FlowCam®

Incorporating Advanced Microscopy Technology into STEM Education

A Case Study from the University of San Diego

INTRODUCTION

Microscopy is a fundamental component of STEM education, providing students with hands-on experience, fostering scientific inquiry, and preparing them for careers in research and industry. However, traditional microscopy poses challenges, including limited accessibility, time-consuming manual processes, and the need for faculty expertise.

As STEM pedagogy evolves, integrating state-of-the-art, yet accessible technologies into classrooms and research programs is crucial. FlowCam, an automated flow imaging microscope, enhances student learning by streamlining data collection, improving research efficiency, and fostering engagement.

Unlike traditional microscopy, which requires manual slide preparation and individual sample analysis, FlowCam automates the imaging process by capturing high-resolution images of microscopic particles in real-time as they flow through a fluidic system. This eliminates the need for tedious manual observations and allows students to rapidly analyze large sample sets with greater accuracy and consistency. Additionally, FlowCam's integrated software enables automatic classification and quantification of particles, reducing human error and making data analysis more intuitive.

By minimizing time spent on sample preparation and manual counting, students can focus more on interpreting results, forming hypotheses, and engaging in hands-on research, ultimately enriching their learning experience. In this way, it levels the playing field, allowing all students to visualize and analyze microscopic organisms with ease.

At the University of San Diego (USD), the Department of Environmental and Ocean Sciences has embraced FlowCam to support undergraduate research and teaching. By incorporating FlowCam into coursework and student-led research projects, the department is expanding scientific literacy, encouraging inquiry-based learning, and equipping students with essential skills for their future careers.

Anthony Basilio is a laboratory technician and instructor at USD who ensures students and faculty have access to instrumentation that helps them achieve their learning and research objectives more easily. Anthony played a key role in identifying the need for an instrument like FlowCam to support student research and enhance teaching opportunities across diverse faculty research interests, from microalgae to zooplankton.

This case study explores how FlowCam has transformed undergraduate education at USD and highlights its impact on student engagement, faculty instruction, and workforce preparation.

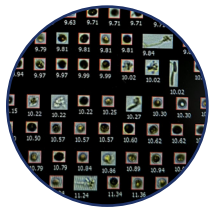
Anthony Basilio manages a variety of instruments in USD's Department of Environmental and Ocean Sciences, and coordinates closely with students and faculty to make sure everyone has access to the instrumentation they need to achieve their research and teaching goals.

ACCESSIBILITY & STUDENT-DRIVEN RESEARCH

Many STEM programs incorporate course-based research experiences (CREs) to engage students in original research early in their academic careers. The faculty and staff of USD's Department of Environmental and Ocean Sciences are committed to this approach and have been integrating their FlowCam 8000 instrument into research and teaching to provide a well-rounded education with immersive lab and field experiences for students.

To date, three students—two of whom are undergraduates—have used FlowCam for independent research. For example, Gabrielle Gaither (Gabby), an undergraduate student researcher, was interested in investigating how water temperature affects zooxanthellae (photosynthetic algae) in the tentacles of the sea anemone *Anthopleura elegantissima*, an important species for helping researchers understand the effect of thermal stress on coastal biodiversity.

Gabby used FlowCam to quantify zooxanthellae density at four different temperature treatments plus a field sample. Without FlowCam, Gabby would not necessarily have had the time to test so many treatments with her busy course load, or the precision to detect the more nuanced changes in algal density that she observed at higher temperatures. Her study highlighted the need for precise algal quantification using instruments FlowCam. Gabby's research culminated in a poster she presented at the Western Society of Naturalists conference. In the future, Gabby hopes to observe longer-term effects of temperature and conduct field studies to validate the results she observed in the lab.



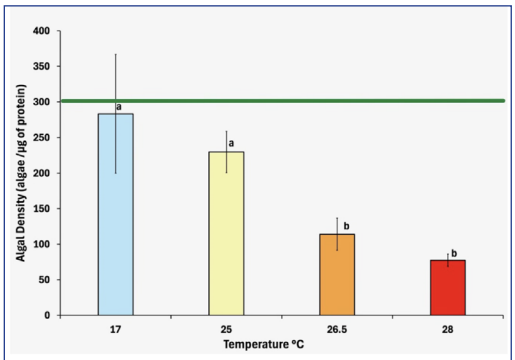


Figure 2 Bar graph of normalized algal density (algae/ µg protein) across four temperature treatments (17°C, 25°C, 26.5°C, and 28°C) in Trial 2. Error bars represent ±1 standard error. The green horizontal line represents the average algal density found in anemones collected on the same day without undergoing temperature treatments, serving as a baseline for comparison. Temperature groups that do not share a lower-case letter represent significant differences based on Tukey-Kramer test ($p<0.05$).

