

Linn Ansteensen Haugli

LearnPathology

An Educational Software

Graduate thesis in Medicine

Supervisor: Marit Valla

Co-supervisor: Cecilie Våpenstad

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Norwegian University of Science and Technology
Faculty of Medicine and Health Sciences
Department of Clinical and Molecular Medicine



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An Educational Software

Master thesis, spring 2023

Medical student

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NTNU

Kunnskap for en bedre verden

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1.0 Introduction

This thesis will present and describe my contributions to the development of the digital learning tool LearnPathology. My main task was to create a quiz solution in the program, and to make quiz questions for the gynecological histology course in collaboration with my main supervisor. The thesis is written as a process report, where I present the work I have done in the project until June 2023.

1.1 Conventional Microscopy Teaching

Before I started at NTNU, I studied medicine in Budapest, Hungary for one year. In Budapest, the teachers used conventional microscopy in histology and pathology teaching, and often drew tissue structures on the blackboard. The students then tried to identify the same structures in the section before drawing them in their own histology and pathology “drawing book”. The students used pink and purple pencils to match the staining in the section, and often used a histology atlas to help identify the structures. The students often needed guidance on how to use the microscope.

Conventional microscopy teaching at NTNU, prior to the pandemic, were held in a designated microscopy room where each student had a microscope, and a box of sections. There were 75 students and only one university teacher in the class. In the microscopy courses, the teachers usually started the class with an introductory lecture to give an overview of the topic. After the lecture, the teachers would instruct the students on how to examine the selected sections in the microscope. The students’ sections were similar, but not identical to the section used by the teacher. The students often needed one-to-one feedback from the teacher, to understand what they were looking at, and to adjust the microscope to get a clear view of the section. Learning histology and pathology requires practice and guidance, but to practice on their own before or after the microscopy courses, the students would have to turn up during the teachers’ work hours to borrow a box of sections to study in a microscope. With digital microscopy, the sections can be made accessible for students anytime and anywhere. A digital learning tool may

also motivate students to practice more, thus increasing their understanding of histology and pathology.

1.2 Digital Pathology and the Covid 19 Pandemic

In diagnostic pathology, there is an ongoing transition from conventional to digital microscopy. This transition takes place in Norway, as well as globally. In 2016, the Pathology Department at St. Olavs Hospital in Trondheim got the digital pathology solutions in place as one of the first hospitals in Norway. Digital pathology is now an integrated part of the department's routine diagnostics.

Only a few medical students will later specialize to become pathologists, but a good understanding of the processes that lead to illness is important for all doctors. Furthermore, many doctors will receive reports from a pathologist, and to give their patients the right follow-up and treatment, they need to understand the report. The diagnostic transition from conventional to digital pathology soon also took place in teaching. In 2015, the Teaching Unit for Anatomy, Pathology, and Forensic Medicine at NTNU started scanning the glass sections used in microscopy courses in histology (normal tissue) and pathology. A few years later, in 2017, these scanned sections, the whole slide image (WSIs) were organized into a database intended for use in the digital, web-based program OlyVia®. In OlyVia®, the WSIs were organized into folders based on different organ systems, and further separated into histology and pathology. Using OlyVia®, you can select WSIs and view them at different magnifications, similar to what is done in a regular microscope. Not all students and teachers adopted it, mainly due to challenges getting access to the program, digital barriers, the program's user-friendliness and robustness with several simultaneous users.

For several years, both teachers and students have given feedback that the teaching groups in the microscopy courses are too large, and that one teacher is insufficient to handle all the questions raised by the students. The Grimstad Report (1) indicates that there will be even more medical students in the years to come. A higher number of students in the future is

therefore a challenge that must be solved. Dividing the students into smaller groups in the microscopy courses may be a solution, but this would further increase the workload for each teacher and create capacity problems for use of the microscopy room. Digital teaching methods could be an alternative solution.

The program (Olyvia®) that the students and teachers currently use for teaching, has limited functionality. The teachers can use the program to display sections but lack user-friendly solutions for marking sections, and options for interactive learning. By developing a new digital learning tool adapted to the needs of students and teachers, we could facilitate even better microscopy teaching. Digital solutions could possibly ensure more standardized teaching and more equal learning outcomes for students in central and decentralized campuses. Some of the medical students at NTNU spend two years of medical school in Levanger Hospital as part of the decentralized study program (2). There are no pathologists in Levanger, and teaching pathology to these students has therefore been challenging. Starting fall 2023, some students will also move to Ålesund to take part in decentralized teaching there. Ålesund has a pathology department, but currently lacks teacher resources to handle the microscopy courses. They are therefore currently depending on digital microscopy courses made by teachers in Trondheim.

When the Covid pandemic hit the world in 2020, it made a major impact on the way teaching at schools and universities was organized, but also offered an unprecedented opportunity to evaluate current methods of pathology education (3). Like the rest of the world, students at NTNU were used to going to physical lectures on campus, but suddenly, they had to stay at home. The university teachers converted their teaching methods from teaching in classrooms, to teaching online. This change happened very quickly, and for regular lectures, converting to a digital platform was manageable for most teachers. For the microscopy courses, the need for rapid conversion to a digital course was more challenging, as the students and teachers could no longer meet in the microscopy room. All teachers now had to teach histology and pathology using digital pathology and the program Oylvia®. The pandemic introduced significant challenges for students and teachers, but it also led to great advances in the way histology and

microscopy were taught. At the beginning of the pandemic, most teachers used PowerPoint presentations with WSIs of sections. These presentations were often held in real time on Teams, Skype, Zoom and Blackboard. Later, many teachers started using PowerPoint with voiceover, and the students were instructed on how to examine and describe the different sections used, with arrows and pointing functions. The PowerPoint with voiceover was made available in Blackboard, and the students could download it, and go through it as many times as they wanted. This gave the students the opportunity to listen to parts of the lecture several times if a topic was complicated, and they could listen to the whole lecture again for repetition before their exams.

During and after the pandemic, digital pathology has increasingly been introduced to students parallel to the conventional teaching methods. The digital solutions have provided the students better access to microscopy and facilitated better self-studies. The students gave positive feedback to the changes that were made, and teaching prizes were given to the teaching unit leader for all efforts during the pandemic. Nevertheless, teachers still acknowledged the need for further improvement of the digital microscopy courses and felt that OlyVia® lacked several desired functions. Inspired by the need for a better program, and the recent successful development of another digital pathology software, FastPathology (4), teaching unit leader Marit Valla came up with the idea to make LearnPathology. LearnPathology is a new digital learning tool intended for teaching histology and pathology. It is currently under development by the cross-disciplinary research group AICAN (Artificial Intelligence and digital pathology in CANcer) (5). AICAN includes researchers, clinicians, social scientists and technologists from NTNU, St. Olavs hospital, Levanger Hospital and SINTEF. The LearnPathology project is financed by IKOM, NTNU; NTNU Toppundervisning; and the Directorate for Higher Education and Skills.

