Implementing tailor made digital material on a laboratory course to enhance student learning

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Introduction and Justification

Laboratory teaching is a well-established teaching format in science education programs. The general perception is that it promotes student subject learning as well as scientific and practical skills. However, reaching intended learning outcomes (ILOs), using laboratory teaching, are not straightforward and is to a high degree dependent on well design exercises and the teacher´s pedagogic ability (Adams, 2009).

A practice course is integrated, into the oral microbiology course (5 ECTS), for students attending the odontology program (becoming dentists), during their 4th semester. The course is divided into 5 modules, including lectures and SAU-teaching. The laboratory part is mandatory. The students, 86 in number 2024 and approximately 105 in number 2025. perform during seven days eleven different exercises. The extent of the different exercises varies and some exercises are ongoing for several days. The students work, depending on exercise, in groups of two or four. The size of a class is approximately 16-18 students with one instructor.

When the course is given, the students have had less than 10 days, during their education, of laboratory teaching. Subsequently, the students enter, for them, a quite unfamiliar environment − comprising new techniques, procedures and apparatus. Unlike students attending more science related programs, there is no main objective aiming that dentist students should become skilled in working with various techniques in the laboratory. The laboratory class is a complement to lectures and SAU-teaching and the main purpose is to illustrate and promote a deeper learning of the underlying theories i.e. develop their conceptual

understanding (Augustin, et al., 2022). However, when students focus on following laboratory manuals, there is a risk the intended objective fails. A major part of the student´s capacity is busy of understanding the practical parts, i.e. alien procedures and material.

The aim of the project was to produce short video-based instructions, showing procedures and new material, that the students will encounter during exercises of the practice course. The intended outcome was that the produced material would support the students when performing experiments so they can focus more on ILOs. The purpose with produced material was that it can be used before exercises for preparation, during exercises as well as after, when writing reports and/or when study to exams. The overall aim was that the video material would promote deeper learning.

Methods

Planning and producing laboratory instruction videos

Initial meetings were arranged, with the other three instructors of the practice course, in order to find a consensus which elements/exercises that should be recorded. We identified three themes, collectively termed new digital material in this report, as potential video material. First, videos focusing on presenting material, second, videos showing the procedures and third, general videos e.g. showing how to handle waste products. The project was done in collaboration with Anne Kirkegaard and Jonas Nilaus Vilhelmsen from the Centre of Online and Blended learning. Jonas is digital media producer and did all photographing, filming, editing as well as adding voice to the videos. Five working days of Jonas time were available, without costs, for the project. Furthermore, Prof. Daniel Midjord-Belstrøm had been granted 20000 DKr from KU for “pulje til undervisningsudvikling med digitale elementer” to cover costs for the project. Jonas suggested that the “presentation of material” should be presented as pictures and corresponding text, i.e. pdf-format, instead of videos. The scripts were written in table-format, which made it possible to synchronize, the scene, the lines, camera target and texted material in the videos.

Evaluation rational

The new digital material was evaluated in three different ways. The students´ views were collected through a questionnaire and a focus group interview and teachers´ opinions with a variant of the Delphi technique. The developed questionnaire (inspired from evaluation of courses on the Bachelor and Master Program at KU), comprised 6 questions (Appendix A). Four of them were recorded by using the six graded scale (to a very high degree, to a high degree, to some degree, to a lesser degree, not at all and do not know). The questionnaire (paper format) was given last exercise day and time to answer the questions was reserved.

All teachers (n=4 including myself) did the Delphi evaluation (Appendix B). Four questions were sent 3 days in advance. A meeting was held where the teachers viewed the answers from the other teachers and noted if they agreed. The material was analysed for consensus in views and compiled.

Three volunteer students conducted the focus group interview, less than three weeks after the practice course. I was moderator and notes were taken, to avoid distractions, by a person (secretary in profession) not directly related to the course. The open-ended questions (Appendix C) covered three themes i.e. laboratory teaching, the new digital material and aiming for deeper learning and reach the objectives for exercises. The participants got 1-2 minutes per theme to reflect on the questions (displayed on a monitor), before a discussion between the students were encouraged.

Results

Produced new digital material

Altogether, 12 videos were produced, 11 corresponding to the procedure theme and 1 to the general theme (Appendix D – videos with links)**.** The "presentation of material" part, covering all relevant exercise elements with pictures and complementing text, were added to the respective exercises in the practice guide. Furthermore, direct links to the videos were inserted in connection to the presentation of each exercise (Appendix E – day 1 of the practice guide). Prior to the start of the

practice course, the new version of the practice guide was published on Absalon. The new digital material resulted in reorganization of the briefings held previously in connection with exercises. The briefings were shorten down and previous demonstrations removed.