Anthopleura elegantissima (top left) is a species of sea anemone that—like coral—depends on photosynthetic algae called zooxanthellae (bottom left) for photosynthesis. Gabby used FlowCam to enumerate the density of zooxanthellae per µg of anemone protein (data pictured right).

For studies like Gabby's, a student may find themselves using a microscope (which can be time consuming and frustrating), or a particle counter that doesn't provide the images and morphological data needed to differentiate target from non-target organisms.

Instruments like FlowCam help students like Gabby to engage in high-quality data collection and scientific discovery earlier in their academic careers than might otherwise be possible, helping inspire more students to pursue investigations involving microscopic organisms that are the foundation of marine food webs.

A USD student using FlowCam to image, count, and measure algal cells.

EASE OF USE & STUDENT AUTONOMY

User-friendly instrumentation is critical in undergraduate settings, where it is important for students to learn how to operate equipment independently. The Environmental and Ocean Sciences Department prioritizes instruments that are intuitive, robust, and reliable for everyday student use, giving students greater autonomy over their time and research.

"Our department prides itself on training students to use instrumentation independently, as hands-on experience is where they gain the most valuable skills," says Anthony.

An important aspect to gaining that independent experience begins with having instruments that are easy to set up and don't require faculty or staff supervision.

"As the person responsible for maintaining various instruments, I appreciate FlowCam's straightforward setup. Some equipment is highly complex (like our ICP-OES analyzer) or even hazardous (like working with liquid nitrogen) and requires constant supervision. With FlowCam, I don't have to worry."

The ICP-OES analyzer, for example, is an instrument Anthony trains students on, but cannot allow them to use independently. "FlowCam, on the other hand, is accessible and student-friendly. Hands-on experience with real-world instrumentation is one of the best preparations for research or industry careers."

And, when questions do arise, quick responses from the FlowCam team help Anthony and the students he works with resolve questions quickly. "I've contacted FlowCam's customer service, and they responded within the hour. That level of support is crucial, especially when undergraduates have limited time for lab work."

Undergraduate students may only have short windows of time between classes and other obligations to devote to research, and minimizing the time required for technical support helps them make the most of their limited hours in the lab.

ENGAGING STUDENT CURIOSITY & SCIENTIFIC INQUIRY IN THE CLASSROOM

In addition to providing access to advanced imaging techniques for independent research, FlowCam also nurtures curiosity and scientific inquiry in lab-based courses When students see high-resolution images of microscopic organisms, it sparks questions and inspires deeper exploration.

"We try to incorporate active data collection into lab experiences and involve students as much as possible," says Anthony. Having FlowCam available for courses is a great advantage: "Being able to go from sample collection in the field to popping samples into FlowCam and seeing live data—all within a three-hour lab session—is huge for undergraduate engagement."

Many courses at USD, like *Biological Oceanography*, include microscopy lessons. FlowCam is intuitive for students because it takes components they are familiar with—like an objective lens—and combines it with high-speed imaging to make for a much more engaging experience that in turn may help motivate more students to pursue independent research involving microscopy who would not otherwise express interest.

WORKFORCE DEVELOPMENT & CAREER PREPARATION

One of the primary goals of an undergraduate science program is to prepare students for careers in research and industry. Employers increasingly seek graduates with hands-on experience using advanced scientific instrumentation. FlowCam, a tool extensively utilized in biotechnology companies globally, is highly accessible for faculty and students within biology and biochemistry departments. Its integration into the university setting represents a valuable educational investment across multiple departments.

In San Diego, the biotech industry demands professionals skilled in handling microscopic samples, a competency that FlowCam helps students develop. Anthony, who previously worked in biotech, knows this firsthand.

"Companies like Illumina and Truvian are looking for people who are comfortable working with very small volumes of samples," which is one of the skills students develop using FlowCam. "This is a transferable skill that's widely used in the biotech industry."

Moreover, FlowCam exposes students to key concepts in fluid dynamics, sample preparation, and automated data processing—skills essential for scientific and industrial careers.

"Your first six months in biotech involve mastering sample handling and instrument operation. Entering the workforce with prior experience is invaluable," Anthony said, and having FlowCam experience on your resume is a significant advantage.

Working with advanced instrumentation and small sample volumes are two important skills that are attractive to employers in San Diego's biotech industry—skills that students develop and practice by using FlowCam.

SUMMARY

Undergraduate science programs aim to equip students with the skills and confidence needed for success in research or industry. FlowCam plays a crucial role in achieving this goal by providing an accessible, intuitive, and robust imaging solution.

Whether students are conducting independent research, engaging in coursework, or preparing their resume for their first job post-graduation, FlowCam empowers them with hands-on experience that fosters scientific curiosity and professional readiness. By integrating FlowCam into undergraduate education, institutions like the University of San Diego enhance student learning, research opportunities, and workforce development—ensuring that students are well-prepared for their futures.

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