Organization of e-learning resources in a teaching app

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ABSTRACT: We have developed a teaching app, which collects and organizes e-learning modules consisting of text, pictures, sound, video clips and quizzes. The goal has been to create an e-learning tool that fosters student active learning and at the same time copes with increased student class sizes and unchanged teacher density. The specific application "e-ZFapp" uses zebrafish as a model organism in research and teaching. The app has been tested on NMBU's veterinary students since 2016 and has given good results. By organizing teaching in an app, it has been possible to practice flipped laboratory course teaching. Students use the app for preparation, as a tool during the course and for repetition.

1 INTRODUCTION

1.1 Student active learning in the laboratory

In Parliamentary proposition 16 (Meld.St. 16 *Kultur for kvalitet i høyere utdanning*), the Norwegian government advocates teaching methods where the student has an active role and encourages the use of digital work tools and technology where possible and appropriate. Active learning increases undergraduate student performance in science, technology, engineering and mathematics (STEM) courses compared with traditional lecture-based approaches. In a meta-analysis of 225 studies, Freeman and co-workers (2014) found that average examination scores improved by about 6% in active learning sections and that students in classes with traditional lecturing were 1.5 times more likely to fail than were students in classes with active learning. The studies included in the meta-analysis were directed toward class sessions as opposed to laboratory courses. Within biomedical studies, laboratory courses in the basic sciences are a major component of teaching contributing both knowledge and skills to the student's course outcome. A successful outcome for a laboratory course requires the active participation of the student both before and during the course. A successful laboratory course is a "flipped" course with well-prepared students performing the planned tasks and able to discuss the concepts and implications of the course with the course instructors during the course. Poor performance in a laboratory course can often be traced to inadequate preparation by the student or insufficient guidance available for the student (Loveys and Riggs, 2019).

Active learning involves engaging the student in their own learning. The focus of educational authorities and Universities on digitalisation has encouraged the use of e-learning tools in undergraduate education and the educational use of digital technology is a priority area at Norwegian University of Life Sciences (NMBU, www.nmbu.no). Digitalisation of learning resources can make learning modules readily available to students, many of which are relevant to laboratory courses including text, pictures, sound, video clips and quizzes. The widespread use of mobile telephones and app technology provides a format to organize and bind together diverse e-learning resources of a course that is familiar to students and readily accessible.

1.2 Zebrafish in basic sciences

Zebrafish has established itself as an experimental animal with ever-growing use in new research environments, from biomedicine to aquaculture (Aleström et al., 2006). Zebrafish (*Danio rerio*) is a small common aquarium fish derived from freshwater streams in northeast India-Pakistan. Properties such as small, robust tropical fish, easy to keep and multiply in aquariums, a transparent embryo that evolves from fertilized egg to hatched fry in 2-3 days have helped the zebrafish become a popular research model for embryo development in vertebrates. Zebrafish is one of the world's most defined model organisms, with over 70% of the genes common to humans and it is gradually replacing mice and rats as an experimental animal with ever-new uses, as in biomedicine with many disease models (neurodegenerative, cancer, infections and chronic diseases). The genetics and biology of this model fish have been thoroughly studied, and thousands of mutants and transgenic lines have been generated and characterized and are now available to the research community. These resources are also available

to the education community and zebrafish have been used in educational courses at secondary and university level including large laboratory courses (D'Costa and Shepard, 2009).

2 METHODOLOGY

Embryology and cell biology are basic sciences taught in the first semester of veterinary science curriculum at NMBU. The principles and development stages of vertebrate embryology are presented with focus on species of veterinary interest, principally domestic mammals and fish. The broad thematic areas of cell biology include amongst others the presentation of gene technology, genotyping and an introduction to the ethical considerations of biotechnology and experimental animal handling. Laboratory courses are a compulsory component of the curriculum and 70 students participate in the courses. To increase the active role of students in the laboratory course, a laboratory course based on experimental investigation was designed to combine embryology and genotyping.

2.1 Experimental investigation in a laboratory course

A fundamental biological concept is the relationship between genotype and phenotype. The phenotype of an individual is influenced by genetic and environmental factors. The laboratory course consisted of an experiment in which the embryos of two genetically distinct lines of zebrafish were exposed to optimal and suboptimal temperatures for development (Figure 1). Regular observation of embryo development over 48 hours mapped the changing phenotypic appearance of embryos before genotype analysis distinguished the genotypes of the zebrafish lines.

