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Use of Tablets for Instruction and Learning in Microbiology Labs

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Abstract
In the Bachelor Programme of Biomedical Laboratory Analysis at University College VIA, the students work in a classified microbiology laboratory. This means that they are not allowed to bring their personal computers into the lab. Until now the students have used paper based lab instructions and taken notes by hand. Use of tablets in the lab offers new opportunities. In September 2012, nine tablets were introduced into one of the labs of the college. Groups of students use the tablets to access documents, watch video instructions, and to document results and procedures digitally. The objectives of this project are to develop a technological infrastructure to support students’ work in the lab and to develop teaching and learning resources. Our research question is: How is teaching and learning in the laboratory influenced by the tablets and the following multimodal teaching and learning materials? The empirical part of the project has been documented through field observations in the lab (in writing and with photos). We have found the following to be characteristic of the work of the students: the students use the tablets collaboratively, take more photos than requested, use the video based instructions, use the internet access, and combine the use of tablets with paper based instructions.

Keywords
Tablet, biomedical science, laboratory, learning, teaching

Introduction
This project is relevant because of the political agenda in Denmark and the strategy for VIA University College (VIAUC strategy), which focus on an increase in the use of ICT in teaching and learning. Apart from the political agenda there were several other good reasons for implementing tablets into the microbiology laboratory:

- The students work in a classified microbiology laboratory on campus. In a classified laboratory the student has to follow certain regulations to minimise the risk of spreading infectious agents outside the laboratory. This means that the students are not allowed to bring their own laptops into the lab; a requirement, which in the past has made use of ICT in teaching and learning difficult. The introduction of tablets into the laboratory now makes that possible.
- Until now the students have used paper based lab instructions and taken notes by hand. Subsequently they have worked with their handwritten materials in the form of notes and drawings, when they prepared their group reports afterwards. The tablets enable the students to document various results and procedures digitally with photographs and video recordings.
- Until now the lecturer in the laboratory has given instructions to all students at the beginning of each lecture, e.g. “the procedure for the Gram stain”. Picture 1 below shows a normal laboratory instruction. The lecturer sits at the desk demonstrating the different steps in the procedure. It is difficult for the students to observe the details because of the layout of the laboratory. The use of the tablets makes it possible to watch instruction videos when the students are about to perform “the Gram stain”.
- The size and mobility of the tablets make it easy for the students to bring it to the different work stations in the laboratory e.g. the chemical fume hood. In addition the tablet is easy to disinfect compared to a laptop.
- When our students graduate, they will meet technology with a variety of interfaces in their workplaces since paper no longer is a part of the work in a hospital laboratory in Denmark. The use of tablet computers in the microbiology laboratory trains the student’s ability to use other interfaces than the one they know from their personal laptop.

**Picture 1:** Instruction from lecturer to students in the lab

This paper deals with the following three questions, which will be used as the structure of the three main sections of the paper (Theoretical framework; Methodology; and Discussion):

- How to develop a technological infrastructure to support students’ work in the lab?
- How to develop teaching and learning resources for the tablet?
- How is teaching and learning in the microbiology laboratory influenced by the tablets and the multimodal teaching and learning materials?

Mang and Wardly (2012) say about the use of tablets for learning purposes, “Because the technology had only recently become available, there is only a small amount of literature surrounding the academic applications of this technology” (2012, p. 302) and most of the literature has focus on the tablet as an individual device in the classroom. Orinn et al. (2011) found the following, “From our study it is clear that the number of applications developed to run on the iPad are principally targeted at the consumption of content within various media and not necessarily the creation or collaboration of that content” (2011, p. 48). In this study, we focus on the use of the tablet as a shared device, where students are expected to watch instruction videos and collaboratively create various products using different modalities (text, photo, video).
Theoretical framework

For the purpose of this study, we understand learning as an individual cognitive and psychological process, which takes place as an interaction between the individual and the surroundings, as described by e.g. Illeris (2006). By 'surroundings' the author means all the materials and people that the learners interact with as a part of the learning process (Illeris 2006). The students interact with the materials in the laboratory, including the tablet, and the lecturers and the other students.

