Practical microbiology in schools: a survey of UK teachers

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Microbiology has a century-long tradition of commitment to science education [1], relying heavily on practical activity in its teaching. Since the introduction of the National Curriculum in the United Kingdom 1988, the content of microbiology in schools has undergone some changes and additions. For example, the Education Act 1996 highlighted the need for education on HIV/AIDS and sexually transmitted infection, with a more recent push to include PCR. Despite this, practical activity in schools is in decline for a variety of reasons (cost, time, curriculum issues, class size etc.) [2]. Some have even suggested that microbiology as a subject is undergoing a change in direction, from the 'classical' techniques to a more molecular focus, and is potentially losing its identity as an individual science [3, 4].

A recent report [5] found that among the activities that encouraged/discouraged students from school science, the opportunity to conduct experiments, and a chance to learn subjects relevant to the real world as well as science aiding future study/career options were positive motivators. An increase in young students interested in any subject will hopefully result in an increased number of researchers and other professionals in years to come. Thus microbiologists of today should play a role in the promotion of their subject in order to maintain its health for the future [6].

There is little evidence available that reveals the extent to which practical microbiology is being performed in schools, and the issues, if any, that prevent teachers from delivering practical microbiology. Thus, a questionnaire-based survey was circulated to over 700 teachers (teaching ages 11 to 18) in the UK, receiving 248 responses. The survey focused on three areas:

- Were teachers carrying out practical microbiology activities in schools?
- What were the perceived limitations in delivering practical microbiology?
- To what extent was practical activity valued in teaching microbiology?

It was hoped that results would indicate how practicing microbiologists could help to ensure that microbiology in schools remained relevant, stimulating – and indeed present at all. The majority of respondents (77%) considered science practical activity in the classroom extremely valuable and 67% of respondents also found practical activity valuable in the teaching of microbiology. Practical microbiology was utilised by 65.7% of teachers. The activities cover a variety of different topics (n=37), ranging in subject and skill level. Five activities mentioned were not microbiology (investigating animal cells, plant cells, blood smears, DNA extraction from fruit, and cloning cauliflower). The relevant activities addressed a range of principles of microbiology, biology, and science in general (Figure 1). The majority of activities mentioned used bacteria. However, 10.2% used yeast or fungi, with a small number using algae and bacteriophage (1.5% and 0.5% of activities

respectively). It was heartening to note a significant presence of microbiology in the school laboratory.

All respondents stated that they faced at least one limitation to delivering practical microbiology in the classroom (Figure 2). Equipment was the most frequently cited limitation (47.6%), followed closely by financial constraint (41.5%). An autoclave and an incubator were considered essential for microbiology practical activity. Both of these items are 'benchmarks' for the science laboratory in secondary schools [9];nevertheless alternatives can be found (pressure cooker and room temperature incubation). A recent survey [10] on resourcing practical science at secondary level provides further evidence that teachers have widespread problems with equipment and finance. It found biology to be the poorest resourced science taught in English secondary schools (particularly insufficient quantities of working equipment available to perform effective practical work).

Data from our survey suggest significant differences between those teaching 11-14 (n=191) & 14-16 (n=202) and 16+ science/biology (n=144). Although the latter find finance as a limitation, they continue to deliver practical microbiology nevertheless (Teachers not carrying out these activities did not consider finance to be a limitation). Those teaching 16+ did not suggest finance as a limitation, but instead highlighted a number of other issues which included confidence in technique, equipment, technical support and health and safety concerns. The activities carried out at 16+ education were of a higher skill level (for example using plant extracts to investigate antimicrobial action and PCR), compared to 11-16 , where the activities were predominantly 'classic' in nature, with a lower level of skill (for example culturing on agar and practicing aseptic technique). These findings suggest that there is a recognition that more expertise is required for higher level delivery.

