EXPLORING HYBRID APPROACHES IN ENGINEERING THERMODYNAMICS DURING COVID-19 PANDEMIC

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1 Abstract

The unprecedented COVID-19 pandemic disrupted educational schools and Universities, which transitioned quickly from in-person instruction to emergency remote teaching. The crisis gave faculty the opportunity to become acquainted with online and hybrid modes of teaching and to explore their affordances. Moreover, the use of these mixed modes of teaching will continue to expand after the pandemic is over. Most universities supplied straightforward instructional technology to deliver lectures, but it is less obvious how to use diverse learning approaches in online and hybrid environments. Experiences about student's response towards online and hybrid learning approaches are still scarce because of the short period of time passed[1, 2].

The purpose of this contribution is to investigate the perceptions and learning processes of second-year students enrolled in a course on Thermodynamics within the Engineering Electronics and the Industrial Management degrees during the pandemic rapid transition to online and hybrid working environments. We analyzed the use of alternate and complementary approaches to teach the pressure-volume-temperature behaviour of fluids by using online and face-to-face theoretical lectures, experimental lab classes and video-lab classes in a problem-based approach. Results coming from tests, reports, and interviews with students are used to explore the improvement on the meaningful learning of the students.

2 Experimental Apparatus. Description

The subject "***Engineering Thermodynamics***", taught to 2nd course students of the degrees in **Electronics & Automation Engineering**, and **Industrial Management Engineering** at the University of Burgos (Spain), includes a chapter entitled: "*Properties of Pure Substances*". To let the students learn the relations between *p-V-T* properties in a practical way, an experimental laboratory apparatus is used during the practices of the chapter.

Description of the Apparatus:

The experimental laboratory device is composed by a graduated tube that contains Sulphur hexafluoride (SF_6) in gas state. The volume of the gas can be controlled by moving upwards the mercury column operating on a rotating wheel. Thus, the volume can be measured in the graduated column. The pressure of the fluid is measured by means of a manometer located in the bracket of the device. The spin of the wheel modifies the volume, and the pressure is therefore changed. Temperature is measured indirectly. The tube that contains the fluid is surrounded by another concentric tube. The annular space is filled with water coming from the thermostatic bath.

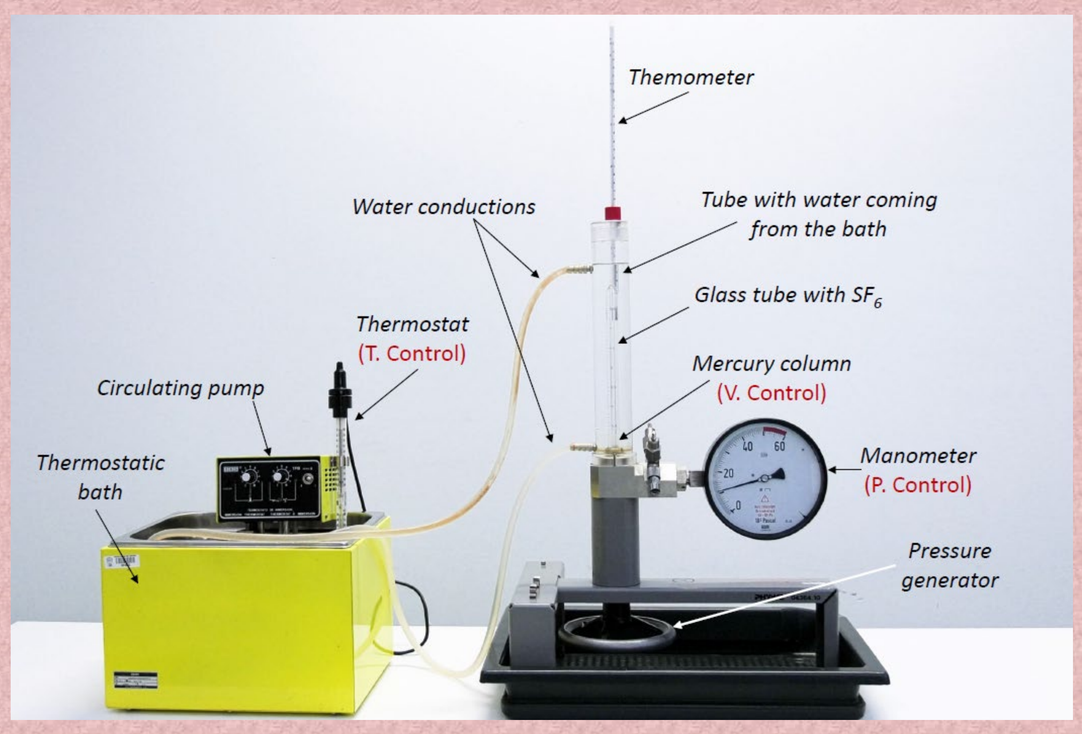


Figure 1. *Experimental laboratory device used in the laboratory practice of the chapter "Properties of Pure Substances".*

3 Materials available for the students in both approaches

Videos of the practice.

