Weblab in Chemical Engineering as a Tool for Cooperative Learning within a Global Environment: a report of experiments among Brazilian Universities connected through KyaTera

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1. The KyaTera Project

KyaTera is a project financed by FAPESP (São Paulo State´s Agency for Research Development) that aims to develop high speed internet applications for research and educational purposes. It is based on an optical high speed packet network interconnecting a number of laboratories, research institutes and universities in São Paulo state focusing on the study, development and usage of technology and applications in advanced Internet.

Figure 1. Optical network connecting research laboratories in the state of São Paulo, Brazil.

2. Cooperative Weblabs in Chemical and Biochemical Process Engineering

The term Weblab was employed to name real - not virtual - experiments remotely operated via Internet. This kind of experiments has been proposed and implemented worldwide by some major universities. In this article we present a unique approach for Weblabs: to offer intercultural experiences to students, while enhancing their communication skills.

Cooperative Weblab experiments must be performed by two groups of undergraduate students, in two different locations and aims to partially fulfill the lack of interaction among students in this level of engineering education. The Cooperative Weblab cluster intends to develop a set of experiments for undergraduate students that should be performed by “mixed teams”. The experimental setups are physically placed in laboratories in São Paulo, São Carlos, Ribeirão Preto and Campinas, four cities in São Paulo state, Brazil.

The Laboratory of Development and Automation of Biochemical Process (LaDABio) of the Chemical Engineering Department of the Federal University of São Carlos (DEQ/UFSCar) and the Center for Chemical Systems Engineering (CESQ) of the Chemical Engineering Department of the Polytechnic School of the University of São Paulo (DEQ/EPUSP) are involved in this project. These groups are 255 km distant and they are among the best chemical engineering courses in Brazil.

Collaboration is achieved by gathering participants of the different institutions into working groups that are asked to simultaneously solve a technical problem, for which an experiment is available. This procedure emulates challenges that will frequently take place in their future professional lives. The Weblab also fosters the learning of Chemical Engineering instrumental concepts. To achieve these goals, students of different departments are required to work cooperatively.

3. Cooperative Weblabs

In this work two Cooperative Weblabs, one in São Carlos and the other one in São Paulo, were employed.

3.1 WebLab for Mass Transfer Experiments at Federal University of São Carlos

During the aerobic cultivation of microorganisms or cells in tank bioreactors, the level of dissolved oxygen must be kept high enough for the organisms to thrive. Thus, it is important for the education of chemical engineers to handle the fundamentals of mass transfer herein involved, and to get familiar with techniques that assess rates of oxygen transfer from the gas phase into the liquid culture medium as well. A scheme of the WebLab for mass transfer experiments is presented in Figure 2.

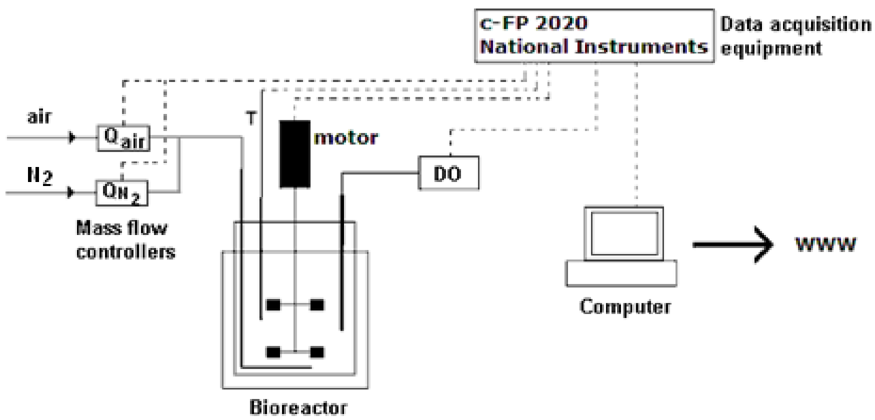

Figure 2. Experimental setup used for mass transfer experiments.

The dissolved oxygen is removed from the liquid phase by bubbling nitrogen into the medium. After reaching a zero oxygen concentration, the nitrogen flow is stopped and air flow is started. The dissolved oxygen (DO) in the liquid phase is measured by an electrode probe. The mass transfer coefficient is represented by the parameter k_La that is estimated by fitting a model for the change of the DO to the experimental data. The experiment intends to calculate k_La values at different operating conditions of air flow rate and stirrer speed employing the gassing-out method (SHULER and KARGI, 2002; BLANCH and CLARK, 1997).