Outcome from the evaluation

The answers from the questionnaire showed a very high satisfaction degree from the students of the new digital material (Figure 1).

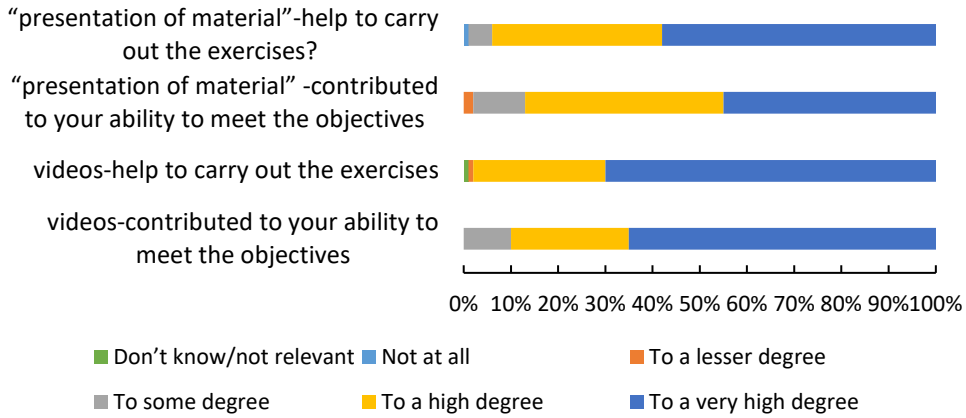

Fig. 1. Students´ responses from the questionnaire. 83 responded out of 86 students on the course.

A total of 94% answered that the "presentation of material" had either to a high degree or to a very high degree been a help to carry out the exercises. The same question regarding the videos resulted in 98%. Furthermore, 87% and 90% stated that the "presentation of material" and the videos, respectively, had contributed to their ability to meet the objectives of the exercises. 73% answered they had seen all videos and 19% that they had seen between 7 and 10 videos. Interestingly, 65% stated they watched the videos both before and during the exercises (Appendix F). In addition, in the comment field of the questionnaire, aiming for constructive criticism, 19 students expressed their undivided positive attitude to the produced material and 17 students responded with suggestions for improvements. The two dominating suggestions were that videos should be made for the remaining exercises (7 students), and all videos should be available at one place, beside the practice guide, on Absalon (6 students). The latter suggestion will be implemented next year.

Comments, from the Delphi evaluation, found to be shared among the teachers, regarding what they liked with the "new digital material" are listed in Table 1. Only partial agreement was reached for negative aspects with the new digital material (included in Table 1).

Table 1. Comments from Delphi evaluation with teachers (some comments are translated from Danish to English).

Aspects you like with the "presentation of material" and videos (consensus).
Flexibility for the students - the material can be used when it suits the students.
Help the students to avoid technical mistakes.
Can be used by the students during studying to the exam.
The instructions are distinct.
The high satisfaction level from the students.
The material is well balanced with not to many unnecessary details.
We can show things that was not possible before.
The students were oriented about what to use and how to use it.
The material made it possible for the students to work more independently.
Generated more time to discuss relevant things with the students.
Aspects you think were or can be negative by using the "presentation of material" and videos (partial consensus).
The students that not have watched the videos before the exercise need some extra help to get started, because we have excluded major parts of the introductions.
The new material does not necessarily promote to an increased level of reflection from the students.

Interestingly, the teachers agreed that the exercise “Orale Streptokokker” had gained most with the new digital material. The exercise comprises a biochemical test system for identification of streptococcal species.

Students´ responses, from the focus group interview, stressed the importance of the practice course. One student said: “I got much more understanding”. Other comments were: “The exercises help you to remember – you do something active. You do not remember a slide in this way” and “The lab work really helps you to see what is essential, even if the lab work itself is not fun”. The latter comment emphasize that laboratory work is of secondary interest for most dentist students.

The students had not experienced laboratory exercise videos on previous courses. One student shared a memory from a laboratory course on 2nd semester: “Many mistakes were conducted during the exercises and it had been frustrating”. Accordingly, the students underlined that the new digital material contributes to performing the exercises correctly and save time. The students remarked: “You get an overview and at the same time you can see details regarding performance” and “The videos could in a short time give an overview and capture the most important parts. You do not get this through reading the practical guidance” and “We (students) are under time pressure. We attend many other courses, when something is not working, one goes home and forget”.