LearnPathology will contain a collection of WSIs similar to what was accessed in Olyvia, as well as learning material comprising lectures, courses, and quizzes, with interactive solutions for teaching. In the LearnPathology project, the cross-disciplinary team works in iterative processes with monthly meetings where the focus is on user-input and evaluation of technology solutions.

During the project period, which is currently planned for until 2024, the research group will develop the learning tool and prepare, implement and evaluate student activating teaching activities in the microscopy courses at the Faculty of Medicine and Health Sciences at NTNU. Teachers at the University of Bergen are included as collaborators in the project, and interest has also been shown from teachers at other universities in Norway. The software is web-based and available on pc/phone/tablets via a website without the need of installing or downloading a program. Availability, user friendliness and formative feedback are key to software development.

1.3 Student Activating Learning

Active learning is a teaching strategy that engages students to take a more active part in the learning process (6). These strategies are based on different types of methods, exercises and other tools that are supposed to activate the student to improve the learning outcome. Active learning helps motivate and improve the students' thinking and writing, and further develops their ability to reflect (7). A simple way to activate students in a traditional class could be to ask the students to pause for a couple of minutes to discuss a task with a partner. In this way the students can discuss the learning material and process it before moving on to the next topic.

Problem based learning (PBL) is another example of a student activating learning method (8). PBL is an instructional method, where a case is presented at the beginning of the lesson (9). The problem or the case, is meant to provide the context and further create motivation to learn (9). At NTNU, PBL is used regularly as part of the mandatory teaching from the 1st until the 4th year. Approximately two or three hours are reserved each week to discuss a medical case in a PBL session. In every PBL meeting, a teacher or a student facilitates the group's PBL activities. Each semester the students are divided into a new group for the actual semester, which rotates the next. Switching groups helps develop the student's cooperation skills (10).

Team-based learning (TBL) is a student activating learning method based on teaching in three different phases: preparation, skills insurance and application (11). In the first phase, the students prepare for the class, by reading relevant theory, watching a video, writing or answering questions etc. The second phase, the skills insurance phase, consists of the Individual Readiness Acceptance Process (iRAT), the team Readiness Acceptance Process (tRAT) and a mini lecture (12). Firstly, the students will conduct a multiple-choice test individually, based on the preparation material. Then, in the tRAT the students conduct the same test as a group. Lastly, the teacher will go through the answers in plenary and supply and answer whatever questions the students have. The teachers end the second phase with a lecture. In the application phase, the students work together in groups to acquire a deeper understanding of the curriculum. One of the main goals using TBL in teaching is for the students to achieve increased learning outcome through working with the syllabus in different ways, both individually and in groups (11).

A mix of individual work, group discussions, and discussions in plenary is shown to be an effective learning method for health professions students (12). It promotes an active learning process, good learning outcome and develops skills in teamwork and communication. The purpose is to activate students in their work and learning process, primarily in close collaboration with others.

Flipped classroom (FC) is a student activating method where the students study the learning material before the class (3). It is also called “inverting a classroom”, because the course / learning material are introduced to the students outside of class (13). The students spend their in-class time demonstrating knowledge, doing exercises and discussing challenging parts of the learning material, often in small groups (3, 8). The purpose of flipped classrooms is to engage learning on a deeper level (13). One example of a way to activate the students further is “collaborative learning” (14). Working in this way, students either work in pairs or in small groups teaching each other by correcting misunderstandings and finding solutions to problems.

By using this strategy in active learning, the students will, among others, develop a higher level of thinking as well as self-management and leadership skills.

Formative feedback is feedback while learning as opposed to summative feedback, which is given after e.g., an exam (15). Formative feedback helps teachers focus on student learning and enables them to understand the limits of their own knowledge and how to improve (9). In a digital learning tool, formative feedback could be used to give students digital, automatic feedback, for instance after identification of a structure in an image, or after answering a question in a quiz. The student would then receive instant feedback on whether the answer was correct or not, without involving the teacher (16). Student activating methods could improve the students' learning outcome (9) improve their self-confidence and give them a higher degree of autonomy in the learning process (7). Digital learning methods and technological solutions can make students more engaged in the learning process (17). In pathology education, digital alternatives can increase student participation and at the same time enable teaching more medical students at the same time (18).

2.0 Methods

2.1 Development of LearnPathology – a cross-disciplinary approach

In the LearnPathology project, teachers, students, social scientists, an interaction designer and developers collaborate in iterative processes. The group has monthly physical meetings and continuous email correspondence. In our monthly meetings, the developers demonstrate the newest changes, and the functionality and layout are discussed in the cross-disciplinary team. In the end of the meeting, we agree on what is the next step and what needs to be done before the next meeting. Continuous email correspondence helps us agree on important issues that occur between meetings. As the developers have improved and created different solutions, the monthly meetings can be used for testing functionality before giving direct feedback to the developers.

2.2 Transferring WSIs for creation of the LearnPathology database

As part of the team, I helped in the process of transferring the WSIs from the OlyVia® database to the new LearnPathology database. Two separate Excel worksheets were used; one for the already scanned WSIs with their premade names and slide box numbers as they appeared in OlyVia®, and one sheet for the new systematization of the WSIs in LearnPathology. If some of the necessary information was missing, this information was added to the new LearnPathology excel sheet. The WSIs were renamed and systemized according to organ type, and then further divided into either the histology or pathology category. A detailed description of the WSI was provided, including information about the type of specimen, diagnosis, grading, staining etc. Finally, the developers transferred the WSIs with updated information into the LearnPathology database. The database will be quality checked by a pathologist at a later stage. A separate LearnPathology server has been purchased for storing the database.

2.3 Main task for thesis: Creating a quiz solution in LearnPathology

In the process of deciding on which types of questions to include in the quiz solution, the developers first created 10 different question types that were presented to the teachers and students. We focused on making the quiz solution ease the learning process for the students, making the question types intuitive, motivating and fun for the user. The solutions were tested by the developers and presented to the users, and after several cross-disciplinary meetings and discussions, a selection of question types was chosen and included in the software. In April 2023, we had a workshop in our monthly LearnPathology meeting. The two medical students in the project, NTNU teachers, developers and an interaction designer at SINTEF participated. Everyone got the opportunity to make their own course and quiz questions in LearnPathology. Technologists were available if the teachers and students needed assistance, but the goal was to test user friendliness and whether the solutions were intuitive and self-explanatory. At the end of the meeting all participants gave constructive feedback to the developers for further optimization of the program.

Valla's lecture "Microscopy course - Histology Female Genitalia and Menstrual Cycle" was used as the starting point for my development of a gynecological histology quiz in LearnPathology. Annotations of the preselected WSIs were first made, naming structures that the students should learn to recognize. Based on these annotations, quiz questions were made in collaboration with the main supervisor. The questions are presented in the results section. Students and teachers worked closely with the developers to achieve the best possible solution, and to identify errors and limitations to the functionality for the users. The student perspective was considered carefully, through the work presented in this thesis, and through another project resulting in a second LearnPathology thesis this semester.

