Maximizing the benefits of shared instrumentation: Fostering flexibility rather than "one-size-fits-all" approaches

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Maximizing the educational and research impact of analytical facilities at CU will require a variety of approaches. The needs, goals, and responsibilities of each PI and analytical facility need to be considered when making campus-wide recommendations. Specifically, analytical instruments cannot always be considered static task performers, but must also be viewed as equipment that will be constantly modified, tested, and adapted to meet changing teaching and research goals. CU will be best served by helping labs meet their individual scientific and fiscal goals rather than by imposing "one-size-fits-all" policies across campus, which will prevent some labs from thriving and from successfully serving a broad off-campus user community.

We emphasize that "shared equipment" and "centralized equipment" are not synonymous. Although they can both be exceptionally important to the success and sustainability of analytical facilities, we argue that it is important to take the individual needs and goals of a lab into consideration when designing campus-wide recommendations. Here we define "shared" equipment to be that which is employed to serve a broad user community, whether on- or off-campus, but which is managed by a single research group. We define "centralized equipment" as that which resides within a single lab at the university, possibly with rules in place to prevent its duplication in other labs, and is cooperatively managed by a larger group of users. It is difficult for some shared labs to serve and grow their user base, and meet their method-development goals, while being required to use centralized equipment over which they have no scheduling control and little flexibility for experimentation. Although we agree that centralized instrumentation may make sense in some cases, we contend that it also can also be at odds with the research and educational goals of some labs. We suggest that success for analytical facilities will look different to each lab and PI, and that frameworks and mechanisms that are flexible enough to deal with this inherent diversity will be the most useful and sustainable.

Some important considerations include:

- **User networks can extend off campus.** Some analytical facilities at CU may be one of only a handful of similar labs in the country. Achieving fiscal stability and maximizing the profile of the research group will therefore require developing a large network of users, most of whom are at institutions other than CU. Facilities must therefore have the flexibility to host visiting scholars, provide efficient turnaround time on analyses, and provide specialized, experimental services. This can be difficult to achieve with "centralized" equipment.

- **Innovation requires tinkering and experimenting.** Scientists with different research foci will use the same piece of equipment in a variety of ways. Often, as a research group tries to refine analytical methods or develop new techniques they will modify existing

equipment, or experiment with analyzing new materials on a particular machine. These activities are difficult to carry out on centralized equipment, because they can leave an apparatus unavailable for extended periods of time. Small, initial steps of experiments are also often performed with no direct funding source, and it is crucial that facilities be available for low- or no-cost developmental work.

- **Lab managers are often experts with the equipment, but are also experts within the specific field.** Helping PIs design and carry out innovative research requires knowledge of both the best laboratory methods to be used as well as the specific scientific question that is being asked. Centralized facilities cannot maintain expertise in every relevant field.

- **Laboratory facilities in teaching laboratories will break regularly, and that's OK.** Labs at CU are integral components of the PI's teaching and educational mission. For students to be competitive on the modern job market they must be experts in laboratory methods. Students, especially while learning, can be slow, and will make mistakes. Centralized facilities may have less ability to accommodate this learning process. Recovering from accidents will slow work flows, and it is therefore important that labs not be judged by industry-style productivity quotas or expectations.

- **Many essential shared support facilities that have existed in the past, such as sample preparation, machine, electrical, and glass shops, are being discontinued.** These facilities were once common on university campuses, but are increasingly rare and/or dependent upon soft money. As managers of these facilities retire, they are not regularly replaced. Their responsibilities are either divvied up amongst remaining staff or entirely abandoned. Support for these facilities should be a priority, because their disappearance undermines the ability to maximize the potential of equipment investments.

- **Laboratory needs will change over time, so strategies for the long-term success of a particular lab must be flexible.** Machinery availability and use, staffing, fiscal sustainability, the need for outside expertise, and the size and distribution of the user base will all change as labs evolve and grow, and it is important that campus or department mechanisms recognize this.

Our recent success at obtaining external NSF funding for new instrumentation, and the positive contribution that instrument makes to achieving our lab's research and educational goals, highlights some of our concerns with universal calls for centralized facilities. The analytical technique we use in our research group requires three separate types of equipment; a noble-gas mass spectrometer optimized for measuring total He abundance, calibrated optical microscopes with imaging capabilities, and an ICP-MS. Up until the summer of 2017 we were using an ICP-MS in a laboratory directed by another faculty member. The capabilities of the machine itself were more than adequate for our analyses and we had entirely positive interactions with the faculty director who welcomed our usage; indeed his expertise was

critically important during the early development and refinement of our analytical techniques. However, as our lab's user base grew rapidly, as our number of external visitors mounted, and as our focus on method-development increased, a variety of factors related to efficiency, educational needs, and experimentation made it increasingly desirable to have an ICP-MS in our own lab.

The substantial contributions that an in-lab ICP-MS makes to our ability to achieve our lab's research, innovation, and educational missions, include:

1. Our new facility shares lab space with existing equipment, and is in the same building as the PI and manager's offices. This makes it possible to multi-task while analyses are running, perform routine maintenance, and perform analyses when the manager has other obligations throughout the day. The machine we used previously is housed in a facility that is not on the main campus, and has no nearby available parking. This meant that transport to and from the facility was non-trivial, and made multi-tasking difficult.
2. The new machine is optimized for the types of measurements and analytes used in our research. This means that we can significantly reduce the analysis time (> 50%), and use the most efficient sample preparation methods possible for our work, saving significant time. The machine we previously used was optimized for different types of samples, and required substantial set-up time prior to our analyses.
3. We designed our new facility to be able to accommodate our development of new methods. Some of the materials we experiment with will introduce potential pollutants into the machine, and/or must be dissolved in very strong acids. Because the previous machine did not belong to us, we did not feel comfortable experimenting with these types of materials. These machines can suffer significant loss of sensitivity after analyzing large amounts of certain elements (like Fe). Because we were one of many users, we could not risk affecting other users. This also highlights that the needs of a lab can change over time, and that strategies for sustainability must be able to evolve.
4. Because of the proximity of the new machine to the offices and other lab facilities of the research group, it is easy to train students on the new machine. Not only is it possible for shorter training sessions interspersed throughout the day that can fit in between classes, meetings, and other responsibilities, but it can also be timed so that inevitable mistakes do not disrupt other users.
5. The new machine is small and relatively easy to repair and maintain. Most of the repairs and routine or preventative maintance can be accomplished by the lab manager, without the need for external service engineers or expensive service contracts. Because our research group has a full-time, dedicated lab manager, this should help reduce down-time. Down-time negatively affects our fiscal stability, with unpredictable delays in analysis making it difficult to attract or retain outside clients.

We suggest that university approaches to instrumentation be flexible in accordance with lab goals and the reality of centralized facilities. The recently established "Shared Instrumentation Network" has provided a valuable database of the enormous range of expertise and analytical capabilities that reside in multiple departments, research institutes, and schools across campus.

This network will undoubtedly facilitate future research and education, as well as communication among labs across campus. We feel that the success of analytical facilities at CU will require multiple approaches, and that the most effective way to support the research, innovation, and educational goals of the University is to find mechanisms to help each lab define and achieve their individual goals and needs.