Mass laboratory exercise on distance

M. Alsved, and J. Löndahl, *Ergonomics and aerosol technology, LTH*

***Abstract*— How can an experimental laboratory exercise at distance be arranged for over 70 people? We asked ourselves that question when we developed a new course for health care personnel during spring 2021. We sent material for a laboratory exercise by mail to each of the participants in advance, they carried out the experiments at home and reported their results in an online document. The allocated time during the joint course meeting was used to discuss the method, the results and the experiment in general.**

***Index Terms*— commissioned education, distance course, hands-on training, laboratory exercise, flipped classroom**

I. Introduction

TEACHING of theoretical knowledge in online courses is relatively straightforward, but laboratory exercises at distance are challenging. Practical hands-on training cannot fully be replaced by video demonstrations. “What we have to learn to do, we learn by doing”, to quote Aristotle. Here we describe an attempt to transfer an advanced laboratory lecture to the home environment for a large group of course participants. Could the learning goals be achieved and were there benefits of the new approach that may be used in future, also when physical presence in the laboratory is allowed? [1]

II. COURSE DESCRIPTION

A. Course syllabus

The purpose of the course Transmission of infectious diseases via droplets and aerosols (MAM015F) is to provide the participants with an overview of airborne transmission of infectious agents in various environments and to give them knowledge on methods to detect and prevent airborne spreading of such agents.

The course had been provided previously for PhD students within the field of infectious diseases, but not as a commissioned education targeting health care personnel. As Covid-19 travel and working-from-home restrictions were still present, the course was provided completely digitally over three full days. Participants who were enrolled in a PhD education could get 2 credits if they completed one pre- and one post-course assignment.

B. Course development

The course was developed during the Covid-19 pandemic upon request from infectious disease medical doctors and financers who thought that it was urgent to increase knowledge in this area among medical practitioners. Lectures were given by invited experts in infection medicine, infection control, virology, clean room technology, ventilation and history of infectious diseases. We included several tasks where participants contributed actively, such as frequent discussions in smaller groups during lectures, a panel discussion, a digital laboratory exercise using a modelling tool, and a longer group discussion on a topic of their own choice.

III. Laboratory exercise description

Since we cannot see, smell or touch the microorganisms that are present in the air, we risk to neglect them. The objective of the laboratory exercise was to visualize airborne microorganisms and to give hands-on training of sampling techniques. During the course occasion before the pandemic, this was achieved by use of advanced instrumentation at the LTH Aerosol laboratory.

For the new home laboratory exercise, we instead had to use the simplest available detector of airborne microorganisms. Five petri dishes with nutrient agar were sent by post to the participants the week before the course. Participants were instructed to expose the petri dishes in different ways in their homes, incubate them, and then count the mold and bacterial colonies that had grown (Fig 1).

During the course, participants shared their data in an online document, where it was automatically visualized in diagrams. They compared the results within smaller groups and discussed the choice of methodology and analysis, the generalizability of the results, the need for positive and negative controls, and the number of samples needed to answer a certain question. After the group discussions, the same questions were discussed in whole class.

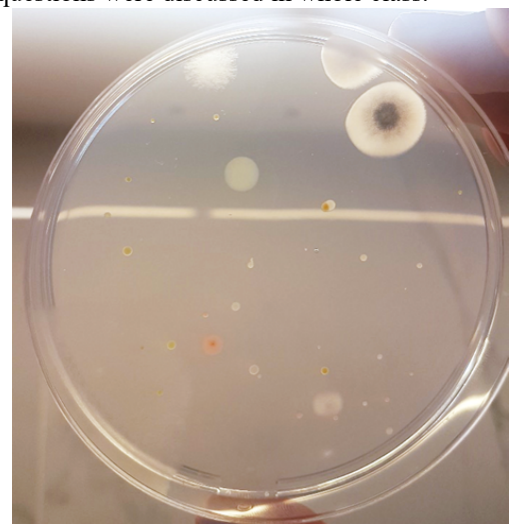

Fig 1. Picture of microbial growth on an agar plate

IV. Outcome of the home laboratory

Of the 71 participants who received a home laboratory kit, 62 (87%) completed the task and reported their results in the online document. The discussions in the groups were vivid, and the participants were amazed (and disgusted) to

see what was in the air they breathe every day. We lack specific evaluation of the home laboratory exercise; however, the course was rated 4.7 in the evaluation (scale 1-5, 63 respondents), and a dozen participants commented that it was particularly fruitful with practical exercises.

V. Reflection on the concept of home laboratory exercise

We assumed that practical experience of microbial air sampling would improve understanding of sampling techniques beyond what could be mediated through an ordinary lecture. We also thought that practical training would make it easier to relate to applications in the participant's own occupancy. Compared to the use of advanced instrumentation on site, the simplicity of the home laboratory exercise might in fact have had at least similar educational value. Simplicity has been shown to enhance generalization [2]. An indication of this was observed in the following virtual demonstration of advanced instrumentation, where the questions indicated good understanding.

Although simple, the experimental home task made it possible to obtain practical experience of basic but crucial concepts such as contamination, blank samples, measurement uncertainty and importance of sterile sample handling. Since the participants performed the task prior to the course, we used the time during the course to discuss. This flipped classroom strategy for a laboratory lesson appeared to support student engagement, although we have not been able to carry out a controlled comparison with a traditional laboratory exercise for the same audience [3]. The flipped classroom approach has primarily been explored for other types of home studies such as textbooks and video material, but it seems to work well also for laboratory tasks.

One potential advantage of the home exercise is that each person has to manage on their own from the instructions. This gives an increased possibility to self-pace and a feeling of accomplishment if successful. Another advantage is that the home lab could help contextualize the methodology, making it easier to see possible applications [4]. Home labs could also contribute to engaging family members in science, promoting future scientists, as seen by Kennepohl [4].

The outcomes of virtual labs have been debated, however Hawkins and Phelps [5] saw no difference in conceptual understanding from a virtual to a hands-on laboratory. Though not evaluated, the authors suggested that students taking the hands-on laboratory had learned to use the apparatus in the laboratory, and would therefore be more likely to be able to perform the experiment again [5]. Thus, a well-designed virtual laboratory could be as good as a hands-on laboratory for conceptual understanding, however, for practical understanding, practice is needed.

In the context of online education during covid-19, the lack of social factors and student-student interactions seem to have decreased motivation, leading to learning difficulties [6]. Despite the distance format of our course and the individual home lab exercise, the course evaluation indicates that the joint discussions in groups compensated for this.

VI. Other reflections from the course

Giving this course digitally made it possible for participants to attend from all parts of Sweden, the majority being medical doctors and nurses within hospital hygiene. It is likely that we would have had less course participants if the course were on site.

As this course was directed to medical professionals within the field, the participants had extensive previous knowledge on the subject. It was acknowledged in the course evaluation that many participants enjoyed the discussions with the others who had similar or different experiences as themselves.

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