Methodological framework for Flipped Classroom scenarios

for microscopy teaching

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covid-project

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General need analyses and teaching solutions

For the general need analysis and the choice for a teaching solution we used the six-step approach for curriculum development for medical education (Thomas, Kern, Hughes, Tackett, & Chen, 2022)

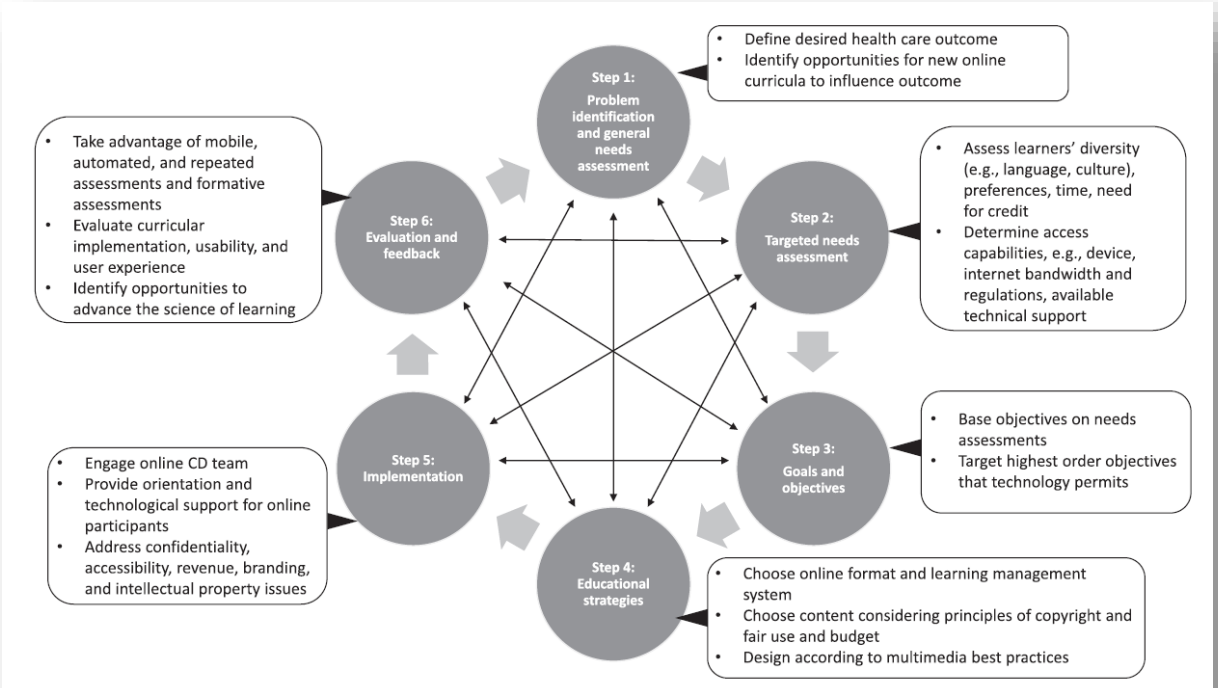


Figure 1 Considerations for online curriculum development according to the Six-Step Approach for Curriculum Development for Medical Education.

For undergraduate medical education:

Step 1 and 2

The opportunity was to bring together medical students at different universities (e.g. university of Turku, Finland and of Maastricht, the Netherlands) in flipped classroom scenarios to work collaboratively on microscopic pathology topics. Objective was to focus on conceptual and procedural knowledge of patho-physiology and disease mechanisms instead of on factual knowledge about an exhaustive list of diseases and their associated pathological images.

The key issue the cLovid-project wanted to address, was to enable active collaborative learning in a fully online or a hybrid (on campus\distance learning) setting to cope with periods of forced social-distancing (e.g. corona pandemic). The project also wanted to provide for possibilities of distributed across-campus teaching in case of limited technical infrastructure (e.g. large computerrooms) at educational institutions.

Because argumentation on disease mechanisms among peers was seen as an important ingredient for learning, a good command of a common language was essential. Both Finnish and Dutch students had an adequate proficiency in the English language to participate in English spoken and written academic discourse. Regarding collaborative learning, there were differences between the involved universities: Maastricht, unlike Turku, had a problem based learning (PBL) curriculum and in addition different cultural backgrounds might influence how students would collaborate in small groups.

Both universities had on-campus infrastructures that were well suited for online activities with large images. Moreover, students were able to work with a "bring your own device" approach off- and on-campus, as most of them owned computers and had good internet connections at home.

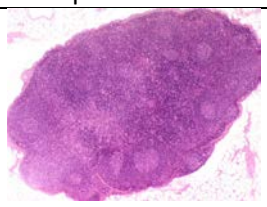
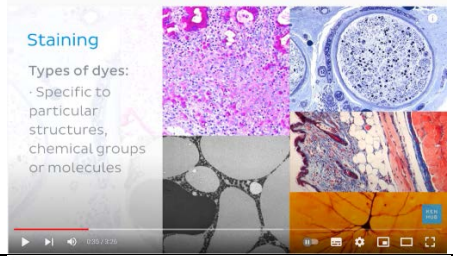
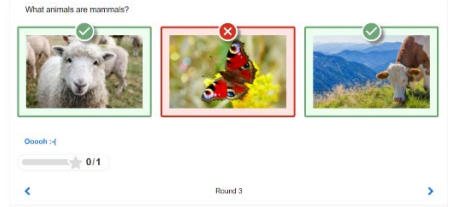
The setting for the to be designed microscopic pathology lesson was different at the two involved universities. At Maastricht University the lesson was new and added to an elective four-weeks pathology course during the second bachelor year of the international track in medicine. At the University of Turku, a similar topic was already part of a four-weeks elective course in the third year of the medical study, but was in need to be adapted to meet the MEDigi project's (a national endeavour to harmonise and modernise medical education in Finland) aim of placing more emphasis on pathophysiologic mechanisms in pathology education and on an issue like the histopathologic report.

Step 3 and 4

Writing histopathologic reports is too ambitious for undergraduate medical students, but worked-out examples of such reports and understanding their relation to whole slide images (WSI) is feasible. For this we could present parts of authentic histopathologic reports in an assessment program like VQuest and ask students to answer questions on a presented report and relate the content of the texts with elements in a WSI with marker-questions.

The flipped classroom is a pedagogical approach in which basic concepts are provided to students for pre-class learning so that class time can apply and build upon those basic concepts. This means that two elements are characteristic for an flipped classroom approach: 1) packaging and delivering key foundational content to students prior to class and 2) in-class active learning where the acquired prior knowledge is applied and students get feedback on their performance.