3.0 Results

3.1 Question Types

After cross-disciplinary discussions with input from teachers and medical students, we selected five question types; "single choice", "multiple choice", "free-text question", "click question" and "one-to-one sorting". All five question types are now implemented in LearnPathology.

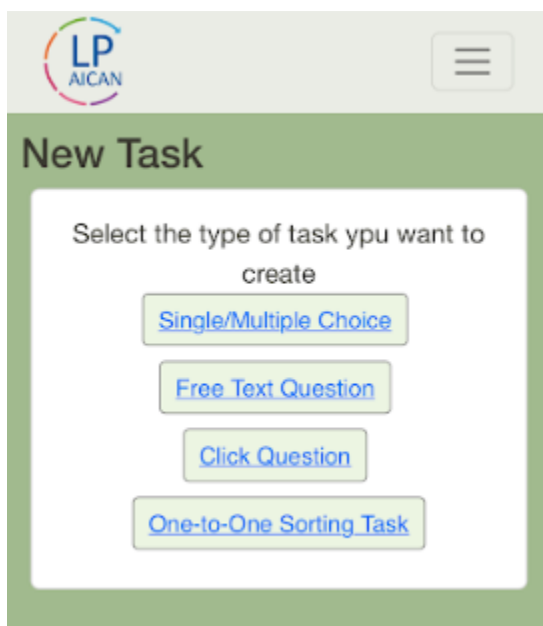


Figure 1 - The different question types



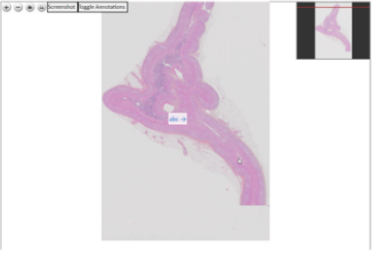
Single Choice

What structure is annotated in the image?
Choose the correct answer.

Task Overview

- Structure 1
- Structure 2
- Structure 3
- Structure 4
- Structure 5

Check Answer Next Task



Teknologi for et bedre samfunn

Figure 2 - Single Choice Question

In the “single choice question”, there are three to five alternatives, and only one correct answer. The student selects one of the alternatives and presses either “Check answer” or “Next task”. If the student presses the “Check answer” button, the text of the chosen alternative will change into the color green if the answer is correct. If the answer is incorrect, the text will turn red. If the student wants to finish the quiz before checking the answer, the student should press “next task” and continue to the next question. After finishing all questions, the correct or incorrect answers will be colored in red or green in the summary. A solution for users with red/green color blindness is under development.



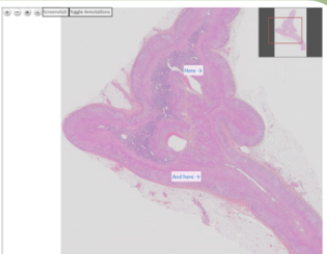
Multiple Choice

What structures are annotated in the image?
Choose all correct answers.

Task Overview

- Structure 1
- Structure 2
- Structure 3
- Structure 4
- Structure 5

Check Answer Next Task



Teknologi for et bedre samfunn

Figure 3 - Multiple Choice Question

In the “multiple choice question” there is more than one correct answer. Apart from this, the layout and functionality are similar to the single choice question.

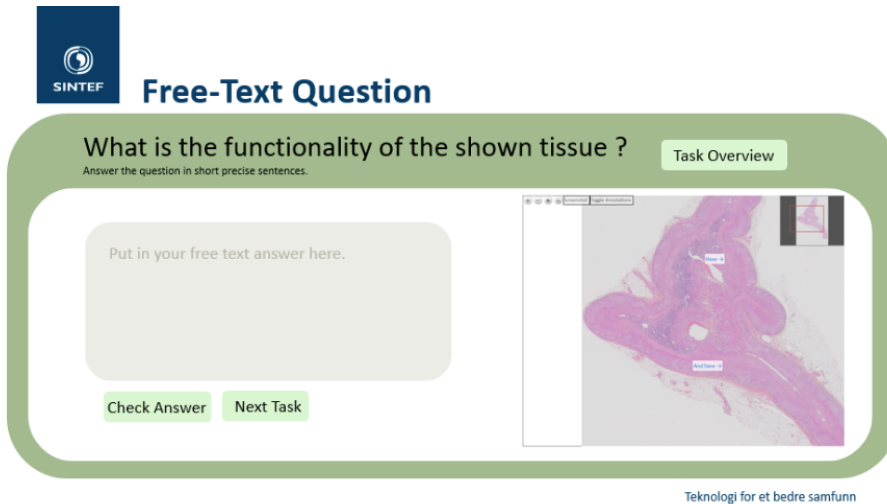


Figure 4 - Free Text Question

In the “free text question”, the student will write a free text answer in the text box section. When the student submits his/her answer, there will be a suggested description that the student can compare his/her answer to.

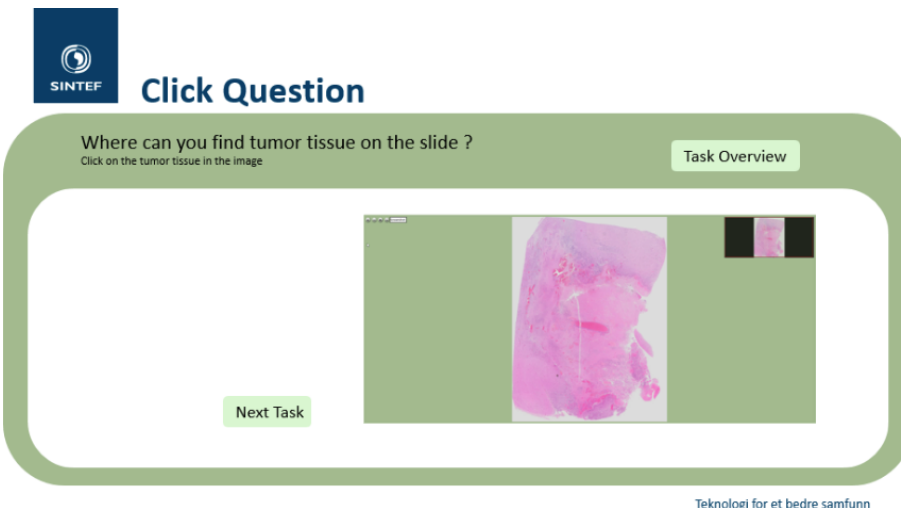


Figure 5 - Click Question

In the “click question”, one or more structures in the WSI are annotated (marked) by the teacher. The marking is not visible for the student. The student studies the WSI and tries to click

within the annotated area. If the student clicks within the correct area (for instance within an area marked as tumor), the student will get feedback on whether he/she hit the correct area. The student can also check by pressing “check answer”.