The bioreactor is an aerated and agitated tank reactor. Gas (air and nitrogen) under pressure is supplied to the sparger (a ring with holes) located inside the reactor and above of the impeller. The system is constituted by a stirrer with two Rushton impellers. This impeller is typically a disc with 6 to 8 blades designed to pump fluid into radial direction. The WebLab was build employing National Instruments hardware for data acquisition and LabVIEW software as the supervisory system.

Figure 3 shows the main screen of the WebLab for mass transfer experiments. Through this screen users can choose the experiment operating conditions (air flow rate and stirrer speed).

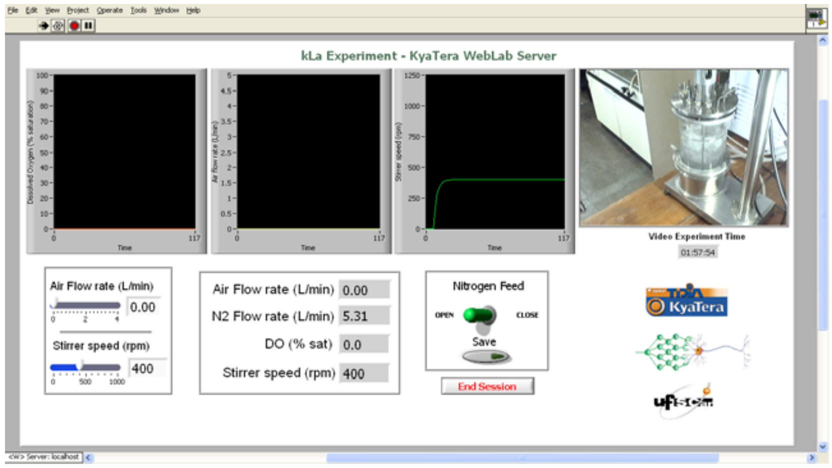

Figure 3. WebLab for mass transfer experiments' main screen.

3.2 Weblab for Reactor Temperature Control at University of São Paulo

The reactor is a jacketed glass vessel with capacity of 4.5 L. Inside the reactor there is a stainless steel coil connected to a 3.000 W thermal bath, a temperature sensor (PT100) and a stirrer (Heidolph). The jacket is connected to cold water (room temperature). Both the streams, from the thermal bath and cold water have their flow controlled by electropneumatic valves. An electrical heater is inserted inside the reactor, in order to simulate various kinds of reaction without risks. The electrical power to the resistor is controlled by a power module.

The temperature of the reactor can be controlled by manipulating the hot water flow through the coil or the cold water flow through the jacket. In figure 4 a screen shot of the temperature control experiment is presented. This screen includes a live camera for visualizing the experiment.

4. Performing the Experiments

In order to perform the experiments, two students in São Carlos and two in São Paulo are gathered into a group. An instructor supervises each group of two students. The students are left free to decide what measurements and experiments are to be performed and how to manage the experiments (who is in charge of what). Students interact using video conference software. Video streaming is very effective because KyaTera network supplies a performing communication capability. This gives the students an improved perception of the reality.