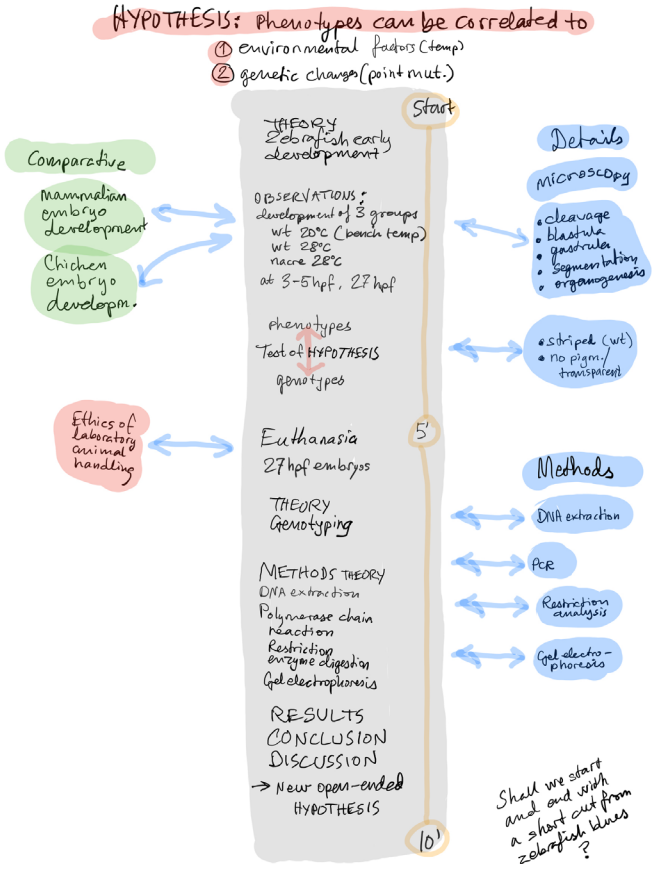

Figure 1. Experimental investigation in laboratory course design

The laboratory course in embryology and genotyping is conducted over three practical sessions. The first two 3-hour sessions are held 24 hours apart to follow early embryo development. The third laboratory session uses DNA collected at the end of the second laboratory session to determine the genotype of the zebrafish lines. The DNA can be stored, and the third practical on genotyping using PCR can be executed at a later suitable timepoint.

2.2 e-Learning modules

In collaboration with the Learning Center at NMBU, e-learning modules were created to assist the student to prepare for the course and to support the student during the course (Table 1). Short video films were made to introduce the laboratory course and to provide guidance for each of the laboratory procedures included in the course. In addition, short video films, picture archives and animations were made to provide theoretical background and reference material to support the course. In the current version of the laboratory course, 24 digital modules have been created to support the laboratory course.

Table 1. e-Learning modules available for Embryology and Genotyping laboratory course

Module	Title	Number
Short video films	Instruction videos	12
Short video films	Theory/background videos	6
Text and pictures	Quizzes and picture archive	5
Animation	Zebrafish embryo development	1

2.3 Teaching app as an organizational tool

In collaboration with the Learning Center at NMBU, an app was created to be an organizational work tool for the laboratory course (Figure 2). The app provides the student with the sequence of activities in the laboratory course and gives access to the appropriate supportive digital modules. The Zebrafish APP is available at App Store, Google Play and can be used from the Internet website *zebrafishlab.net*.

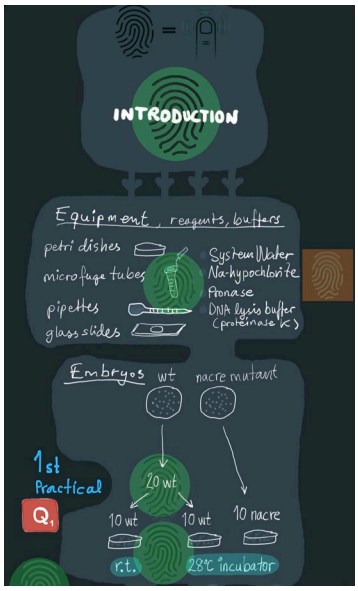

Figure 2. The Zebrafish APP functions as the laboratory protocol and provides access to supportive digital modules.