Developing a technological infrastructure to support students’ work in the lab

For faculties considering adopting tablets as a mandatory component in their classrooms, Colin et al. (2012) recommend that they should know everything about the tablet operating system and decide how the tablet is to be used by the students, and describe the features. They also recommend working closely with the Information Technology department in your institution, and considering how to distribute the tablets (Colin et al. 2012). In this project we were familiar with the iOS operating system used on the iPad. We decided how we wanted the students to use the tablet in the laboratory so that it could be a relevant part of the students’ work there. Via the Internet connection of the tablet students had access to the college LMS, where they could watch instruction videos, pick up laboratory instructions and save a copy on the tablet. The students could then write and insert photos in their personal copies of the instructions. In addition, we wanted to make use of the built-in-video recorder in the tablet. We decided that the tablet should provide access to a camera app, a video app, and an editing opportunity. The tablet should also enable export of the students’ results from the laboratory to their own laptops so they could continue the work with their results from the laboratory. The tablet also provided access to e-mail. We assisted the students with the tablets in the laboratory when they attended the first lesson, and we had written a one page document about the use of the iPad for the students to read before the first lesson in the lab. This document was also available in the laboratory. We did not involve the IT department for technical assistance because the tablets stayed in the laboratory, and we would assist the students ourselves with the few technical problems, which occurred during the lessons.

Developing teaching and learning resources for the tablet

Mang and Wardly recommend that the lecturer designs activities that make use of the Internet connection of the tablet and its ability to let the students share information and collaborate, because it will enrich the students’ learning experience (2012). In this project we planned student-activities where the students had to work in groups of 2-4 around one tablet. We re-modelled the laboratory instruction so the students could write text and add photographs when they were in the laboratory.

In addition to this we produced two instruction videos. The instruction videos were produced with textboxes to explain the demonstrator's actions instead of a soundtrack, so that groups could play the videos without disturbing other students. The videos had to be accessible from the laboratory and from the students’ laptops at home, so students could use them in preparation for the lessons in the microbiology laboratory.
Link to the video instructions (in Danish):
Preparation for gram stain:
http://www.youtube.com/watch?v=HY2kCr01Yxw&feature=youtu.be
Gram stain: http://www.youtube.com/watch?v=VRYqVK4-RsU&feature=youtu.be

Methodology

Research questions

- How to develop a technological infrastructure to support students’ work in the lab?
- How to develop teaching and learning resources for the tablet?
- How is teaching and learning in the microbiology laboratory influenced by the tablets and the multimodal teaching and learning materials?

Setting the scene

The Bachelor Programme of Biomedical Laboratory Technology at University College VIA is a 3½ years programme, which consists of 14 modules. Almost all modules include teaching both at campus and in hospital laboratories. The students are typically between 20 and 30 years old, the majority being female. Attending the programme is free of charge, but they have to buy their own textbooks, and they are also requested to bring a laptop to college every day. Lecturers at VIA University College create study plans on the basis of the study regulations and the curriculum, and have a certain degree of freedom of choice in relation to which themes, books, resources, and students’ learning activities they use in their teaching. The decision to bring tablets into the microbiology laboratory can be seen as one such pedagogical decision made by the lecturers.

In the autumn of 2012, twelve tablets were introduced into the microbiology laboratory at VIA University College. We provided the groups with a base model iPad 2 with 16 gigabytes (GB) of storage capacity.

In the lab

The students read the lab instructions as a home assignment before the lessons in the lab. The students work in groups of 2-4 persons in the lab around one tablet with digital access to lab instructions. The lecturer demonstrates various procedures to the students, e.g. plating of bacteria. The students watch instruction videos and work with various procedures, e.g. the so-called gram stain. During their work they take notes, document their results, and take photos. Some students may record videos. The tablets stay in the laboratory, which means that the students need to e-mail their products to their own e-mail addresses and upload their video to the Internet. After the lessons they prepare and hand in a group report.

Participants in the study

Two classes (60 students in total), one lecturer per class, and two observers participated in the study. Each group of 2-4 students received a tablet when they entered the microbiology laboratory. Anecdotal evidence and observations of students in the classrooms suggested that many of the
students were already familiar with the iOS operating system from using iPhones. A few students owned an iPad prior to the course.

Research design

The students were observed in the laboratory during 12 lessons. The observations were documented in writing and with photos. To find out how other researchers had implemented and evaluated the use of the tablets for learning purposes, we used ERIC for our literature search. We read all abstracts and selected five articles that we found relevant for this study.

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Table 1. Results from literature search

Findings

The analytical focus was on the students’ learning experiences with the tablets, which meant that the observers focused in particular on the students’ meta-communication related to the multimodality of the tablets and their roles as producers of material during the lab work.