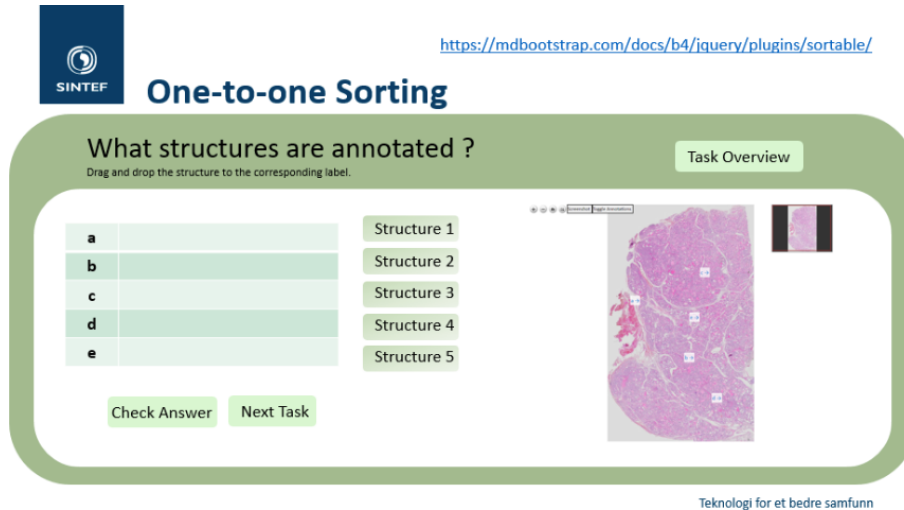


Figure 6 - One-to-One Sorting Question

In the “one-to-one sorting” question annotations in the WSI are marked with letters or numbers. The student must link these annotations to the list of structures on the left. By pressing “check answer”, the correct combination is marked in green, and the wrong combination is marked in red.

3.2 Annotated WSIs

Annotated WSIs are the starting point for the gynecological histology quiz made as part of this thesis. Figure 7 shows a WSI with annotations. The student selects whether to show the annotations or not. Using the zoom function, the student can study the structures in more detail.

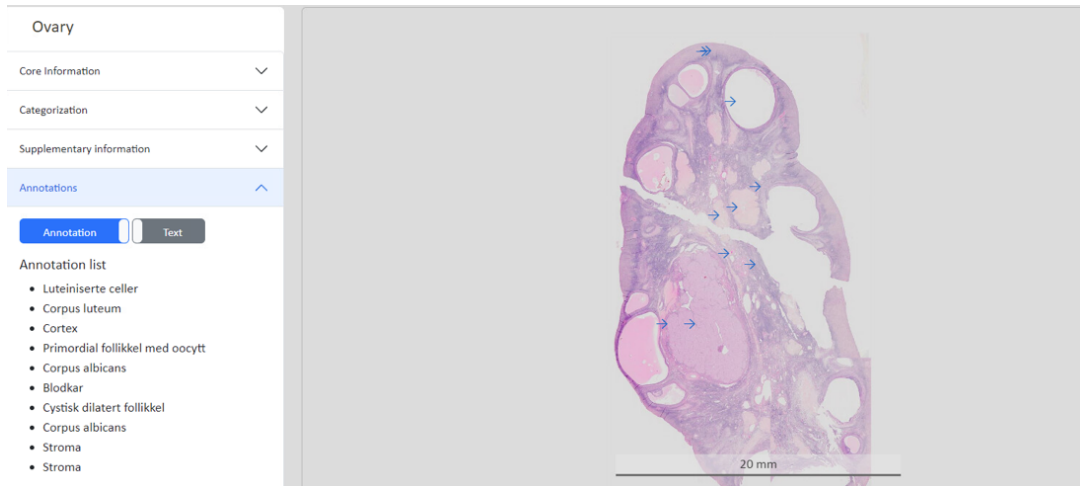


Figure 7 - Annotations with arrows

Figure 7 shows the WSI of an ovary with arrows pointing at annotated structures in the WSI. On the left side, the marked structures are listed.

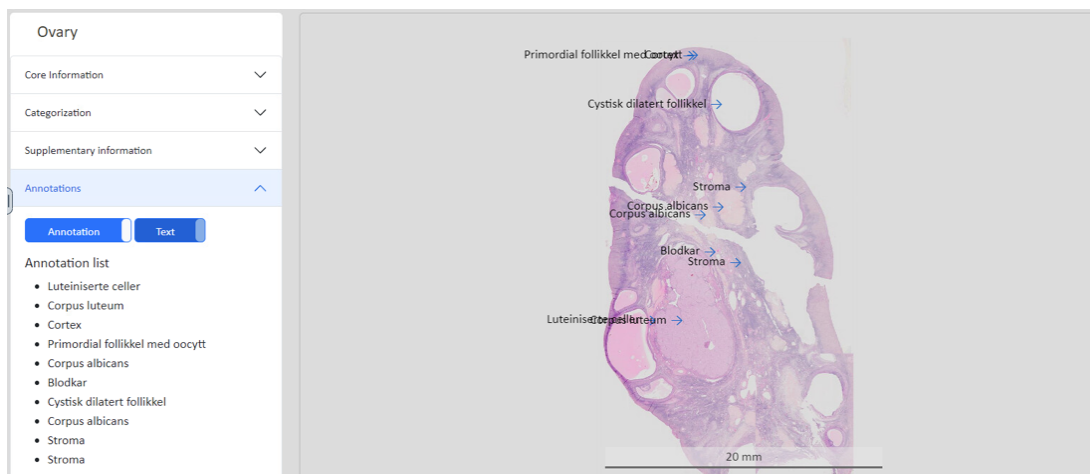


Figure 8 - Annotations with arrows and names

Figure 8-10 shows the same WSI at different magnifications, with arrows and names of the annotated structures.