Important principles in developing the self-study material for the out-of-class phase were to prioritize the visual aspect of the content and to encourage students to actively interact with the images. The self-study materials had to be delivered via the learning managment systems used at the involved universities (Moodle and Canvas). The complexity of the visual content (pathology images) was built up gradually (Table 1)

Visual content	Example
Still images with text	 Text, text, text, text, text, text
Video organizer for processes	
Still images compared with H5P Image Choice Rounds	

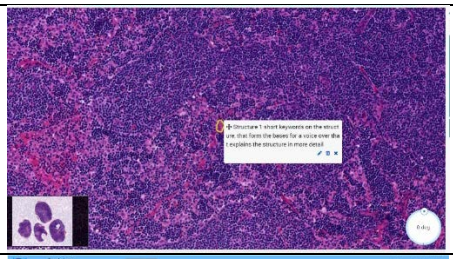
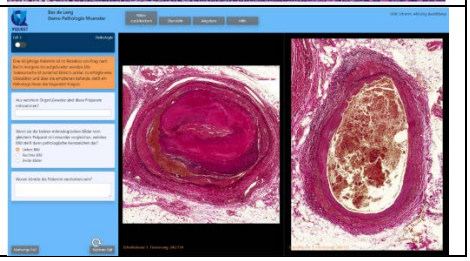
Guided videotour through WSI, by Camtasia screencapture of prepared WSI	
WSI with marker questions	

Table 1 Visual content with increasing complexity (increasing downwards in the table)

For pilot postgraduate medical education

Step 1 and 2

The opportunity was to connect pathology residents at different far apart university medical centres in Finland (Helsinki, Kuopio, Oulu, Tampere, Turku) and support them with a flipped classroom scenario in preparing for the final national exam of their training. Until then, they prepared for this national pathology exam with a series of face-to-face meetings. Residents couldn't fit these full events easily into their busy everyday practice and lost much of their sparse time to travel. The full day program was dedicated to a specific topic for which pathology experts gave presentations. This was combined with individual work on tasks with digital microscopic specimen with a follow-up discussion. During the corona pendemic these face-to-face events were not possible anymore.

The key issue that the cLovid-project wanted to address was to enable flexible active learning in the residents own time and location and to build a community of practice in which residents could discuss their experiences with pathology experts together with their peers, even in times of forced social distancing.

Participants were in different years of their specialist training (first-third year) and the moderators completed their pathology training. Although the tasks can be in English language the online discussions should be in Finnish to stimulate the community building. Technical infrastructure and computer ownership did not cause limitations for a fully online scenario.

Step 3 and 4

Although in flipped classroom scenarios the foundational knowledge is often provided to learners for pre-class learning, in the case of the residents, additional self-study material was not necessary because they have access to sufficient sources of high specialized knowledge. The diversity of experience and sources of knowledge would also benefit the communal debriefing.

Aim was to offer the residents an opportunity to participate in an histology practical that mimiced the national exam. An important part of this exam is a three hours assignment on eight microscopic specimen.

Creating and modifying digital resources with teachers

The European Framework for the Digital Competence of Educators (Commission, Centre, Redecker, & Punie, 2017) states that teachers required the following competencies with repect to digital resources: selecting, creating & modifying and managing, protecting ans sharing digital resources. A systematic review on digital resources of Heine concludes that digital resources themselves do not bring innovation and that an interaction of the teacher with these resources to design the material for teaching is essential. She therefore recommended an action-theoretical model (Figure 1) because the design-process plays a crucial role in taking advantage of digital resources for teaching.

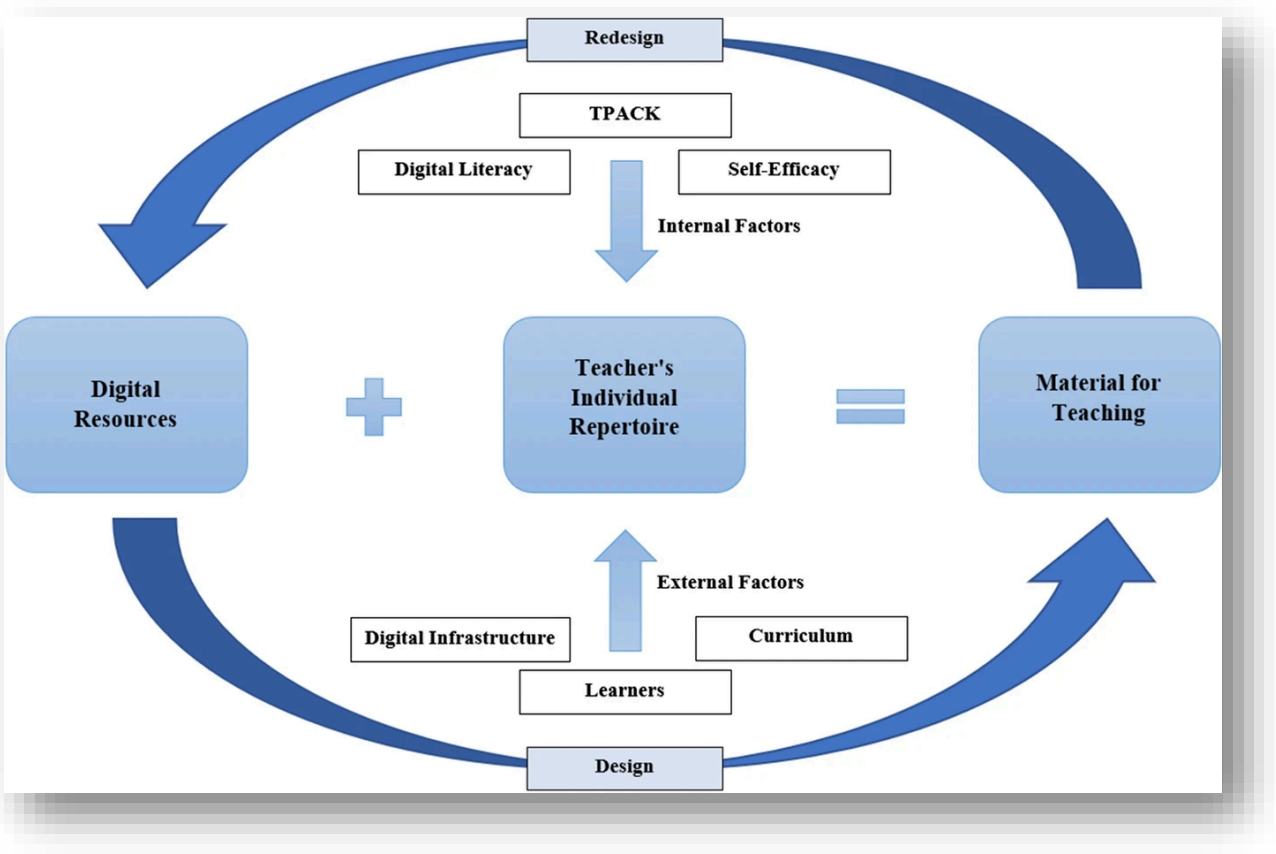


Figure 1. Designing digital resources

For both the out-of-class and the (virtual) in-class phase of the flipped classroom approach the design of teaching materials during the cLovid-project was given concrete form in the way shown in figure 2.

