Lessons Learned 4, 1 (2024)
Submitted: 04.10.2023
Accepted: 22.05.2024
DOI: https://doi.org/10.25369/ll.v4i1/2.86
ISSN: 2749-1293 (Print); 2749-1307 (Online)

The Shanvi project - Discovery-based learning in fluid mechanics

L. C. Haenel, F. Rüdiger, J. Fröhlich*

Chair of Fluid Mechanics, Institute of Fluid Mechanics, Faculty of Mechanical Science and Engineering, TU Dresden

Abstract:

The article provides an initial assessment of the Shanvi learning project (german for Strömungen hautnah, nicht virtuel) It was designed to offer students independent experiential opportunities in fluid mechanics that go beyond regular university operations. Examples are a student project in a company, demonstrations for the general public, small self-steered experiments during lectures and exercises as well as during excursions. In addition to direct exposure to physical phenomena and the autonomous structuring of experiments, another aspect of the project is the promotion of teamwork, which is often lacking in university life. After one year, very positive results are evident, but they also require a corresponding commitment from the faculty.

Der Beitrag zieht eine erste Bilanz des Lernprojekts Shanvi (Strömungen hautnah, nicht virtuell). Es wurde konzipiert, um Studierenden eigenständige Erfahrungsmöglichkeiten in der Strömungsmechanik zu bieten, die über den normalen Universitätsbetrieb hinausgehen. Beispiele sind ein studentisches Projekt in einem Unternehmen, Demonstrationsversuche bei Veranstaltungen für das breite Publikum, sowie kleine, selbständige Versuche in Vorlesungen und Übungen und bei Exkursionen. Neben der direkten Erfahrung zu physikalischen Phänomenen und der eigenverantwortlichen Strukturierung von Versuchen ist ein weiterer Aspekt des Projektes die Förderung der Teamfähigkeit, die im Universitätsalltag oft zu kurz kommt. Nach einem Jahr zeigen sich sehr positive Resultate, doch erfordern diese auch entsprechenden Einsatz des Lehrstuhlpersonals.

* corresponding author jochen.froehlich@tu-dresden.de

1. Motivation

The idea for the project was born in 2022 from the experiences of the coronavirus pandemic and aims to bring students de out of the virtual world and back into the real world through direct contact with flow phenomena. The approach is to encourage students to take their own creative action by providing mobile measurement technology and expert support. Students' interest in self-directed design of learning content and learning methods is to be encouraged in the spirit of discovery learning [1]. Specialist knowledge is practically applied, consolidated and expanded. In addition, general engineering skills (e.g. design of experiment, measurement electronics, and scientific communication) are promoted.

Even before the pandemic situation, there was a tendency for practical aspects of education, and in particular independent learning by students , to play a smaller and smaller role in the learning process - despite the knowledge of its importance. "Independent" here means: set in motion by own motivation, pursued by the inner drive of the joy of discovery and, if necessary, the exchange with peers, as well as the independent formulation of an insight. The pandemic situation has once again massively highlighted the need for such forms of teaching.

Independent learning, even if it is predominantly self-directed, requires expert guidance and supervision, which in our case will take place in the laboratories of the chair. Additionally, the project creates opportunities for interaction with other institutions, e.g. with companies and schools in the region, which broadens students' horizons in the real world.

These issues were discussed among the authors leading to the project objectives formulated in Fig. 1.

Fig. 1: Aims of the project

2. Status of implementation

The learning project is based on mobile measurement technology sets configured in a targeted manner, which make flow phenomena directly tangible through time-averaging methods and visualization of instantaneous flow. Two cases with measurement technology were procured for this purpose, one for measurements in water and one for measurements in air. In addition, a mobile high-speed camera was purchased for observing the processes that are often too fast for the human eye *(Fig. 2).*

Fig. 2: Measurement technology procured as part of the Shanvi project. Top: AHLBORN measuring device case [2] for measuring the mean flow in air, bottom: CHRONOS 1.4 high-speed camera [3]

The data loggers included in the measurement technology sets enable the connection of additional sensors with voltage output and thus allow students to produce and use their own measuring instruments and probes for their specific application.

Activities planned as part of the project include

- Support for students' own projects,
- Student projects in cooperation with companies in the region,
- thematic excursions,
- student contributions to exercises,
- Lecture experiments and demonstration experiments and
- internships of high-school students.

In the first year since the start of the project, the following activities were supported:

- Excursion of an 11th grade class from Schwerin to Dresden with a visit to the Chair of Fluid Mechanics in June 2022
- Internships of pupils in spring 2022 (10 participants) and spring 2023 (6 participants), see Fig. 4
- Practical course on experimental fluid mechanics in summer semester 2022 and summer semester 2023
- Demonstration experiments for the courses "Technical Fluid Dynamics" and "Gas Dynamics"
- Long Night of the Sciences (LNdW) 2022 and 2023, see Fig. 3
- Excursions with staff and students of the chair to the Rabenauer Grund (July 2022) and the Dresden Heath (July 2023)
- Measurements in a test setup for the production of paper fleece in the Bärenstein paper mill (Fig. 5)
- Use of the high-speed camera to demonstrate everyday effects such as the coalescence of soap bubbles (Fig. 7)
-

3. Experience in the individual projects

Demonstrations LNdW

During the Long Night of Science, the high-speed camera was used to observe the rise of bubbles in a water column (Fig. 3). The camera was set up in such a way that recordings can be made, saved and played back directly from the camera without a computer. Visitors were thus able to get a vivid picture of the rise of bubbles of different sizes and related form instability, which is a subject of the chair's current research work. Thanks to the availability of the measurement technology, it was possible to independently determine ascent speeds and bubble sizes by reading the time and position from the camera image and thus carry out observations using the diagram provided. The clear presentation offered many opportunities to build on the various previous knowledge and to impart knowledge and methods in dialog. The new measurement technology thus opened up new opportunities for communication, both with the general public and with the students present during the LNdW.