Regarding how the videos enhance the learning process the students responded: “The new material take away the burden of practical difficulties and make you focus on the essential things” and “You get tired by reading practical guidance. You get more motivated with videos”. Furthermore, “You are done faster, and thus have more time to interact with each other”.

All teachers had noted the use of videos during the exercises. The questionnaire indicated the use of videos to a high degree both before and during the exercises. According to the students in the interview group the videos were used to prepare for the practice sessions. A student said: “Best outcome was when everybody in the group had looked at the videos in advance”. The students were unanimous that it would not be necessary to watch videos again e.g. for exam preparation.

Before the questions of the last topic i.e. aiming for deeper learning and master the objectives stated for exercises, a student elaborated on what deeper learning meant for her: “The knowledge remains for a longer time”. Bloom´s taxonomy of thinking was not familiar to the students, but they knew that active methods and practice was important to gain deeper learning. The formative feedback applied by the teachers, i.e. talking to each group individually regarding their results were highly appreciated, and an important complement to the videos that enhanced the learning outcome. A student said: “Videos cannot replace face to face” and “More is not always better”. The latter comment referred to choose the most essential material when you teach and not add too much of everything.

Regarding the final question of the group interview, i.e. the most important take home message for the teachers in development of the laboratory course, the students´ answers were: “To make the practical parts as easy and available as possible” and “To release time for reflection and discussions with teachers”.

Discussion

A few students suggested, from the questionnaire survey, that the videos should also include the underlying theory. One of the key assumptions, in the project, was to focus just on showing the execution of exercises. The core of the project follow the cognitive constructivism theories, to promote students to gain new knowledge by stimulating active learning techniques (Shiland, 1999). The essential content and objective will become more available, by making the exercises easier to perform. The laboratory work leads to a “product”, a result, that should be analysed, interpreted and reflected based on the current knowledge of the student in order to obtain deeper learning. The tailor made digital material contribute to that fewer mistakes are done and likely promote students´ engagement, an important factor for reaching deeper learning. Deeper learning in this context does not mean aiming for highest levels in Bloom´s taxonomy (Andersson *et al.* 2001). This would not align with the ILOs of the course and exercises. Many of the ILOs of the course align at the level of master understanding. However, by applying, be

active, discuss with peers and later get formative feedback from the instructor, will subsequently fuel the foundation of Bloom´s pyramid i.e. remembering and understanding. A new feeling and understanding for the field of study will be reached.

The data, received from the three evaluation surveys, complement each other. The questionnaire resulted in solid information (97% frequency of course participants) of students´ attitude to different aspects about the new digital material. The Delphi evaluation sought among other things unbiased convergence, regarding positive and negative effects experienced by the teachers. It was interesting by itself, but the different surveys made it possible to find similarities or differences between the two groups i.e. teachers and students. In the focus group interview the project could be put into larger context, i.e. views about laboratory teaching and students insights in deep learning. Furthermore, it was possible to go deeper or emphasise views obtained from the questionnaire e.g. when videos were used or if it was a disadvantage with the lack of demonstrations and longer briefings before exercises. Procedures that have been applied on previous classes.

Making videos is a time consuming process and to reach qualitative productions there is a need for financial resources and special competences. It has been found that students generally have a positive attitude regarding videos as teaching form, especially practice videos (Kruse *et al.,* 2023). The concept aligns with a modern learning style. The quality will have an impact on students´ satisfaction. Short and effective videos, i.e. well planned and edited, are appreciated according to the interviewed students.

There is a paradox, in investing resources in producing teaching material that do not directly provide content, correlated with well-defined learning outcomes. The new digital material just support the students with the upcoming laboratory activities.

With regard to limitations in this project, it lacks analyses and measured effects of e.g. exam results or quizzes and regarding enhanced learning outcomes. In addition, we did not have a control group of students without the new digital material. The teachers´ views have in this respect a unique position, since they can relate to previous classes. In discussions with my department supervisor we concluded that the new

digital material do not guarantee that the students reach the ILOs. Other teaching strategies are essential e.g. face to face feedback as well as report writing (García-Ros and Alhama, 2023). Report writing is applied on the course on the more comprehensive exercises. Report writing is an example of a post-laboratory activity. Pre-laboratory activities directly in combination with exercises have been low on the practice course. According to the students´ feedback, it seems the new digital material can take a position in this matter.