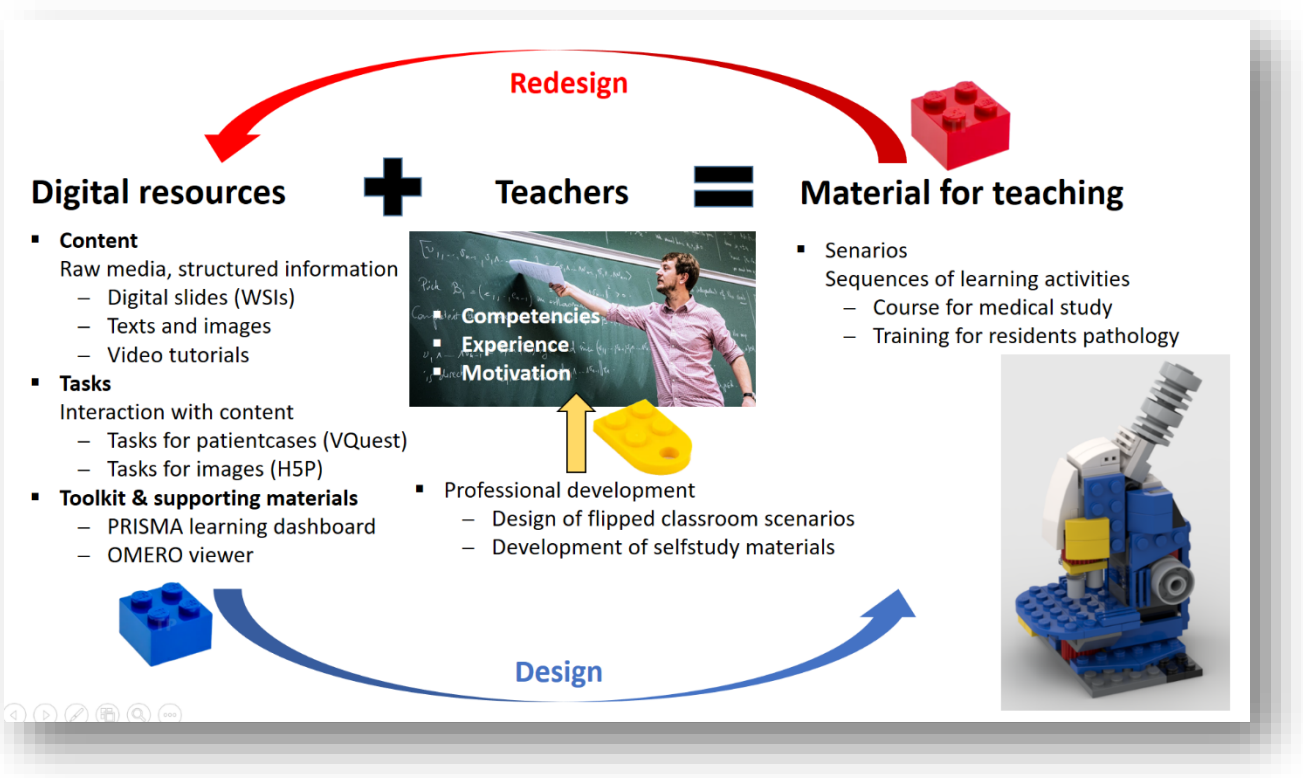


Figure 2. Design framework used in the cLovid-project

The teachers are viewed as both users of existing digital resources and designers who adapt and extend these resources to make them suitable for their own teaching.

A review of the UK Joint Information Systems Committees (Littlejohn, Falconer, & McGill, 2008) classified learning resources by their granularity. It described four types of resources dependent on the degree to which information content is embedded within an activity or tasks oriented learning context:

a) Digital assets – normally a single file (e.g. an image, video or audio clip), sometimes called a 'raw media asset'.
b) Information objects – a structured aggregation of digital assets, designed purely to present information.

Digital assets and information objects can be viewed as 'information content' and, in isolation, have no learning or teaching effect. They acquire this by being placed within the other two types of resources:

c) Learning activities – tasks involving interactions with information to attain a specific learning outcome.
d) Learning design – structured sequences of information and activities to promote learning.

Like the EU DigCompEdu report the JISC report stresses that ,manipulation and interaction are key aspects of effective learning resources: by interaction practitioners construct their own understanding and use of the resource; and by embedding digital assets or information objects into an interactional framework, practitioners give them educational purpose and value, producing learning activities or designs.

Furthermore, the JISC report breaks down into three stages of working with resources by teachers:

1. Conceptualisation: source a resource and use the resource for information
2. Construction: adopt the resource into his or her own practice and repurpose the resource for reuse in new contexts
3. Integration: develop new examples of the resource and use the resource to help others adapt their practice.

To ensure that the digital resources are easily found by other teachers, they have to be described with metadata. De metadata that the cLovid-project assigned to the digital resources encompase the following items:

Metadata	
Title of the material	
Author*: - ORCID - Name* - Academic degree - University*	
Other contributors: - ORCID - Name* - Academic degree - University*	
Short description	
Discipline*	Medicine, Pathology
Licence*	CC BY-SA
Language of learning resource*	English
Media type*	
Keywords	
Funding*	EU 2020-1-DE01-KA226-HE-005813

Table 2. Template for the metadata for the cLovid products

The adoptation of the digital resources is encouraged when they are free from legal restrictions and availabe at approriate costs. Both issues are addressed in the cLovid-project by publishing the materials as open educational resources (OER) and sharing them with existing OER repositories like:

- Erasmus + project results platform: https://erasmus-plus.ec.europa.eu/projects
- Finland: Library of Open Educational Resources; https://aoe.fi/
- Germany: Open Resources Campus.nrw; https://www.orca.nrw/
- Netherlands: Edusources; https://edusources.nl/en

The fact that large national or european organisations maintain such resources gives greater assurance of the longer-term availability of OER-materials.

The adoption of digital teaching materials by teachers will be promoted when the resources are sufficiently small to be reusable. In general , the more granular a resource, the greater the possibility of it being re-used in another context. Therefore, we for instance delivered the video-tutorials both as streaming video-link and mp4-file and kept the ‚chapters' and ‚subtitles' separate from the video-file, so others can easily change the content (e.g. language) in the corresponding vtt-files.