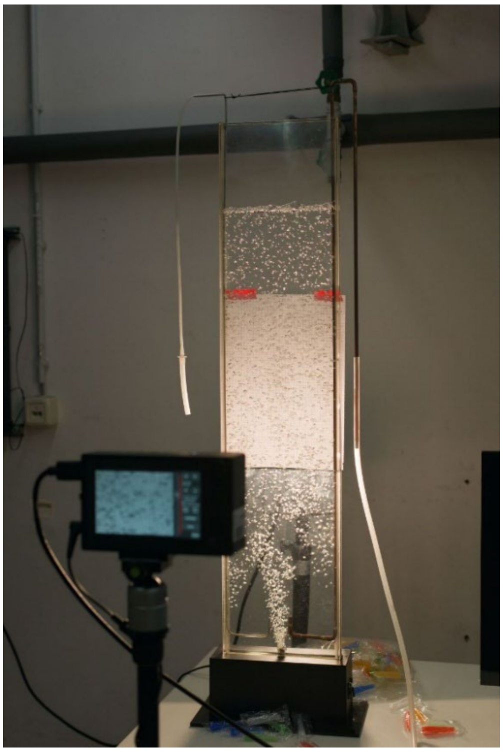

Fig. 3: Use of the high-speed camera on the bubble column for the Long Night of Science 2022

Student internships:

Various previously initiated internships of high-school students were carried out as part of the project. The main focus was on awakening interest in science, particularly in fluid mechanics. Instead of just frontal teaching, the pupils were encouraged to deal with the subject matter independently by carrying out experiments in which the setup, implementation and evaluation were discussed among themselves with the support of a supervisor. This enabled the pupils to actively experience science and thus gain their first child-friendly insights into research.

Fig. 4: Measuring a free beam during the 2023 student internship

Project: Flow-induced inhomogeneities in non-woven deposition

As part of an investigation to improve a test stand for dry web separation (Fig. 5 and 6), different flow velocities were measured at various points in front of the screen for collecting the fibers using mobile measurement technology. The different velocities indicate an inhomogeneous flow, which explains the irregular surface of the nonwoven as shown in Fig. 6. Based on the measured values, a simulation to improve the flow conditions could be validated allowing measures for improving the test stand at a later stage.
These investigations were used to establish contacts with two companies in Saxony. Furthermore, the student involved, through his on-site measurement campaign, also gained an insight into paper production and into the engineering work in a paper mill, i.e. the day-to-day work of a professional engineer in industry. For the chair, these investigations open up opportunities for further research activities and cooperation.

Fig. 5: Experimental setup for the production of paper fleece

Fig. 6: Non-woven layer after completion of the deposition process

Coalescence of soap bubbles

The high-speed camera offers the possibility of imaging exciting everyday effects, such as the coalescence of soap bubbles. In a research project at the Institute of Fluid Mechanics, it was possible to show how the soap bubbles merge and form a single bubble. Due to the high number of images that can be recorded per second, it is possible to depict the individual phases of this effect step by step and thus make visible what would otherwise remain hidden to the human eye.

Fig. 7: Presentation of everyday effects, such as the merging of soap bubbles and the associated change in shape and size, as part of a 2023 diploma defence. Recorded with the high-speed camera.

Student's self-proposed projects

In the lectures of the chair, students were encouraged to come forward with their own research questions that they would like to investigate under supervision using the measurement technology procured. Unfortunately, despite several calls, there were no reports of this kind. The authors attribute this to the fact that no credit points can be acquired with such an independent project, but "only" knowledge and the joy of implementing one's own ideas. In the current study situation, with pressure on grades and little time, this approach has unfortunately not yet been possible. Nevertheless, the opportunity to carry out independent projects will continue to be offered and advertised. This includes that students carry out studies on their own topics and have them recognized as coursework. Particularly for distance learning students, this opens up opportunities to work not only theoretically or numerically but also experimentally.

Options for expansion

It was found that the range of possible investigations can be significantly enlarged by using apps for cell phones, among others. Here, for example, phyphox was used to measure various physical parameters (RWTH Aachen), as well as SmartPIV, an application for measuring velocity fields (TU Ilmenau).

This potential is to be further explored in the future and will be used to increase the attractiveness of studying fluid mechanics phenomena.

4. Summary and outlook

In all the activities carried out so far as part of the project, the participants have gained a better understanding of the flow phenomena they have investigated themselves or demonstrated in experiments. The personal experience of the flow situation and the experience of carrying out self-steered measurements - especially learning from the mistakes made - have contributed to the enthusiasm for the topic. The use cases designed in the first year will be expanded in the future. In particular the high-school students internships can promote interest in STEM subjects and thus counteract the decline in the number of university students.

5. Acknowledgements

The authors would like to thank the Faculty of Mechanical Science and Engineering for funding the measurement technology required for realizing this learning project.

Literature

[1] In discovery learning, the focus is on learning stimuli or learning arrangements that are intended to motivate self-active learning [Wikipedia]

[2] https://www.ahl-born.com/de_DE/produkte/messgeraetekoffer (19.06.2022)

[3] https://www.krontech.ca/product/chronos-1-4-high-speed-camera (19.06.2022)