Conclusion

The new digital material, implemented in the practice guide, were appreciated by students and teachers. It helped the students to familiarize themselves with the laboratory material and procedures. The flexibility for the students increased e.g. when and where to use it and the possibility to prepare and reflect. The students could work more independently during exercises, they made fewer mistakes and this likely promote their motivation. The time available, for reflection of the intended purpose of the exercises, increases. However, the new teaching material does not automatically provide deeper learning to the students. The instructor´s pedagogic skill, providing formative feedback in a constructivist manner and other teaching strategies are still essential for a successfull learning outcome. With larger classes of dentists in the education pipeline, I believe more of these digital learning strategies, particularly on other practical courses, would be of great value.

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APPENDIX

A

Student evaluations of new digital material - Questionnaire

Your opinion is important to us. Therefore, we hope that you will participate in a short evaluation regarding the new elements in the practice guidance (øvelsevejledning) i.e. the "presentation of material" and videos. It will only take a couple of minutes to complete the questionnaire.
Your and your fellow students' answers are anonymous. All answers are an important contribution to the ongoing work with quality assurance and development of oral microbiology course.

1. To what degree do you experience that the "presentation of material", i.e. pictures and complementing text in the practice guidance (øvelsevejledning), has been a help to carry out the exercises?

❑ To a very high degree ❑ To a high degree ❑ To some degree
❑ To a lesser degree ❑ Not at all ❑ Don't know/not relevant

2. To what degree do you experience that the "presentation of material" has contributed to your ability to meet the objectives described for the exercises (see if necessary relevant objectives in the introduction of each exercise in the practice guidance)?

❑ To a very high degree ❑ To a high degree ❑ To some degree
❑ To a lesser degree ❑ Not at all ❑ Don't know/not relevant

3. Have you watched some of the video material provided in the practice guidance?

❑ Yes, 1-3 video/s ❑ Yes, 4-7 videos ❑ Yes, 7-10 videos ❑ Yes, all videos ❑ No

4. When have you watched videos (more than one alternative is possible)?

❑ Before the exercises

❑ During the exercises

❑ After the exercises

5. To what degree do you experience that the videos, provided in the practice guidance, have been a help to carry out the exercises?

❑ To a very high degree ❑ To a high degree ❑ To some degree

❑ To a lesser degree ❑ Not at all ❑ Don't know/not relevant

6. To what degree do you experience that the videos, when provided, have contributed to your ability to meet the objectives described for the exercises (see if necessary relevant objectives in the introduction of each exercise in the practice guidance)?

❑ To a very high degree ❑ To a high degree ❑ To some degree

❑ To a lesser degree ❑ Not at all ❑ Don't know/not relevant

7. I will suggest the following improvements of the "presentation of material" and/or the videos:

B

Teacher evaluations of new digital material - Delphi survey

Write up to three aspects you like with the "presentation of material" and video material.

1.

2.

3.

Write up to three aspects you think were or can be negative by using the "presentation of material and video material" on the course.

1.

2.

3.

Was there a specific video or presentation of material" element that you found particularly useful in supporting the students? Do you have any explanation of your observation?

Do you think there is a need of complementing with videos and in that case which elements/exercises shall the video/s cover?

C

Student evaluations of new digital material - Focus group interview
Topics, questions and discussion points

Laboratory teaching
How much laboratory teaching have you had during your education?
How justified do you think laboratory teaching is on the oral microbiology course?
What do you consider the reasons for using laboratory teaching on the oral microbiology course (pedagogic point of view). Challenges?

Videos (new material) - as a complement in teaching
What do you see as the main purposes and benefits of using videos in teaching (general)?
Any disadvantages (general)?
How does above align with the new material on course?
Videos versus briefing. Is briefings in the course lab good?
Was there a specific video or "presentation of material" element that you found particularly useful/supporting?
The videos as pre and/or post lab material?

Aiming for deep learning and master the objectives (formal)
The video concept to promote deeper learning
Can/should the videos be complemented with other teaching strategies to promote deeper learning. How?

End question
Of all the things we discussed, what do you think is the most important take home message for us teachers regarding development of the laboratory course?

D

Table showing produced videos and links

Theme	Name and link to produced video
General	Affaldshåndtering
Procedure	Introduktion til mikroskopi med lysmikroskop
Procedure	Forberedelse af præparater til Gramfarvning inkl. flammefiksering
Procedure	Gramfarvning
Procedure	Fugtigt præparat
Procedure	Tæt og trinvis spredning
Procedure	Gram positive kokker A – procedure
Procedure	Gram positive kokker B – procedure
Procedure	Orale Streptokokker B - Api Strep del 1
Procedure	Stereomikroskop
Procedure	Orale Streptokokker C - Api Strep del 2
Procedure	Dyrkning fra tandoverflader og tungeryg A - procedure

E

Day 1 in the new version of the practice guide – shown as an example. Text form fields indicate where new digital material have been inserted.