Assignment of active learning formats to course content

When looking for an appropriate format the learning content, it can be useful to determine at which cognitive level this content should be mastered. Bloom's taxonomy provides concrete guidance for such a determination. Table 3 shows an example how the contents of the course ‚Clinical Pathology' of the cLovid-project course was categorised according to the different levels of Bloom's taxonomy.

Structure of the Knowledge Dimension of Bloom's Taxonomy	
A. Factual Knowledge – The basic elements that students must know to be acquainted with a discipline or solve problems in it.	
Aa. Knowledge of terminology	Lymph node lobule, subcapsular sinus, hilus, afferent and efferent vessels, primary and secondary follicles, germinal centre, centrocytes, centroblasts, mantle zone, paracortex, tingle body macrophages, hyperplasia, inflammation, neoplasia
Ab. Knowledge of specific details and elements	Lymphatic fluid and vessels, lymphatic organs, status of follicles and paracortex in relation to immunological status, Location B and T lymphocytes in lymphnode, Cellular processes during antigen exposure
B. Conceptual Knowledge – The interrelationships among the basic elements within a larger structure that enable them to function together.	
Ba. Knowledge of classifications and categories	Histologic appearance of normal, reactive and pathologic lymph node. Overall and cellular structure in each category Disease mechanisms that lead to observable signs and symptoms in patients: tumor in the neck.
Bb. Knowledge of principles and generalizations	Lymph circulation, Role of lymphatic system in defending body against infections, Neoplastic diseases of lymph node, Metastastic disease of lymph node
Bc. Knowledge of theories, models, and structures	N.a.
C. Procedural Knowledge – How to do something; methods of inquiry, and criteria for using skills, algorithms, techniques, and methods.	
Ca. Knowledge of subject-specific skills and algorithms	Identifying the primary tumor (cell morphology, location of metastatic lymph node, detecting tissue-specific antigens) Making a differential diagnosis: probabilities of disease mechanisms in clinical case 1
Cb. Knowledge of subject-specific techniques and methods	Methods of tissue sampling, types of material obtained by each sampling method and their diagnostic opportunities. Methods of histopathological tissue processing. Methods of immunohistochemical detection.
Cc. Knowledge of criteria for determining when to use appropriate procedures	Benefits and risks of tissue sampling methods Application of pathologic laboratory findings for diagnostic decisions: findings in cytology report, findings in histopathological report (PAD), findings of immunohistochemical analysis. Using pathologic laboratory findings for treatment decisions
D. Metacognitive Knowledge – Knowledge of cognition in general as well as awareness and knowledge of one's own cognition.	
Da. Strategic knowledge	N.a.
Db. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge.	N.a.
Dc. Self-knowledge	N.a.

Table 3. Content of the course ‚Clinical Pathology' categorised according to the different levels of Bloom's taxonomy

Based on the Cognitive Process Dimensions of Bloom's Taxonomy (Remember, Understand, Apply, Analyze, Evaluate and Create) appropriote active learning formats were thought out (Table 4).

Structure of the Cognitive Process Dimension of Bloom's Taxonomy	
Process dimension	Active learning formats
1.0 Remember Retrieving relevant knowledge from long-term memory.	
1.1 Recognizing	– Text and images with retrieval practice (MC questions)
1.2 Recalling	– Video tutorials with explanations of structures, processes and mechanisms (Virtual Slide Tours) – Retrieval practice with Free text questions
2.0 Understand Determining the meaning of instructional messages, including oral, written, and graphic communication.	
2.1 Interpreting	– Images with retrieval practice (MCQ, Ranking, Free text) – Interpreting histopathological reports (PADs) with worked-out examples in VQuest (Whole Slide Images with Marker, Longmenu, Free text and MC questions) – Interpreting in small group discussions with Learning Dashboard (online Seminar)
2.2 Exemplifying	
2.3 Classifying	– Categorizing normal and pathological lymph nodes with Compare & Contrast rounds
2.4 Summarizing	
2.5 Inferring	– Inferring in small group discussions with Learning Dashboard (online Seminar)
2.6 Comparing	– Comparing with Compare & Contrast rounds
2.7 Explaining	– Explaining in small group discussions with Learning Dashboard (online Seminar)
3.0 Apply Carrying out or using a procedure in a given situation.	
3.1 Executing	– Applying procedure in VQuest (Whole Slide Images with Marker, Longmenu, Free text and MC questions) – Applying in small group discussions with Learning Dashboard (online Seminar)
3.2 Implementing	
4.0 Analyze Breaking material into its constituent parts and detecting how the parts relate to one another and to an overall structure or purpose.	
4.1 Differentiating	
4.2 Organizing	
4.3 Attributing	
5.0 Evaluate – Making judgments based on criteria and standards.	
5.1 Checking	Dialogue in small group discussions with Learning Dashboard (online Seminar)
5.2 Critiquing	Dialogue in small group discussions with Learning Dashboard (online Seminar)
6.0 Create – Putting elements together to form a novel, coherent whole or make an original product.	
6.1 Generating	
6.2 Planning	
6.3 Producing	

Table 4. Active learning formats chosen for Bloom's cognitive process dimensions

In accordance with the previous categorisation and the active learning formats assigned to it, the content can be created (Figure 3)