The Society for General Microbiology (SGM) is one of the largest learned societies promoting microbiology. It provides significant support to teachers in microbiology education via a school membership scheme. The survey investigated whether school membership affected delivery of practical microbiology. The data suggest that non-members of SGM were significantly more likely ($P<0.05$) to find equipment, technician support and reliability/reproducibility a barrier to their use microbiology, compared to members. This finding clearly demonstrates the value of appropriate professional support for the delivery of microbiology in schools

Overall, although the educational benefit of practical microbiology was acknowledged throughout the survey, many teachers encounter difficulties with relevance to the curriculum, and deliverability. Results of the survey indicate that teachers hold certain misconceptions about the excessive cost, technical difficulty, reproducibility/reliability and health and safety aspects of performing

microbiology in the classroom. All of these limitations can be addressed by using trusted and tested practical resources, and by following the advice given by professional bodies and organisations that endeavour to aid teachers in improving practical science in the classroom.

In a 'free text' section of the survey, teachers noted that although students enjoyed the subject of microbiology as a whole "the National Curriculum (NC) chokes creativity" (one comment), with another teacher suggesting the NC does not provide the time for practical microbiology, possibly restricting student's interaction with the science. However, such views are ill-founded: microbiology is well represented in the National Curriculum and teaching specifications [11]. In addition, microbiology offers a range of opportunities for teachers to utilise microorganisms to demonstrate other phenomena, for instance, using algae to demonstrate photosynthesis and the effects of pollutants, or yeast to demonstrate gas cycling [12].

Thus, there are two audiences keen to increase their encounters with practical microbiology – teachers and students. One way to address this need is to provide effective two-way communication between subject 'experts' and teachers. It is important that teachers (especially those who may not be biology/microbiology specialists) are encouraged to utilise microbiology in the laboratory. Professional practicing scientists, who understand the subject, should be able to provide this support. The Reward for their efforts should also be significant. By getting involved in the development of inspirational school practical science which illustrates concepts required by the NC; troubleshooting when problems are encountered, , and ensuring relevance and impact to the world at large the number of students who become interested in the field should increase. Hopefully, this will result in more microbiologists and researchers in years to come. Thus, professional microbiologists should be prepared to play a greater role in the promotion and delivery of their subject in schools in order to maintain its health for the future.

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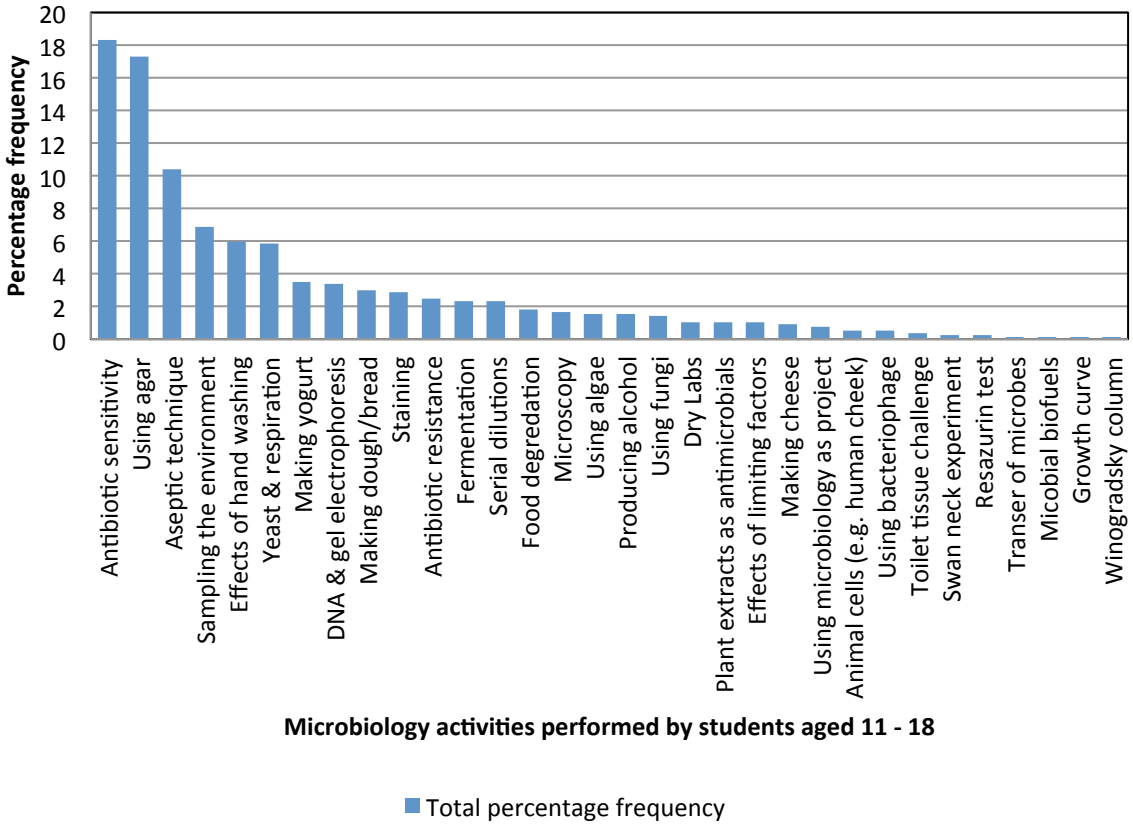