DAG 1

MIKROSKOPISK KARAKTERISERING AF BAKTERIER OG GÆRSVAMPE

ØVELSE A

Formål: At lære hvordan de mest almindelige bakterier og gærsvampe ser ud på et Gram-præparat: At give indtryk af mikroorganismers farve, form, størrelse og lejring.

Deltagerantal: Man arbejder sammen i hold på 2 deltagere (2 mikroskoper).

Videos: Affaldshåndtering
Introduktion til mikroskopi med lysmikroskop

Materiale: Kasse med 5 præparater (a-g)

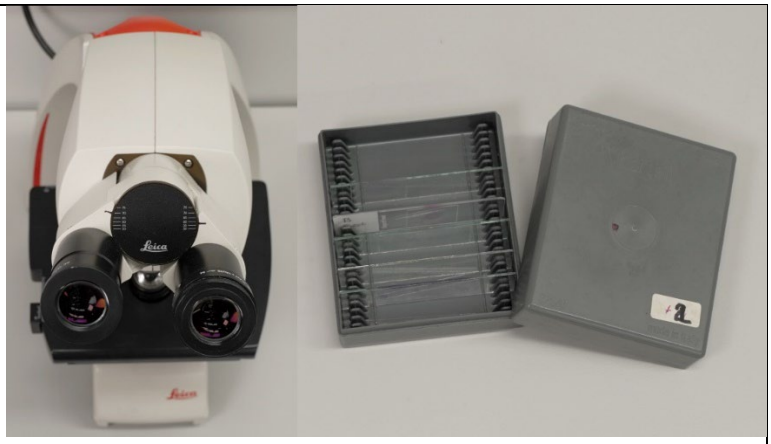
a) *Staphylococcus aureus* Gram+ kok (hobe)
b) *Eschericia coli* Gram- stav, mellem
c) *Streptococcus pyogenes* Gram+ kok (kæde)
d) *Candida albicans* (gærsvamp)Gram+, stor rund/oval
g) *Lactobacillus casei* Gram+ stav, mellem

Links to videos inserted in the uppdated practice guide (see also øvelse B)

Below: Presentation of new material, i.e. text and pictures (see also øvelse B)

I denne øvelse skal du bruge et lysmikroskop til at kigge på form, farve, størrelse og lejring af forskellige bakterier og gærsvampe

Du skal bruge denne kasse som indeholder 5 objektglas med 5 forskellige mikroorganismer"



Procedure: Mikroskopi med brug af olieimmersionsobjektiv (x 100) gennemgås.

Præparat a-g mikroskoperes. Bemærk farve, form, størrelse og lejring på de enkelte præparate

ØVELSE B

Formål: At lære at fremstille præparater til mikroskopi, som kan bruges til indledende diagnostik af bakterier og gærsvampe

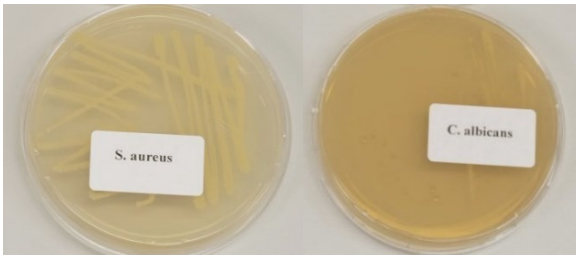
Deltagerantal: Man arbejder sammen i hold på 2 deltagere.

Videos: Forberedelse af præparater til Gramfarvning
Gramfarvning
Fugtigt præparat

Materialer:
a) 6 objektglas, 3 dækglas
b) Kultur af *Staphylococcus aureus* (A) på agarplade
c) Kultur af *Proteus mirabilis* (B) på agarplade
d) Kultur af *Candida albicans* (C) på maltagar

.

I denne øvelse skal du høste bakterier fra en agarplade og fremstille et fugtigt præparat og et Gram-farvet tørt præparat af tre forskellige mikroorganismer, som du derefter skal kigge på i dit lysmikroskop.	

Du skal bruge 6 objektglas og 3 dækglas, som du finder i din æske på bordet.	
Derudover skal du bruge i alt 3 agarplader – en med hver af følgende mikroorganismer - *Proteus mirablis*, *Staphylococcus aureus* og *Candida albicans.*	 

F

Graph showing students´ response of question 4 (questionnaire) - When have you watched videos (more than one alternative is possible)?