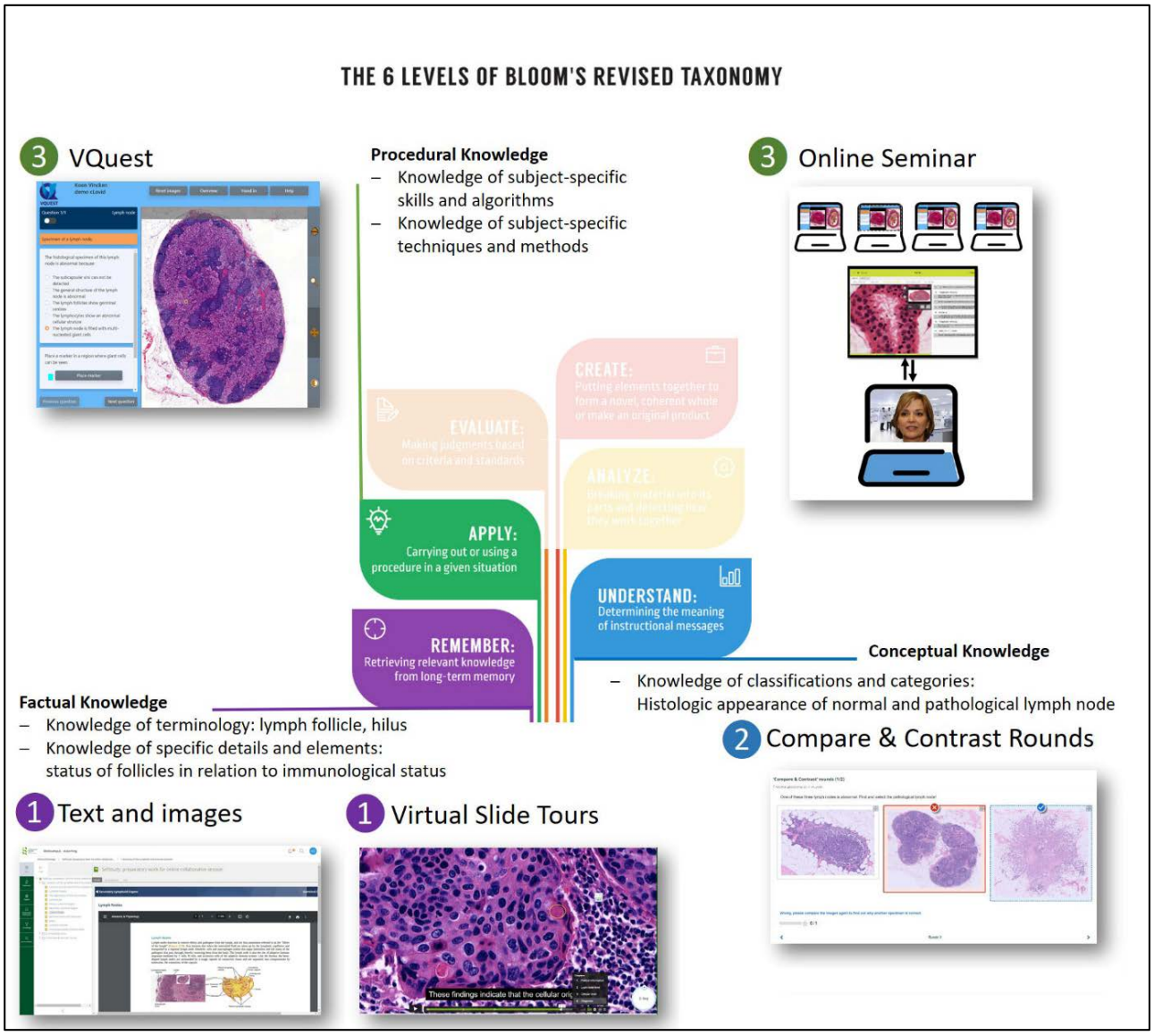


Figure 3. Active learning format for the content of the course ‚Clinical Pathology'

Creating course content for self-study (out-of-class phase)

Text and images

In general, before starting to construct learning content yourself, it is wise to explore what valuable integral learning resources are already available at the university. In the case of publications from commercial publishers, the university will obviously have to pay license fees, but if a high quality and authoritative product is available in a good e-learning format, this may be a sensible option. Of course, a critical review of the suitability of the content for the intended target group and an indication of which parts of the material are relevant for this target group, is important.

In our project both universities had a campus license for an online version of Robbins & Cotran ‚Pathologic Basis of Disease' and the teachers referred in the coursematerial that was delivered via learning management system (LMS) of the university to the chapter ‚Diseases of White Blood Cells, Lymph Nodes, Spleen, and Thymus'. For knowledge on histology the two universities used different online resources: Maastricht, Junqueira's ‚Basic Histology Text and Atlas' and Turku, Stevens & Lowe's ‚Human histology' and Wheater's ‚Functional Histology'.

Also, if teachers want to add own texts, it may be wise to look for existing sources with texts and pictures and to incorporate these existing elements with the own texts in the learning management system. In addition to resources from commercial providers, these can also be open educational resources (OER). OER-materials are free of charge, but one has to comply with the licensing conditions (Figure 4).

