INCOPRORATING RESEARCH INTO A FIRST YEAR FLUID MECHANICS CLASS

Tsung-chow Su*

*Department of Ocean & Mechanical Engineering, Florida Atlantic University, Boca Raton, FL 33431, USA

Summary Through simple flow visualization experiments, it is possible to introduce students to research in fluid mechanics during their first fluid mechanics course. Our visual sense is so powerful that in an instant we can grasp the big picture in an amount of detail that cannot otherwise be described. To quote Richard Feynman, "fundamental questions can be easily answered just by looking at the thing." One should know, however, precisely *how to look*, analyze and investigate visually. Interesting small scale fluid motion may be observed and photographed to reveal fundamental processes in an inexpensive and team-building manner that builds confidence, skills for life-long learning, and preparing for graduate research. This paper presents our students' experience.

BACKGROUND

In the summer of 2010, Florida Atlantic University approved its Quality Enhancement Plan for Undergraduate Education with a focus on (1) integrating and expanding a culture of research, scholarship and creative activity (2) supporting initiatives associated with building a culture of undergraduate research, scholarship and creative activity, and (3) defining research, scholarship, and creative activity as broad as possible to reflect the creative activities of undergraduate in all colleges. The faculty was encouraged to find the best means to implement the plan. In teaching our introductory level fluid dynamics class in the fall semester of 2011, 15% extra credit on a small independent project was assigned to encourage students to start exploratory research in fluid mechanics. The ideal project at this level is often based on visual investigation of small scale flow. These projects are inexpensive and driven by student curiosity. To combine students with various talents and increase motivation, these experiments were performed in a group setting.

METHODS

At the beginning of class, some classic examples of flow visualization experiments [1] were introduced. The instructor suggested research topics as needed. Often these topics dealt with flows that could be visualized simply and appeared in their daily life. Students were guided on how to write research papers and the importance of publishing their findings [2]. To encourage students to go beyond their standard effort, they were asked to submit their findings for a conference presentation and if possible, publish their findings. They would receive additional bonus credit amounting to 10 points of their semester grade, if their result were deemed fit for publication by the instructor. There were 3 tests prior to the final examination. Following each test, students put additional effort in research to aid their classroom performance.

RESULTS

In a class of 17 students, 15 submitted a paper for conference presentations. One group investigated a modification of the circular hydraulic jump and noticed that with some geometric changes, the supercritical flow degenerated into tiny vortex rings and finally into a spray of tiny droplets (Figure 1).

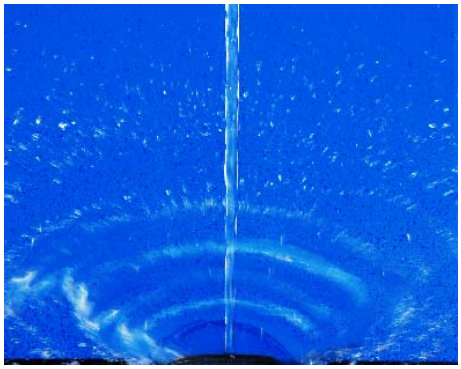

Figure 1: A hydraulic jump degenerates into vortex rings before turning into spray.

Another group investigated water drainage with multiple outlets in a symmetric arrangement. They noticed that with two identical drainage holes, only one drainage vortex will form while the other will drain in sink flow bringing the upstream end of the drainage tube about the sink. In addition, the drainage vortex switches periodically between the two holes (Figure 2).

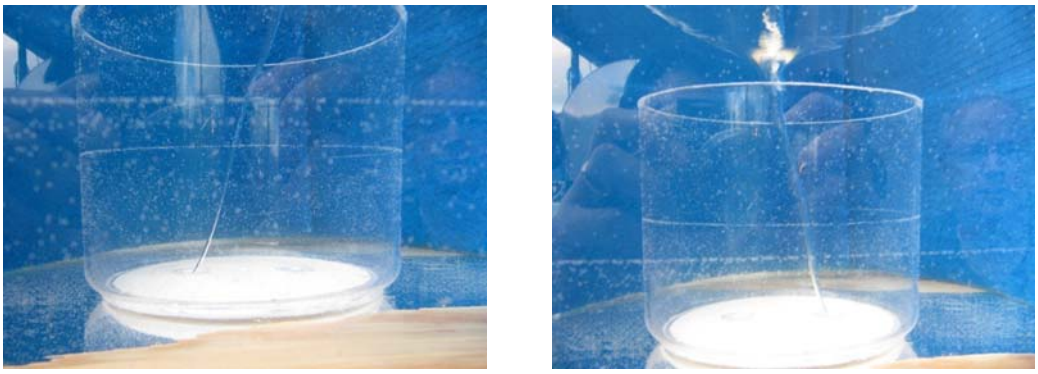

Figure 2: Drainage vortex switches periodically between drains.

One group partitioned a water basin with a removable wall. After each side formed its drainage vortex, the wall was then removed. They found that if the two vortices were of the same sign, both disappeared quickly, otherwise they both lasted for a while. The liquid impact and the resulting heart-shaped spray pattern interested students as well (Figure 3).

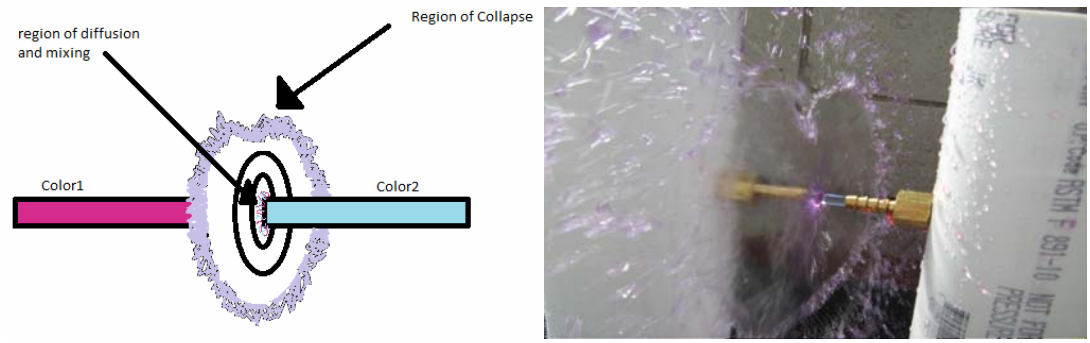

Figure 3: Liquid collision resulting in a heart-shaped water sheet

In addition, hydrophobic interface problems were also popular. Many students signed up for a Directed Independent Study course in the following semester to carry out detailed investigations for publication. The course passing rate also improved significantly.

CONCLUSIONS

We found that undergraduate students are motivated and capable of carrying out exploratory research in fluid mechanics. There are many interesting flow phenomena around us that are visible and are suitable for research by undergraduates.

References

[1] Illustrated Experiments in Fluid Mechanics: the National Committee for Fluid Mechanics Films movie series.http://web.mit.edu/hml/ncfmf.html
[2] G. M. Whitesides, “Whitesides’ Group: Writing a Paper”, Advanced Material, 2004, V. 16, No. 15.