- URL spanish video: *https://youtu.be/WjUXDfVVq3s*
- URL english video: *https://youtu.be/vYbFmuneL3Y*
- URL french video: *https://youtu.be/sfmMwDZ4JVM*
- URL arabic video: *https://youtu.be/NP3MfzD0eYg*

Ebook of the practice.

- URL ebook: *https://www.ubu.es/catalogo-de-publicaciones/ingenieria-termodinamica-ecuacion-de-estado-termica-de-fluidos-mediante-experimentacion-engineering-thermodynamics-thermal-equation-fluids-experimentation*

4 On-site (laboratory) approach of the practice

In the on-site mode, the practice is developed in two sessions of 100 minutes length each. The first session corresponds to the *p-V-T* data acquisition done by the students with the device. The second session uses the previous experimental data to construct the whole *p-V* diagram of the substance.

1) Application of Inquiry with students concerning *p-V-T* relations

2) Explanation of the apparatus

3) Measurement of isotherms (done by students)

4) Representation of *p-V* diagram in the blackboard (done by students)

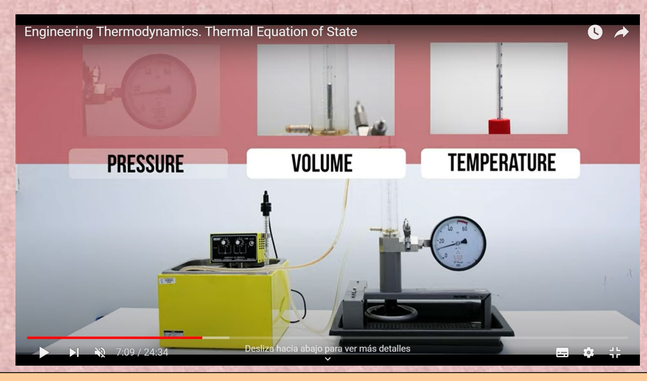
5) Determination of saturation curve and liquid-vapor regions

6) Evaluation test (10 questions) or work concerning the practice

5 Out of laboratory approach of the practice (COVID-19)

Due to the reduction of the seating capacity in laboratories during COVID-19 pandemic, the experimental practice was recorded in order to be used in the practical session. The practice is developed in one session of 100 minutes length. The videos (esp; eng; fr; arab), as well as an ebook are hosted in UBUVirtual (Moodle) platform.

1) Application of Inquiry with students concerning *p-V-T* relations



2) Visualization of the video in class. Resolution of questions by the teacher

3) Evaluation test (10 questions) or work concerning the practice

6 Evaluation. Comparison of Results. (2019-20 to 2021-22)

Table 1. *Evaluation results (passed/total) for two different degrees (Electronics & Automation Engineering and Industrial Management Engineeering), along three different courses. Boxes in blue (■) refer to the on-site approach, whereas boxes in orange (■) refer to the out of laboratory approach.*

	DEGREE		
COURSE	***Electronics & Automation Engineering***	***Industrial Management Engineering***	**TYPE OF EVALUATION**
2019-20	**30/30**	**20/28**	Test (10 questions)
2020-21	**13/23**	**12/31**	Test + problems (work)
2021-22	**31/31**	**25/25**	Test (10 questions)

- Passed / Total achieve the 100% in the on-site approach.
- The use of a sole test means better results than when problems are included.

7 Conclusions

- Results (passed / total) are better with the on-site approach.
- Evaluation by using only tests obtains better results. This could mean that exercises touch points of the chapter more difficult to understand for students.
- The on-site approach, combined with the availability of the videos and the ebook in the UBUVirtual (Moodle) platform brings the students the opportunity to better understand fundamental concepts of Thermodynamics that should be used along the subject.

8 References

[1] R. Kaur, A. Garg and P. Kaur, J. Eng. Educ. Transform., 34, 62 (2021).
[2] S. Krishnakumar, T. Maier, C. Berdanier, S. Ritter, C. McComb and J. Menold, J. Eng. Educ. 111, 474 (2022).

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