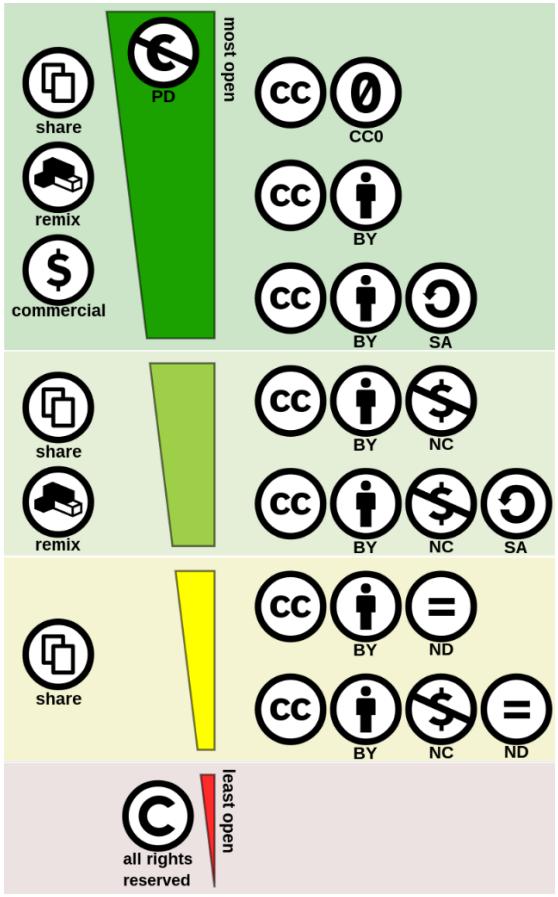


Figure 4. Creative Commens licenses

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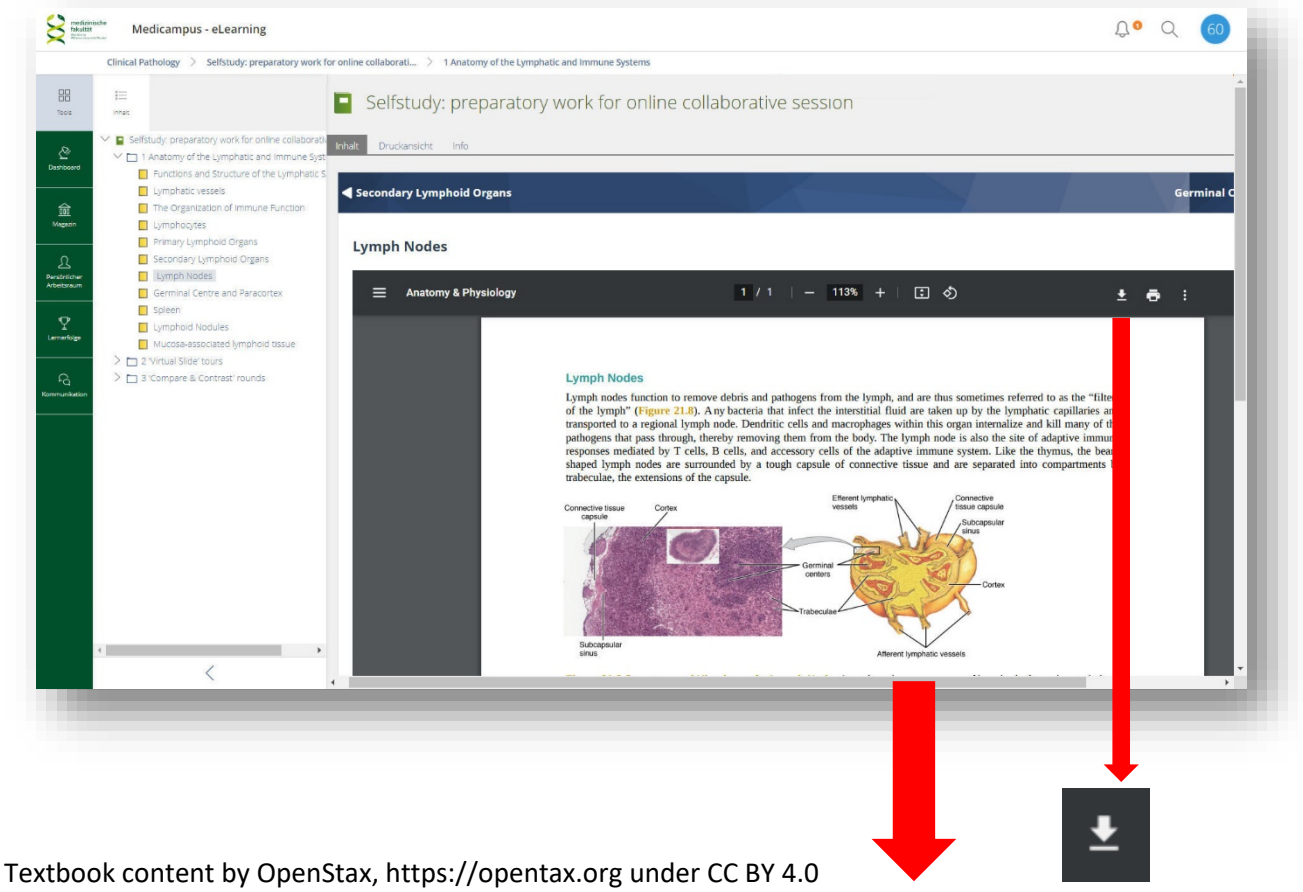
For the course ‚Clinical Pathology‘ of the cLovid-project, selections of texts were made from the opensource textbook ‚Anatomy and Physiology‘ published by OpenStay. The license lets others distribute, remix, adapt, and build upon this textbook, as long as they credit OpenStax for the original creation. We added some texts and homemade images ourselfes and licensed the work under CC BY-SA (Figure 5). In addition we took care that the content could easily be shared with others: a PDF file format and button to download the pages.

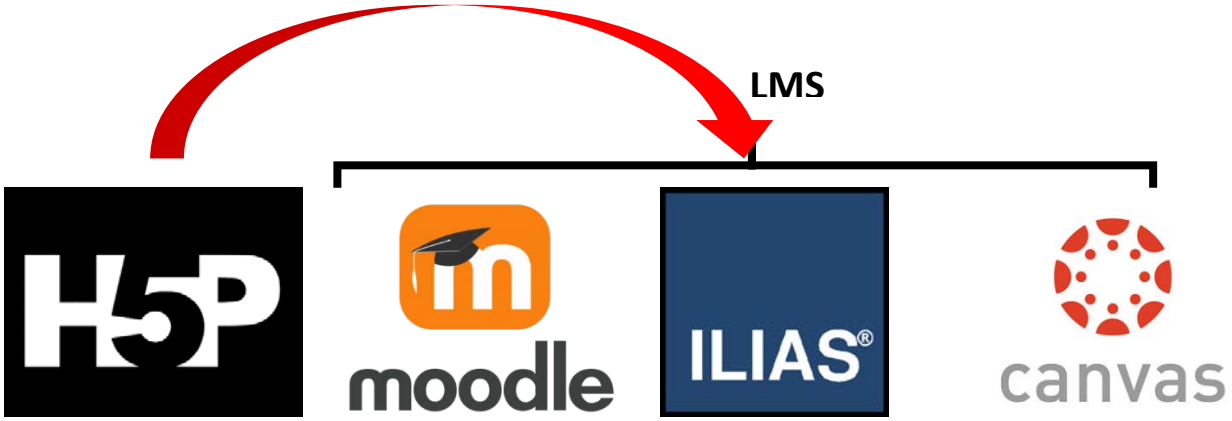


Textbook content by OpenStax, https://opentax.org under CC BY 4.0

Figure 5. Opensource textbook in ILIAS course

H5P interactive content

H5P is a free and open-source content collaboration framework, licensed with the MIT license. Demos/downloads, tutorials and documentation are all available for users who want to join the community. The aim of H5P is to make it easy for everyone to create, share and reuse interactive HTML5 content. The H5P content can be included in many Learning Management Systems, like: Moodle, Drupal, ILIAS, Canvas and Blackboard.



For sharing interactive HTML5-content a Learning Management System needs a H5P- plugin or a LTI-support functionality.

All that is needed to view or edit H5P content is a web browser. H5P content can be created on any H5P enabled web site like H5P.com or your own Drupal or WordPress site with the H5P plugin installed.

Examples of H5P-content like: Interactive Videos, Presentations, Games, Quizzes Preview can be seen and downloaded at: https://h5p.org/content-types-and-applications

In the cLovid-project we developed a new interactive content-type for comparing of images. This new H5P, image Choice Rounds with Feedback and Zooming‘ content-type provides a template for comparing and contrasting images in a sort of ‚One -Armed Bandit‘ game. Contentdevelopers can use this template to create their own ‚One-Armed Bandit‘ games by adding images, texts and by changing the settings so that the game fulfils their goals (Figure 6).

The templates for the content types can be found on our example page: https://clovid.uni-muenster.de/docs/examples/h5p/. There is also a link to the GitHub repository of the developed content type (https://github.com/hpawe01/h5p-image-choice-rounds, this link will likely change in the near future). To use the provided template files the administrator of the LMS where the template is imported needs to allow the uploading of “own” content types (or libraries). After that the new content type will be installed automatically when uploading the file and can be used to create new content.

