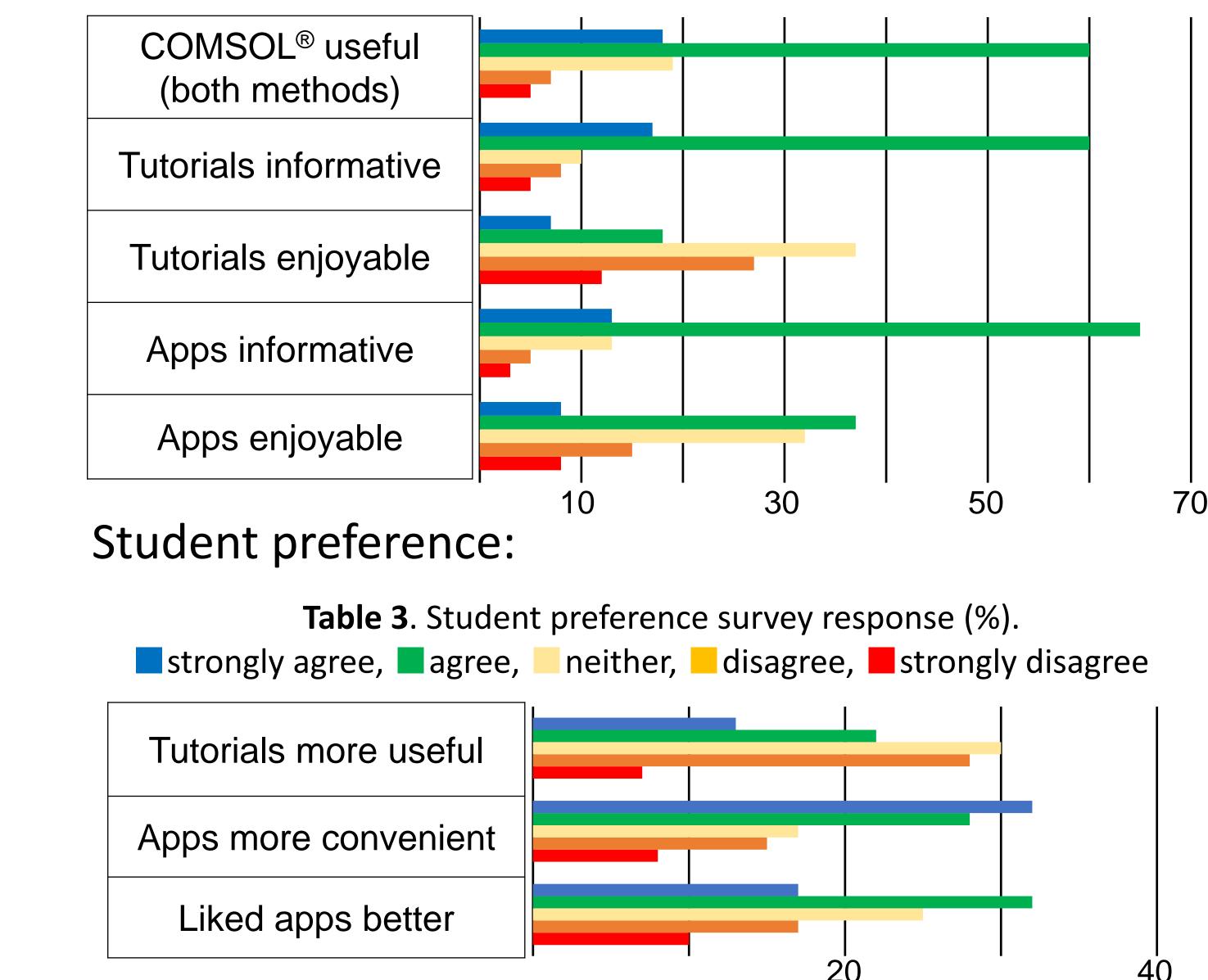
**Table 2**. Student satisfaction survey response (%). strongly agree, agree, neither, disagree, strongly disagree

Figure 2. Customized login page and application library.



### **Figure 3**. Convection during pipe flow application.





#### O no significant effect.

#### Ouestion 8

<ul> <li>Question 8</li> </ul>			
Considering the equation Q=mCp(Tout -Tin), what happens to Tout if m doubles while Q increases less than twofold?			
<ul> <li>the senario described is not possible.</li> </ul>			
<ul> <li>Tout will increase, because the velocity increases.</li> </ul>			
Tout will decrease, because there is more material to heat.			
$\bigcirc$ Tout will remain unchanged because it does not depend on the mass flow rate.			
<ul> <li>Grade and Submit</li> </ul>	Quiz		
Enter your name:	Sally Student		
When you click the Submit Quiz button your grade and the correct answers will be shown below and sent to the grader.			
Email of grader:	wmclark@wpi.edu	Submit Quiz	
Maximum Points	8	Correct Answer Sequence 2_3_3_4_2_1_3_3	
Your Points	7		

**Figure 4**. Students see their grade and the correct answers after they submit the quiz via email directly from the app.

**CONCLUSIONS**: COMSOL Server<sup>TM</sup> is a convenient way to deliver interactive online learning materials. Apps are time consuming to build, but only slightly more so than models plus detailed tutorials. Both the tutorial and app delivery methods were very effective with regard to student learning. Student satisfaction and preferences varied. Most students believed that both learning methods were useful. Most students preferred apps, but others preferred working directly with .mph files while following tutorials. Very few students preferred neither.

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