The use of the tablet for reading the laboratory instructions

The students started using the tablets immediately, without prior training, and the tablet quickly became a part of the workplace (pictures 2, 3, 4). The students read the laboratory instructions and used the scroll and zoom functionality on the tablet. They used the tablets collaboratively, took turns, and helped each other. They talked about the procedures that they were about to perform. Picture 3 shows how the students bring the tablet to the various workstations. Photo 4 shows the students combining the use of tablet, paper based instructions, and paper for taking notes, indicating that they use a combination of modalities. The students cannot bring paper into or out of the lab, which means that they have to take a photo of their notes and e-mail this to their own e-mail addresses.
The use of the tablet for watching the video instructions

The students used the video-based instructions: “Preparation for gram stain” and “The gram stain” to a great extent (pictures 5, 6). In the laboratory the students watched and paused the video in parallel with carrying out the procedures. Some of them said, “It is very clever with such a video, I hope they will make more”, and ”Where is the video for the next procedure?”. Some students used the paper-based instructions in combination with the video instruction.

The use of the tablet for documentation of results

The students were asked to document some of their results with photos (pictures 7, 8, 9). They took more photos than requested, and some of the students said, ”We should take a photo of it”, “Just to remember”, and “It’s a pity that we can’t take photos in the microscope – now we are getting used to taking photos”. One student said while capturing a photo, "It is easier for us, when we can use the iPads ...".
The students were also asked to write texts about their laboratory results on the laboratory instruction sheet (pictures 10, 11, 12). At the end of the microbiology lessons, the students e-mailed the instruction with their personal annotations and photos to their individual e-mail accounts for access outside the lab. The lecturer helped the students with this e-mail procedure the first time. Afterwards they were able to do it themselves. Problems arose when students had placed too many photos in the document that they wanted to e-mail or the Internet connection was off.

The use of the tablets for recording videos

Some students used the tablet for recording videos (pictures 13, 14, 15). They recorded each other performing a skill, and afterwards discussed the result, and occasionally they made a new video. Video recording was not mandatory, and only about 1/3 of the student groups captured videos. We had technical problems with the upload of videos from the iPads; a fact that may have prevented some students from engaging in this.
General observations

We observed that students used the tablets more than asked to by their lecturer, e.g. to take extra photos and to look up technical terms on the Internet. In addition, they came up with ideas for improving the use of the tablets in the microbiology laboratory. Some students mentioned that they would like to capture microscope-photos, download a timer-app and a Dropbox app to their tablet.

The students’ work in the laboratory took as long time as usual (meaning before the introduction of the tablets). The lecturers express that they are less busy than usual, especially around the gram stain procedure. Furthermore they observed that the reports they received from the student groups contained photos of a high quality, and the theoretical parts and analyses of results were better than usual, e.g. with fewer errors and at a higher professional level.

Discussion

How is teaching in the laboratory influenced by the tablets and the multimodal teaching and learning materials?

One result of influence on teaching is that the lecturer is less busy during the microbiology lessons. When the students can “help themselves”, because they have access to the video instructions, the lecturer has an opportunity of differentiating teaching in the laboratory. The lecturer can teach more and guide the students who have difficulties in demonstrating the right skills, managing the different tasks, or even reading the instructions. When the laboratory instruction is available on the tablets, the lecturer does not need to produce updated paper-based and laminated instructions for every class. This means that the lecturer is less busy preparing for the lessons.

Teaching is also influenced in the way that students hand in reports with photos rather than their own drawings of lab results. It is easier for the lecturer to understand the formulations concerning the results in their group reports, which means better reports. This makes it easier for the lecturer to give feedback and to assess the students’ work.

A third way the teaching is influenced concerns the quality of what the students e-mail from the laboratory to work on for the reports. When the students have time to write notes for their reports in the laboratory and also have the opportunity to ask the lecturer questions, the quality of their work improves.

A fourth way the teaching is influenced is by the videos produced by the students. The videos give them an opportunity to evaluate their own skills, when they watch the videos together and
discuss their actions. Now, not just the lecturer is assessing the students’ actions in the lab. The students can teach and evaluate each other as well, which means that the lecturer can spend more time with students who need further assistance and instruction. Some of the students watched their own videos and discussed them in the lab.

How is learning in the laboratory influenced by the tablets and the multimodal teaching and learning materials?

One of the ways learning is influenced is by the fact that students collaborated in the laboratory, they read the instructions together, talked about the procedures, helped each other, and took turns with the tablets for writing and taking photos. The students were generally positive about the use of the tablet. In contrast, other researchers found that “The main drawbacks of tablet technology include the difficulty of typing on the keyboard, which is simply projected on the lower portion of the screen, and also the difficulty of writing or drawing with one’s finger-tip” (Colin 2012, p. 303). This was not a problem in our study, maybe because the students only had to write down results and notes during the laboratory lessons.