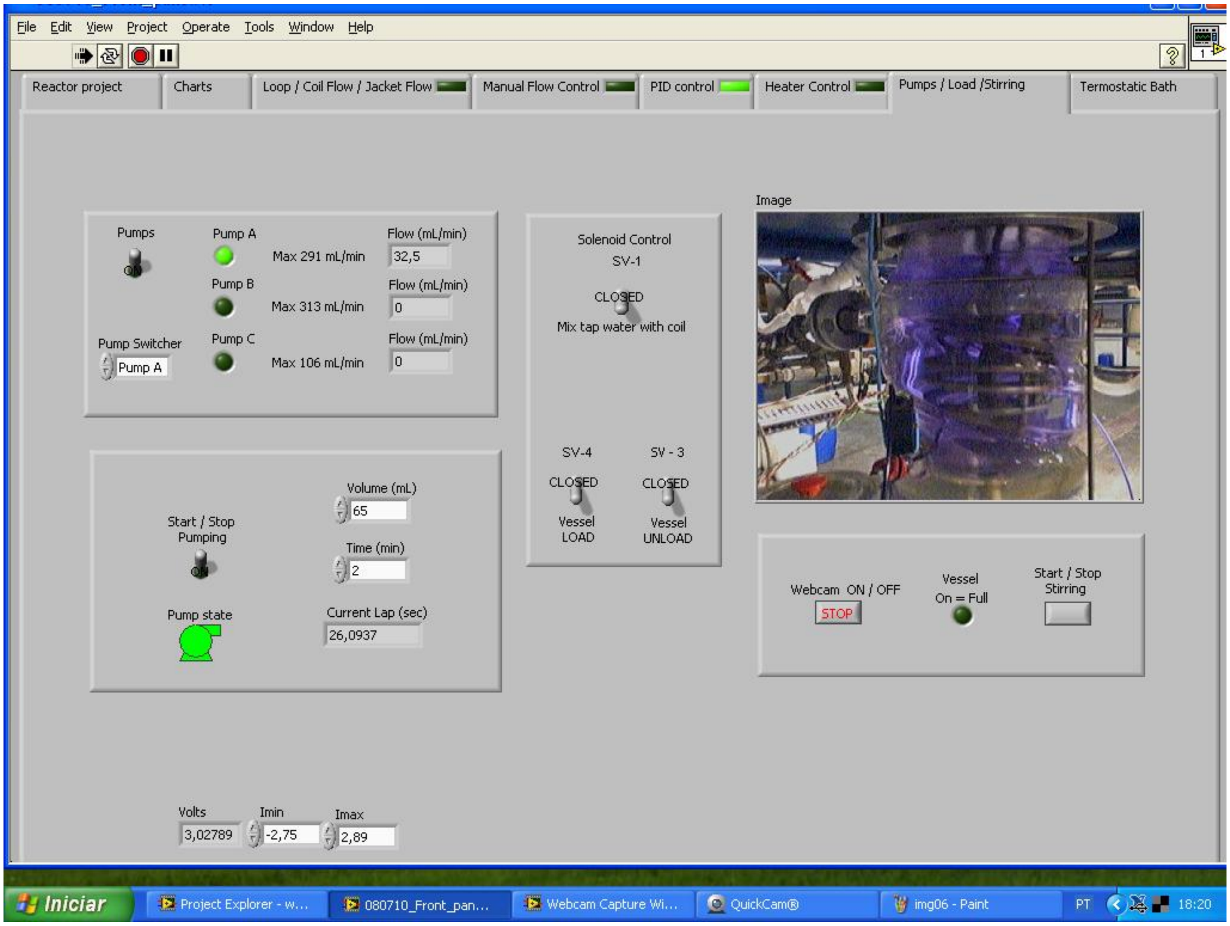

Figure 4. Weblab Reactor Temperature Control' Screen shot.

The students are encouraged to interact. All along the experiments, the students exchange information and opinions about the phenomena that take place. In the mass transfer experiment, the main concerns are about the quality of the mixing, the size of the bubbles and the various problems that arise during the experiment (bubbles blocking the tip of the probe, high coalescence phenomena, and conditions of inefficient mixing). In the temperature control experiment, a step change on the coil flow is performed in order to obtain the response curve. The students must perform calculations together, during the experiment, in order to apply the Cohen-Coon procedure (Seborg et al. 1989) to obtain the PID tuning parameters. The set of PID tuning parameters is implemented by closing the control loop and is tested by different methods, e.g., set point changes and disturbance rejection tests. They are left free to implement other disturbances with the immerged resistor in the reactor.

During the experiment, a high level of interaction takes place between the students, who keep talking and discussing all long the experiment. After the experimental session, the students must process the data collected together in order to produce a unique report for the group. The students are invited to employ KyaTera network to communicate and prepare the final report.

6. Conclusions

Weblab experiments offer a collaborative learning experience to the participants because they are faced with the hurdles of remote team working. Cultural reality certainly does not differ much for a 250 km distance, but the views on which the topics are taught are certainly different. This is an interesting issue, because these experiments also provide new experiences to the instructors involved who perceive how the colleague teach the same phenomena to her/his students.

The overall opinion of students is extremely positive and encouraging. Cooperative Weblabs experiments are valuable educational tools in a world with an increasing interaction. An effort is necessary in order to fit this kind of activity in the curricula of Chemical Engineering courses, because it requires the agreement of two or more institutions. Also some practical difficulties must be faced and overcome such as the difference in time zones and calendars. Nevertheless the impact of these issues is unimportant if compared with the potential improvement that this tool can bring to the chemical engineering education.

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Acknowledgments

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