2.4 Student surveys

To obtain feedback on the use of e-learning work tools in the laboratory course, the students were given a survey to complete at the end of the laboratory courses in 2015 and 2017. The survey consisted of 12 statements asking the student to rate their experience of the laboratory course and digital work tools on a scale from 1 (fully disagree) to 5 (fully agree). The students were also provided with the opportunity to comment on the course.

3 RESULTS

3.1 Use of e-learning modules and the Zebrafish APP in laboratory courses

The digital supportive modules were made available online to first semester veterinary students at NMBU for Cell biology laboratory course in Embryology and Genotyping in 2015. The students had access to the online video films as preparation before the practical sessions of the course and conventional "PowerPoint" presentations were shown during the practical session to guide the student through the tasks. The Zebrafish APP was available in 2016 for the Embryology and Genotyping courses at NMBU. All information and guidance for the course was available through the APP. No additional presentations or handouts were given to the students. The 70 students were organized in 14 groups of 4-6 students. Teachers (2) were present during the course and available for discussions with the students, and for answering questions if required.

Following the completion of each laboratory course, the digital modules were modified to improve their presentation and use.

3.2 Student experience of Zebrafish APP

Student surveys conducted following the completion of the laboratory courses in 2015 and 2017 show that student acceptance of the digital work tools is high. In 2015, 40 of 70 students responded to the survey and 80% of these students agreed or strongly agreed that the course met their expectations. In 2017, 48 of 70 students responded and 88% agreed or strongly agreed that the course met their expectations. In 2015, 83% of students agreed or strongly agreed with the use of online video films while only 68% agreed or strongly agreed with the use of conventional PowerPoint presentation. In 2017, 88% of students agreed or strongly agreed with the use of the APP and agreed that the APP was helpful for them to perform practical tasks (88%) and for theoretical, background and reference material (91%). The initial online quizzes in 2015 were not well received (35%) but the improved quizzes in 2017, which were incorporated into the APP were better received (61%).

4 REFLECTIONS

The use of digital technology, an app, to organize e-learning modules for a large laboratory course was well accepted by the students. The seventy (70) first semester veterinary science students at NMBU used the app and its associated digital modules to guide them through three practical sessions in embryology and genotyping. With the information and instructions available on the app, the student groups were able to work independently during the three large practical sessions. The two (2) teachers present during the laboratory course were able to communicate with the students during the course at the individual or small group level and direction at the whole class level was minimal. The focus of discussions between teacher and students were more related to the biology under investigation rather than to the performance of tasks, which was inspiring particularly for the teachers. The app and the digital modules that it organized enabled a flipping of the laboratory and the benefits that this educational approach delivers (Loveys and Riggs, 2019). The wider use of this digital technology and app has been advocated for life science education (Aleström and Press, 2016a; 2016b) and for the zebrafish research community (Aleström and Press, 2015; 2017).

The students used the app before the laboratory session to be better prepared and they also used the app during the laboratory sessions to increase their independence in performing the laboratory tasks. The ready availability of instructional videos greatly reduced the need for guidance to be given to the students during the practical sessions. For other conventional laboratory courses in biochemistry and cell biology conducted during the first semester of veterinary science at NMBU, the student class is divided into two classes of 35 students and laboratory courses are run twice. The numbers of teaching staff available for

laboratory courses are a limited resource and experience with the use of the Zebrafish App is that a high student:teacher ratio in a laboratory course can provide high quality teaching.

Digital technology is advancing rapidly, and the implementation of apps and the creation of digital learning modules require highly competent technical support. The Zebrafish App was created with the active collaboration of the staff and resources of the NMBU Learning Center. The students showed high acceptance of digital teaching resources, but they also had high expectations as to the digital solutions. Student surveys conducted after completion of the laboratory course revealed that poorly performing modules such as the early quizzes were not well accepted. The successful introduction of digital technology into university teaching is dependent on the technical support and competence of university learning centers. The digital modules need to be maintained and technical solutions upgraded so that the students receive a digital experience that is comparable to non-educational digital resources.

Although it is difficult to obtain objective measures of learning outcome from an individual laboratory course within a larger study program, the teacher experience was that the use of an app to organize digital learning modules improved student understanding and increased student engagement in learning.

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