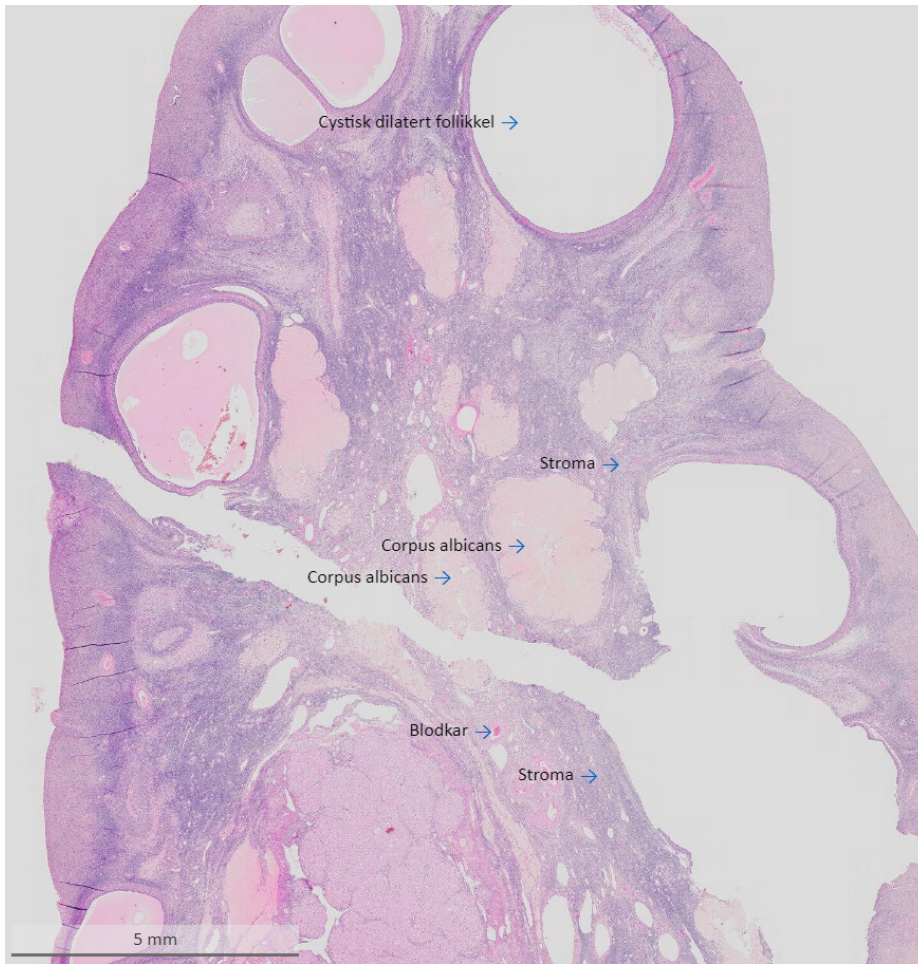


Figure 9 - The same WSI of an ovary with annotation at higher magnification

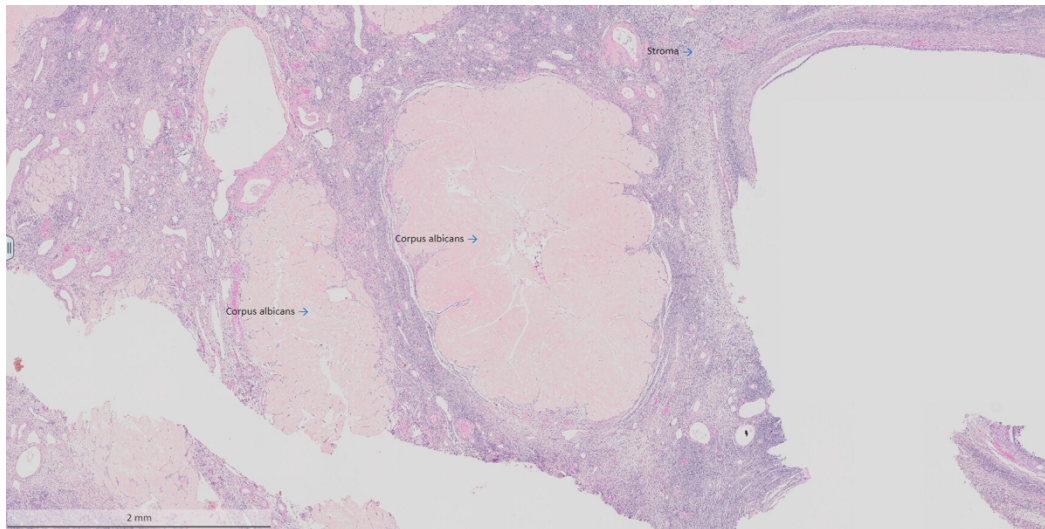
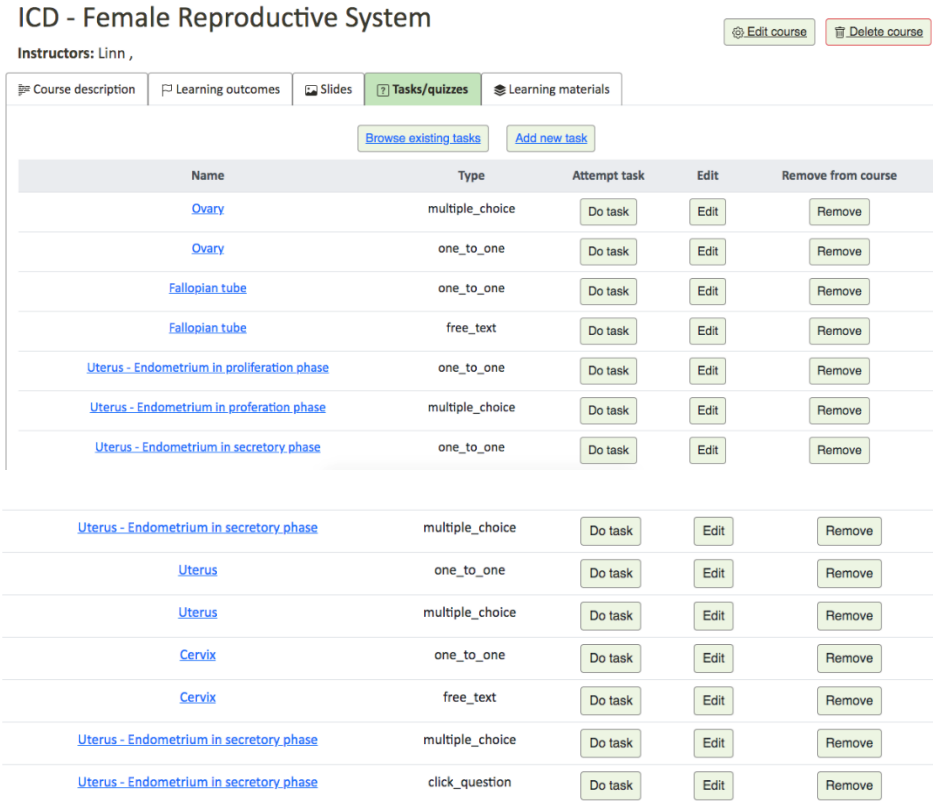


Figure 10 - The same ovary with an even bigger magnification

3.3 The Quiz

In the quiz questions I made for the gynecological histology course, examples of all five question types are included (“single choice”, “multiple choice”, “free-text question”, “click question” and “one-to-one sorting”). Figure 11 shows an overview of the questions. All these questions can be found in the “tasks/quizzes” folder in LearnPathology.



The screenshot shows the 'ICD - Female Reproductive System' course page. At the top right, there are 'Edit course' and 'Delete course' buttons. Below the course title, it says 'Instructors: Linn,'. There are navigation tabs for 'Course description', 'Learning outcomes', 'Slides', 'Tasks/quizzes' (which is active), and 'Learning materials'. Below the tabs are 'Browse existing tasks' and 'Add new task' buttons. The main content is a table with the following columns: Name, Type, Attempt task, Edit, and Remove from course. The table lists 15 tasks with various types such as multiple_choice, one_to_one, free_text, and click_question.