When a template is filled with content (images, texts), the whole interactive content can be shared between different Learning Management Systems. Figure 7 and 8 show an example in which the H5P game ‚find the pathological nodes‘ is exported from ILIAS (LMS University of Münster) and imported in Moodle (LMS University of Turku).

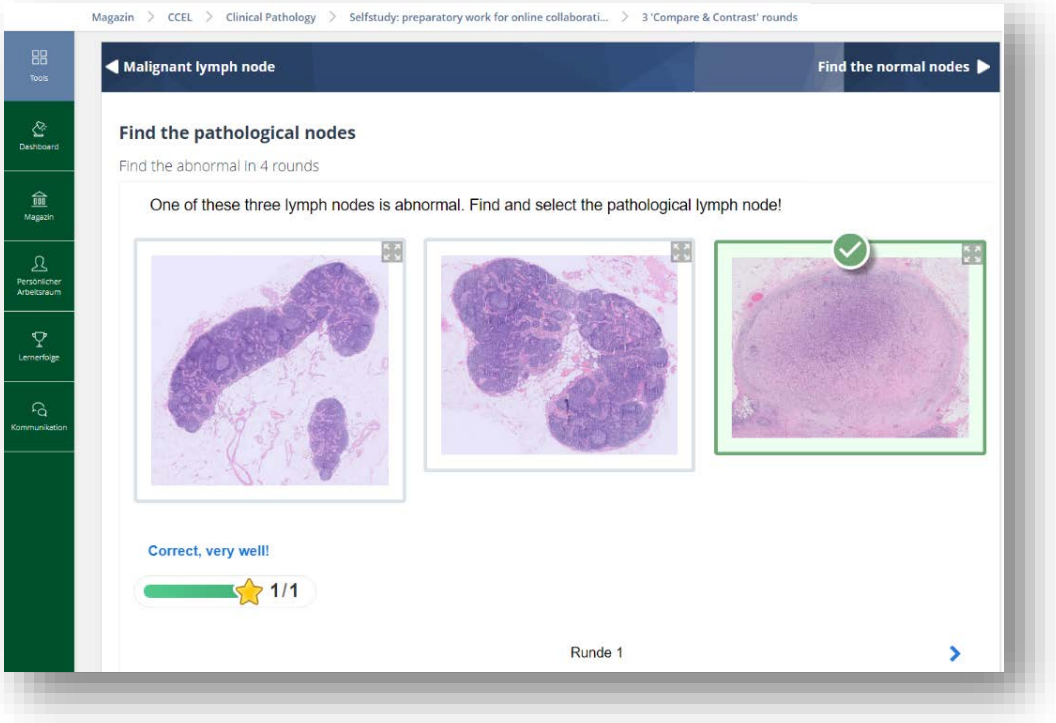


Figure 4. H5P ‚One-Armed Bandit' game with images and texts in ILIAS (LMS University of Münster)