Figure 1 - - A bar chart representing the percentage frequency of the 37 activities mentioned in response to the question 'Do you teach practical microbiology? If yes, what type of activities do you carry out?'.

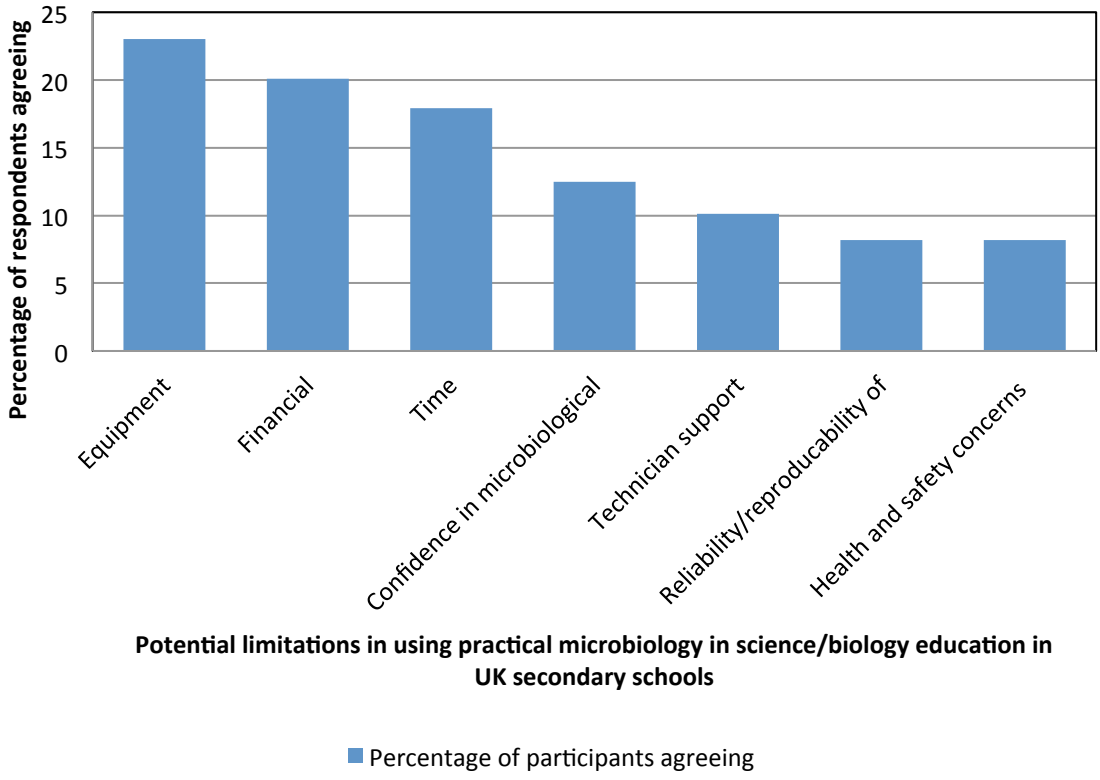

Figure 2 - Percentage frequency of the number of agreements when asked if any of the variables listed limited their teaching of practical microbiology