Name	Type	Attempt task	Edit	Remove from course
Ovary	multiple_choice	Do task	Edit	Remove
Ovary	one_to_one	Do task	Edit	Remove
Fallopian tube	one_to_one	Do task	Edit	Remove
Fallopian tube	free_text	Do task	Edit	Remove
Uterus - Endometrium in proliferation phase	one_to_one	Do task	Edit	Remove
Uterus - Endometrium in proferation phase	multiple_choice	Do task	Edit	Remove
Uterus - Endometrium in secretory phase	one_to_one	Do task	Edit	Remove
Uterus - Endometrium in secretory phase	multiple_choice	Do task	Edit	Remove
Uterus	one_to_one	Do task	Edit	Remove
Uterus	multiple_choice	Do task	Edit	Remove
Cervix	one_to_one	Do task	Edit	Remove
Cervix	free_text	Do task	Edit	Remove
Uterus - Endometrium in secretory phase	multiple_choice	Do task	Edit	Remove
Uterus - Endometrium in secretory phase	click_question	Do task	Edit	Remove

Figure 11 - Overview of the finished course

Figure 12 shows the WSIs that are included in the gynecological histology course and in the quiz. The WSIs include sections from a normal ovary, fallopian tube, uterus and cervix. Two WSIs from the uterus showing the endometrium in the proliferation and secretory phase are also included. All the WSIs are annotated, and it is possible to study the annotations without doing the quiz.

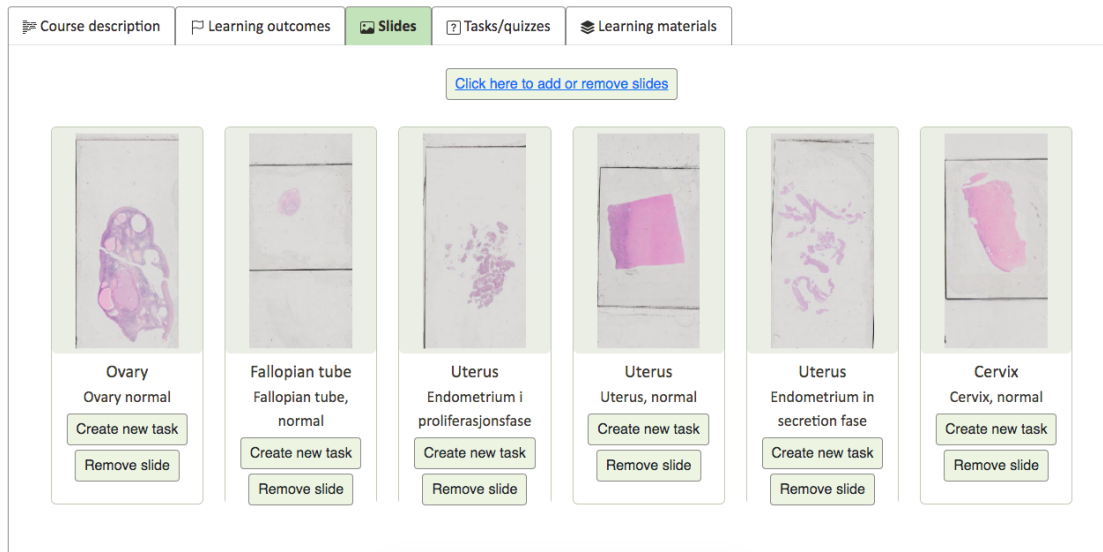


Figure 12 – Overview of the slides in the course

Below (Figure 13-25) are all the questions that were made as part of this thesis:

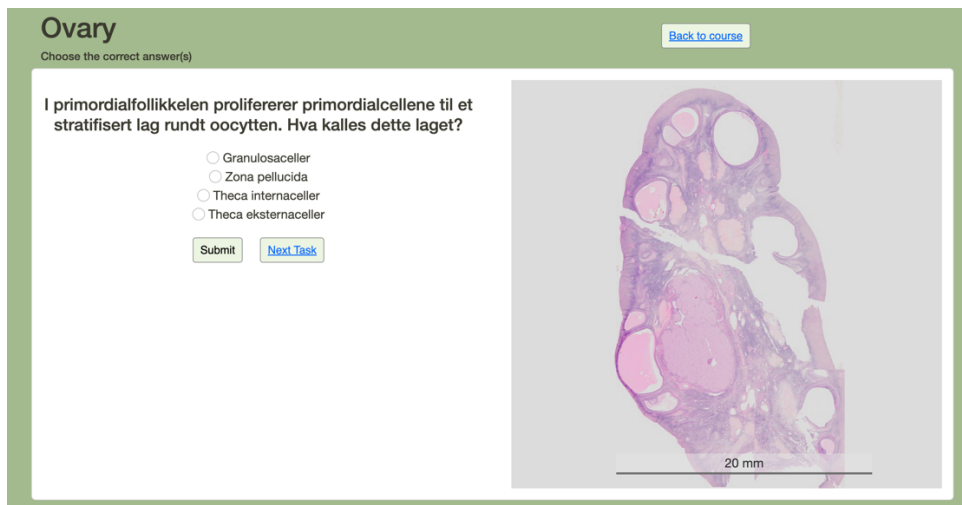


Figure 13 – Ovary, single choice question

Ovary

Sort the elements on the right to their counterparts on the left.

Back to course

Kombinér den markerte strukturen med riktig betegnelse.

a)	Stroma
b)	Corpus albicans
c)	Cystisk dilatert follikkel
d)	Primordial follikkel
e)	Corpus luteum

Submit Next Task

Figure 14 – Ovary, one-to-one sorting question

Fallopian tube

Sort the elements on the right to their counterparts on the left.

Back to course

Kombinér den markerte strukturen med riktig betegnelse.

a)	Cilier
b)	Fettvev
c)	Glatt muskulatur
d)	Enlaget sylindrisk epitel
e)	Blockkar
f)	Sekretorisk celle uten cilier

Submit Next Task

Figure 15 - Fallopian tube, one-to-one sorting question

Fallopian tube

Answer the question with your own words. Use as many terminology as possible

Muskellaget i tuben består av to lag. Hva består de to lagene av?

Compare to teacher's solution Next Task



Back to course

Figure 16 - Fallopian tube, free text question

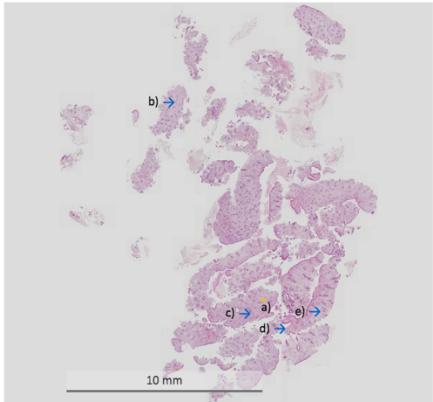
Uterus - Endometrium in proliferation phase

Sort the elements on the right to their counterparts on the left.

Kombinér den markerte strukturen med riktig betegnelse.

a)	Rette trange kjertler
b)	Endometriestroma
c)	Kjertel med mitose
d)	Enlaget sylinderisk epitel

Submit Next Task



Back to course

Figure 17 - Uterus, one-to-one sorting question

Uterus - Endometrium in proferation phase

[Back to course](#)

Choose the correct answer(s)

Når begynner, og hvor lenge varer proliferasjonsfasen?