Learning was also influenced in the way that the students’ work in the laboratory involved the use of different modalities. The students took photos, recorded videos, watched the instruction videos when they needed too, read instructions on the tablets, and took notes on the tablets. Some of the students even read the paper-based instructions and wrote notes on paper as well. This shows that the students use different and even multimodal approaches in their learning process when it is possible. The tablet can support these different approaches as well. In this way the students can choose their preferred way of working, and the learning process then becomes more student-controlled. These findings agree with Rossing (2012) who found that “when using the iPads, students can access visual material such as videos or photographs (...) in an activity that appeals to tactile, visual, and auditory learners“ (Rossing 2012 p. 16).

We found that the students used the video instruction in the lab to a great extent, which meant that the students could “help themselves” in the lab and were not dependent on what they could see or remember from the live instruction at the beginning of the lesson. Crocker et al. (2010) came up with similar findings using instruction videos in connection with students’ work in the laboratory. Crocker’s students often arrived at practical sessions with no clear idea about the techniques, the skills, or the underlying scientific principles. So the lecturers created instruction videos and allowed students to preview the practical assignments beforehand, as we did. They found that the videos enabled students to become more autonomous and efficient learners in the laboratory, and that it allowed more time during the practical sessions for higher level interaction with demonstrators (Crocker 2010). We have similar findings, e.g. in the fact that the students were better prepared than usually for the “gram stain procedure”. The students said that they would like to have access to more video instructions in the laboratory. We find that it will be a good idea to produce more video instructions for use both at home and inside the microbiology laboratory.

With the tablets, students can document their results in a more authentic way than before. One student expressed the opinion that the use of photos “makes it easier for us”. The students do not have to make drawings or describe what was seen on the plates to document the look of the bacterial growth, and they can use the time they save on this to produce notes for the mandatory report, to discuss deviations from theory, and to ask the lecturer any questions that may arise. When the students can write a part of the text in the laboratory, there will be supervision from the lecturer for this part, and also less homework. We observed that the reports were better than usual, e.g with
fewer errors and with a higher professional level, perhaps because the students produced a more thorough rough draft of the group report in the laboratory than they did before the tablets was introduced.

The students’ video productions give them an opportunity to have a conversation about how to perform a skill, and about what is important in connection with this specific skill. When watching the video afterwards, they see for themselves how they actually perform. They get an opportunity to reflect upon their actions in the lab. Pereira et al (2012) have used student produced audiovisual reports in a physics programme, and concluded that one of the advantages of this was the responsibility assumed by the students, since the video they produced would be watched by others. In future we will ask the students to produce videos for the digital notes in laboratory techniques and then lecturers will use students’ videos in the teaching of the class in the ordinary classroom, e.g. for repetition. In this way, the videos produced will be used by other people. Pereira et al (2012) concludes that it is advantageous to use audiovisual reports rather than traditional reports because it may enhance the students’ imagination and creativity, and may also have implicit cognitive aspects. The use of students’ video production in the laboratory, maybe with speech and editing, will give students an opportunity to be more creative and autonomous in their learning process.

In general the students were positive about using the tablets, and they did not experience problems with the tablets that could not be solved immediately by the group of students or the lecturer. Typical problems would be that the tablet was not connected to the Internet, that the documents they wanted to e-mail contained too many photos, and that the students’ mailboxes were too full to receive mail. The students brought the tablet to the different workstations, as we expected. We also found that the use of the tablet was not time-consuming, as the work in the laboratory took as long time as usual. This was an important finding because the work in the microbiology lab should primarily be about microbiology. In addition the students came up with ideas for improving the use of the tablets in the microbiology laboratory.

This study is limited by the exclusive use of the Apple iPad 2. We believe that our findings regarding mobile tablets are applicable to other tablets on the market. As this study used observation of 60 students in the laboratory for a limited number of lessons, the extent to which our results can be generalized may be limited.

**Conclusion**

Our overall conclusion is that the use of the tablet had positive effects on both teaching and learning, as summarised below:

The teaching is influenced in the way that the lecturer is able to differentiate teaching in the laboratory, because the use of instruction videos saves time that can be spent on students who need extra guidance.

The learning is influenced in the way that the students work in a collaborative way; the learning process is more student-controlled; the students can choose different approaches or multimodal approaches to learning in the laboratory, and the students’ learning products (their group reports) are better with the use of tablets in the lab.

In this project it was not mandatory for the student to record a video. In future we will ask all the groups to record videos of different skills or procedures they perform in the laboratory, which can be shared in the LMS or the digital notes in laboratory techniques and used in the teaching of the theoretical part of the subject with the students in an ordinary classroom. In addition we will make it mandatory to capture and reflect on videos from the laboratory.
References