- Starter på dag 1, varer til dag 4
- Starter på dag 14, varer til dag 21
- Starter på dag 5, og varer til dag 14
- Starter på dag 9, og varer til dag 19

[Submit](#)

[Next Task](#)

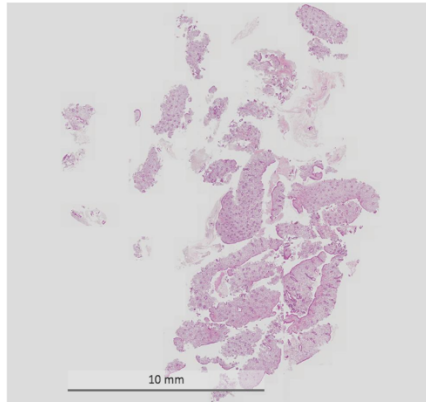


Figure 18 - Uterus, single choice question

Uterus - Endometrium in secretory phase

[Back to course](#)

Sort the elements on the right to their counterparts on the left.

Kombinér den markerte strukturen med riktig betegnelse.

a)
b)
c)
d)
e)

Subnukleære vakuoler
Overflateepitel
Slyngede kjertler
Stroma med ødem
Sekret i lumen

[Submit](#)

[Next Task](#)

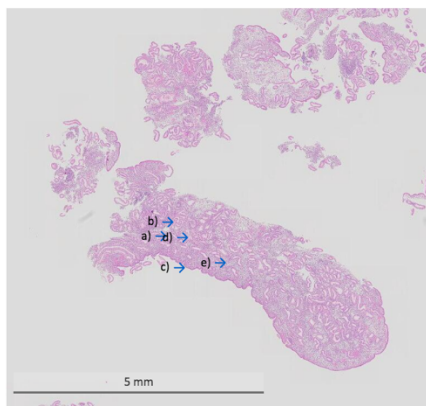


Figure 19 - Uterus, one-to-one sorting question

Uterus - Endometrium in secretory phase [Back to course](#)

Choose the correct answer(s)

Hva kjennetegner endometriekjertlene i sekresjonsfasen?

- Kjertlene er rette og trange
- Kjertlene er dilaterte og slyngede
- Kjertlene slipper ut sekret
- Kjertlene krymper

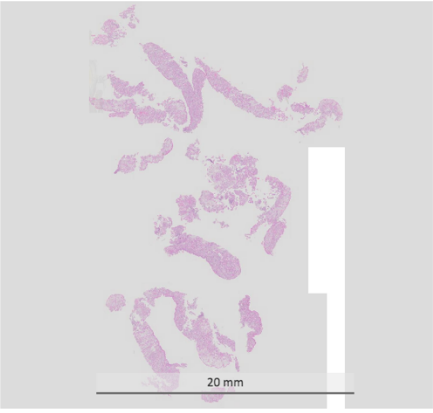


Figure 20 - Uterus, single choice question

Uterus - Endometrium in secretory phase [Back to course](#)

Double click at the correct position on the slide.

Finn slyngede kjertler på bildet.

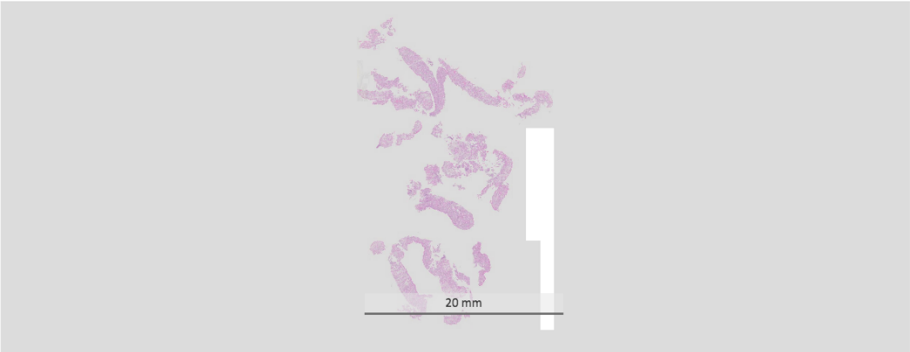


Figure 21 - Uterus, click question

Uterus [Back to course](#)

Sort the elements on the right to their counterparts on the left.

Kombinér den markerte strukturen med riktig betegnelse.

a)	Sekret i lumen
b)	Myometrium
c)	Slyngede kjerler
d)	Blodkar
e)	Glatt muskulatur
f)	Overflateepitel
g)	Endometriestroma

[Submit](#) [Next Task](#)

The image shows a histological section of the uterus. Labels point to: a) the lumen, b) the surface epithelium, c) the endometrial stroma, d) a blood vessel, e) the myometrium, f) a coiled uterine artery, and g) the endometrial stroma.

Figure 22 - Uterus, one-to-one sorting question

Uterus [Back to course](#)

Choose the correct answer(s)

Hva slags epitel dekker overflaten til endometriet?

Enlaget sylinderepitel
 Enlaget kubisk epitel
 Flerlaget plateepitel
 Granulert epitel

[Submit](#) [Next Task](#)

The image shows a histological section of the uterus, focusing on the surface epithelium. The epithelium is a single layer of columnar cells.

Figure 23 - Uterus, single choice question

Cervix [Back to course](#)

Sort the elements on the right to their counterparts on the left.

Kombinér den markerte strukturen med riktig betegnelse.

a)	Glatt muskulatur
b)	Flerlaget plateepitel
c)	Endocervicalt sylinderepitel
d)	Cystisk dilatert endocervical kjertel

Figure 24 - Cervix, one-to-one sorting question

Cervix [Back to course](#)

Answer the question with your own words. Use as many terminology as possible

Hvilke to epitellag finnes i overgangssonen?

Figure 25 - Cervix, free text question

4.0 Discussion

Through cross-disciplinary work and iterative processes, we have developed a quiz solution in LearnPathology and have made a quiz in gynecological histology using the question types developed as part of this thesis. The Covid19 pandemic had a major impact on the way teaching was conducted, affecting both students and teachers. The conversion from conventional microscopy using microscopes in plenary, to digital microscopy made permanent changes to the way histology and pathology were taught at NTNU.

LearnPathology opens up for new pedagogical approaches and more student activating teaching methods, aiming to improve the learning outcome for students (7, 9, 10). We aimed at more student activating learning by developing a quiz solution in LearnPathology, including different question types to reflect the teaching activities and exams at NTNU. On the written exams, medical students are tested in question types like “single and multiple choice” and “free text question”. In the oral histology/pathology exam (objective structured clinical/practical examination (OSCE/OSPE)), students can be tested in recognition of structures, organs and morphological alterations in histopathological WSIs, similar to the “one-to-one sorting” and “click questions”.

In LearnPathology, the teachers can create quizzes and course tests and facilitate interaction between the students themselves, as well as between students and teachers. With annotated WSIs, students are encouraged to more self-studies, and to learn by getting formative feedback from the program (15). An example of such feedback are annotations in the images that can be turned on and off. Such annotations would also be helpful in preparing for the oral exams (OSCE/OSPE). Learning and understanding histology and pathology requires a lot of practice, and many students suffer from a lacking sense of mastery. A digital learning tool like LearnPathology could become an important supplement to the curriculum, and also, a fun way to learn!

We experienced that it could be beneficial to have different types of tasks and questions to help vary the study methods of medical students. By making relevant quiz questions, the teachers can help students focus on what is considered most important. The single/multiple-choice questions can be used for both formative and summative assessment (15). Students can answer multiple choice questions quicker than free recall/free text questions or extended answers, and therefore, a significant amount of knowledge can be tested in a short amount of time (19). The opportunity to get instant feedback after answering is an advantage (15). There is, however, no flexibility using these questions. The answer is either considered incorrect or correct, and even though students have more knowledge related to the question, this will not

be awarded or recognized (12). In the free-text question, the student must learn to make a description of an image and can compare his/her answer to the suggested description. For students who learn slowly or for those who have a limited understanding of histopathology, resources like LearnPathology or other digital platforms, can be of great value (18).

NTNU teachers have developed a large database of multiple-choice questions (MCQ) that are available online for students. However, not all topics and learning outcome descriptions are covered in the database, and using the MCQ database alone may not be sufficient for understanding histology and pathology. Access to digital learning tools can inspire the students to prepare more before microscopy sessions and exams (18).

Including learning material, WSIs, quizzes and focusing on including active learning methods in the software, can improve the students' learning process (9, 11, 20). Digital solutions enable the students to take a break whenever he/she needs it, and this can help keep the students engaged (9). Using a combination of conventional teaching methods, such as traditional lectures and conventional microscopy training, as well as digital pathology sessions, improves students' learning experience in pathology (20). A hybrid solution can help integrate the pre-clinical and clinical years of medical school, making it easier for students to understand the development of disease and use this knowledge in the clinic (10, 18). Using LearnPathology's courses and quizzes, students can prepare for class and exams, and the students will be encouraged to apply and use their knowledge in different ways. This may help the students remember the teaching material better (9).

User friendliness is key in the development of LearnPathology. The program needs to be intuitive, and it must be easy for the users to make courses and quizzes, and find or upload learning material, WSIs, annotations and information. The layout and functionality must be customized for the users. The zoom function for studying the WSIs needs to be fast, without lagging. Our goal is that LearnPathology will be of interest for all medical schools in Norway, and potentially also abroad. The program could also be extended to other disciplines in medicine, such as radiology or microbiology.

In the development of LearnPathology, our cross-disciplinary team has worked in iterative processes, with monthly meetings, while working continuously on specific tasks individually. Meeting once a month have been important for the progress but has sometimes caused delays in our work. Continuous email correspondence has been helpful but has also caused some misunderstandings that could have been avoided if we had met more regularly. This was, however, not feasible due to time constraints for the project group.

During the work described in this thesis, I have communicated regularly with other students and teachers, developers, and social scientists. I have gotten valuable experience and insight into a cross-disciplinary approach.

5.0 Conclusion and future thoughts

In this master thesis we have created a quiz solution in LearnPathology, and a quiz related to the microscopy course in gynecological histology. The development of LearnPathology has come a long way, and much of the desired functionality is already in place. An interaction designer has recently been hired to optimize the design. There is still more work to be done, and funding needs to be raised to continue the project after 2024. A study of user satisfaction and learning outcome from using the quiz solution and the different question types in LearnPathology should be conducted in the future.

6.0 References

1. Grimstadutvalget. Studieplasser i medisin i Norge 2019 [updated 16.03.2023. Available from: https://www.regjeringen.no/contentassets/9b5b81d102384507b85150f2e0f1b089/11745900_rapport_utredning_fra_grimstadutvalget.pdf%C2%A0.
2. LINK. Medisinstudiet - NTNU LINK 2023 [Available from: <https://www.ntnu.no/studier/cmed/link>.
3. Koch LK, Chang OH, Dintzis SM. Medical Education in Pathology - General Concepts and Strategies for Implementation Archives of Pathology & Laboratory Medicine 2021.
4. Pedersen A, Valla M, Bofin AM, Frutos JPd, Reinertsen I, Smistad E. FastPathology: An Open-Source Platform for Deep Learning-Based Research and Decision Support in Digital Pathology. IEEE Access. 2021.
5. AICAN. [updated 16.03.2023. Available from: <https://www.ntnu.no/ikom/aikan#/view/about>.
6. Minnesota Uo. Active Learning 2023 [updated 14.04.2023. Available from: <https://cei.umn.edu/teaching-resources/active-learning>.
7. Bonwell CC, Eison JA. Active Learning: Creating Excitement in the Classroom. 1991.
8. Sayyah M, Shirbandi K, Saki-Malehi A, Rahim F. Use of a problem-based learning teaching model for undergraduate medical and nursing education: a systematic review and meta-analysis. Taylor & Francis Online. 2022.
9. Prince M. Does Active Learning Work? A Review of the Research. 2004.
10. Kantardjiev KO. Studentaktiv læring og diversitet - hva fungerer og hvorfor? . 2019.
11. Loeng S, Mørkved BP, Isachsen BS. Studentaktiv læring - praksisnær undervisning i høyere utdanning Cappelen Damm Akademiske 2019.
12. Wheelera S, Valentinoa AS, Listonb BW, Lia J, McAuleya JW. A team-based learning approach to interprofessional education of medical and pharmacy students ELSEVIER2019 [updated 06.06.2023. Available from: https://www.sciencedirect.com/science/article/abs/pii/S1877129718304374?fr=RR-2&ref=pdf_download&rr=7d70a3bfd11b4ee.
13. Washington Uo. Flipped Classrooms 2023 [updated 06.06.2023. Available from: <https://teaching.washington.edu/topics/engaging-students-in-learning/flipping-the-classroom/>.
14. University C. Collaborative Learning [updated 06.06.2023. Available from: <https://teaching.cornell.edu/teaching-resources/active-collaborative-learning/collaborative-learning>.
15. Neovation. What is Formative Feedback? 2023 [Available from: <https://www.neovation.com/learn/26-what-is-formative-feedback>.
16. Commons T. Formative Assessment and Feedback: Stanford University; 2022 [updated 25.05.2023. Available from: <https://teachingcommons.stanford.edu/teaching-guides/foundations-course-design/feedback-and-assessment/formative-assessment-and-feedback>.
17. Education MB. Elaerning - Benefits of Digital Learning Over Traditional Education Methods 2020 [updated 08.06.23. Available from: <https://mbe.edu.vn/benefits-of-digital-learning-over-traditional-education-methods/>.
18. Gopalan V, Kasem K, Pillai S, Olveda D, Ariana A, Leung M, et al. Evaluation of multidisciplinary strategies and traditional approaches in teaching pathology in medical students. Pathology International. 2018.

19. Jones K. Multiple-choice questions: Prons and cons: Evidence Based Education; 2022 [updated 25.05.2023. Available from: <https://evidencebased.education/multiple-choice-questions-pros-and-cons/>.
20. Jahn SW, Plass M, Moinfar F. Digital Pathology: Advantages, Limitations and Emerging Perspectives. Journal of Clinical Medicine 2020.



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