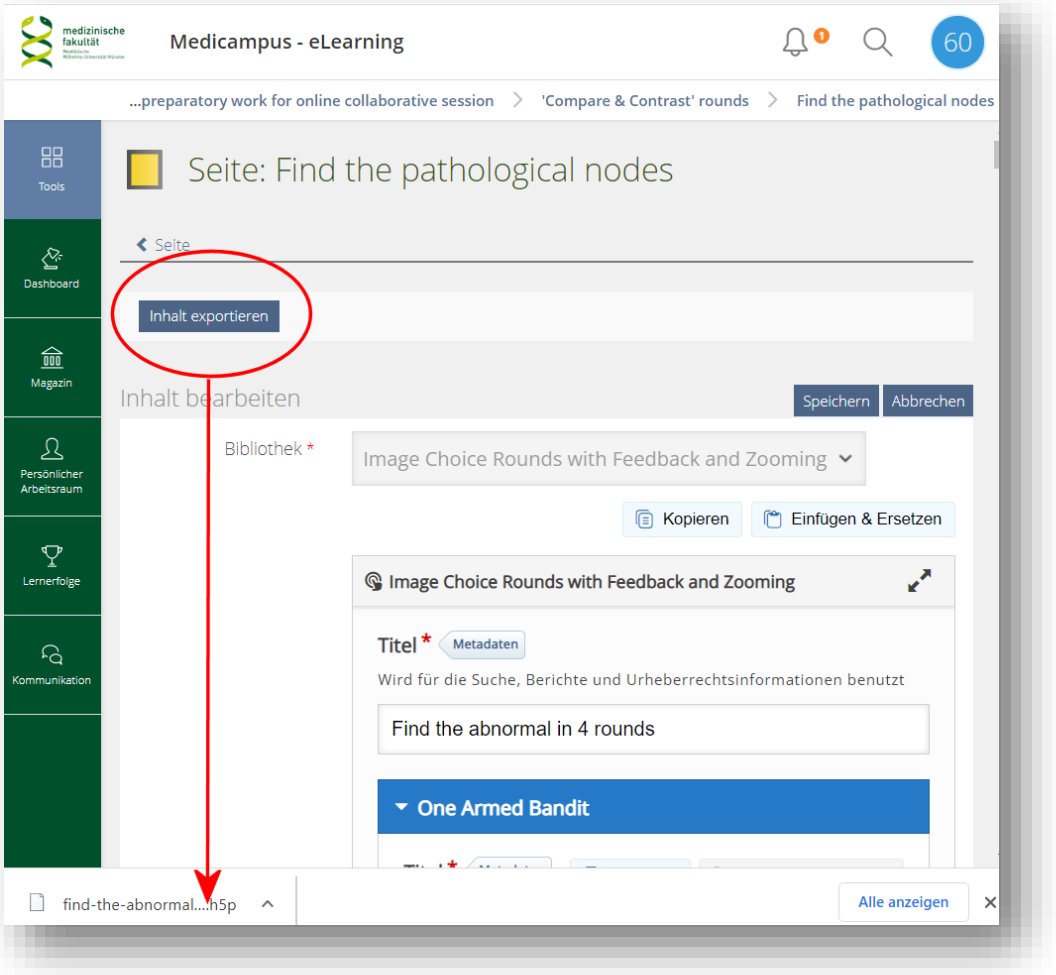


Figure 5. Editing mode in ILIAS: exporting H5P Content

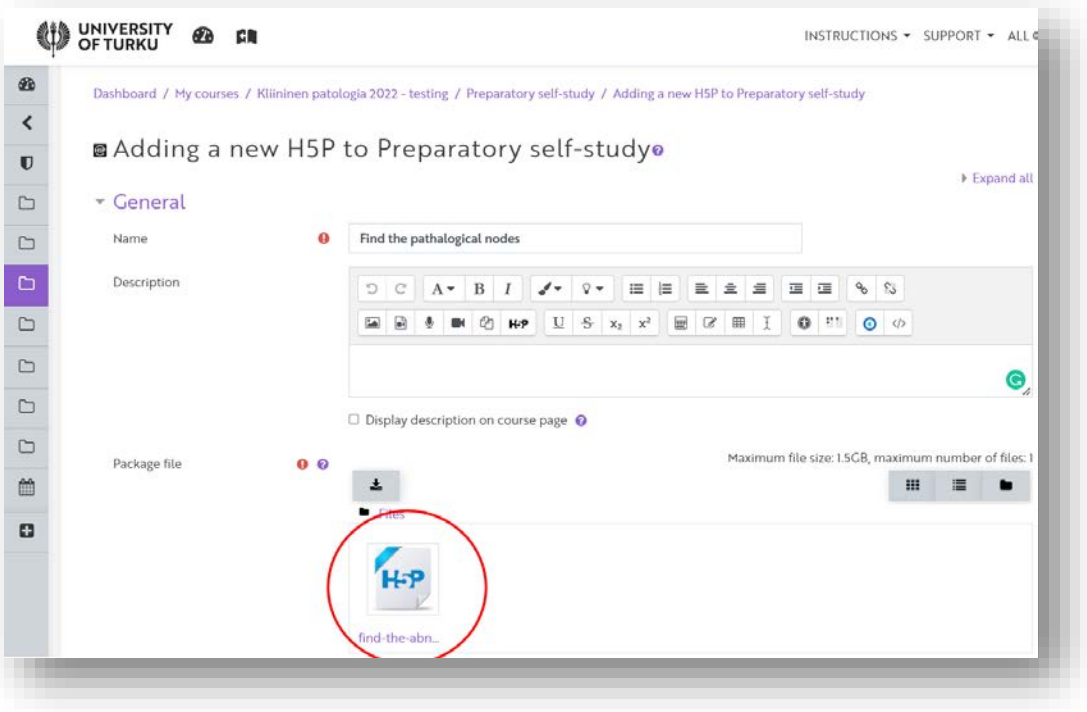


Figure 6. Editing mode in Moodle: importing H5P content

Video tours

Because we wanted to use authentic microscopic images to present learners with the complexity of the subject matter in real-life practice, but did not want to burden them with cognitive overload, we created video tours in which the knowledge of the expert was transfered in a user-friendly and efficient manner. The student looks over the shoulder of the pathologist, who leads him or her through the virtual slides and explains what can be seen. To create such teaching materials online remotely with an expert without the need for the expert to do everything themselves, we used various tools to create a sort of storyboard and script that could be shared so that audio-visual production tasks could be delegated to others. We will describe below this production process and the role of the various instruments in it.

Annotating a Whole Slide Image (WSI)

In order to determine together with the content expert what was interesting to tell about a microscopic specimen, we annotated the structures and elements of interest in a WSI with the help of the ‚PathPresenter' platform (Figure 9). You can register for free at https://pathpresenter.net/home and use the platform under the Creative Commons Attribution-Noncommercial-Share Alike for a limited data volume. The WSI in ‚PathPresenter' was shared with the content expert via Video conference software and the locations of interest were annotated by an assistant on instruction by the expert. Because clicking on an annotation automatically navigates the user to the related location, the list of annotations was the stepping stone for an outsider to find these interesting locations in the WSI for later audio-visual productions.

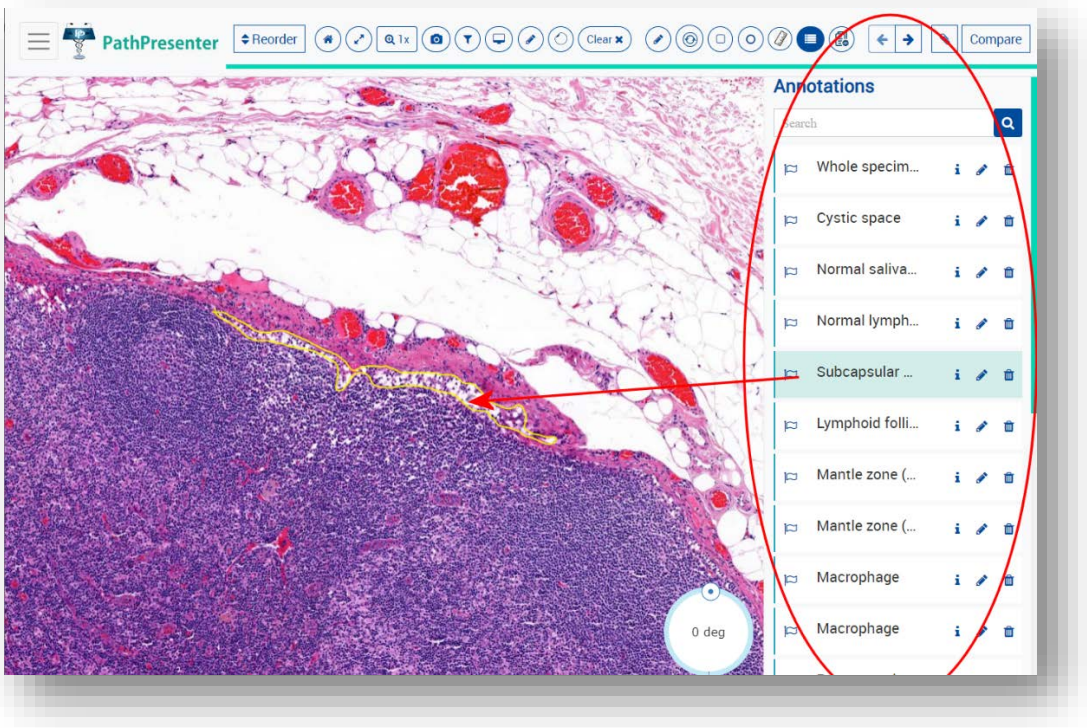


Figure 7. PathPresenter with list of annoted structures and elements

Recording the narrative for a WSI

Then the content expert was asked to tell the interesting facts about the specimen while navigating through the WSI, using the previously created list of annotations. This ‚guided tour' was recorded in a screencast. ‚PathPresenter' itself has a function for making such video recordings, but of course any other screencast programme can be used for this. Because these recordings were solely used as scripts for later voice-over productions, the fluency and pronunciation of the stories were unimportant. Only the message had to be conveyed to enable others the make the final voice-overs.

Creating the final video

Depending on the quality and usability of the ‚script' screencast, the video was either edited directly or re-recorded. For this purpose we used the screen recorder and video editor software ‚Camtasia'. Also here any other suitable software programme can be used. When the shared ‚script' video could be used directly, we first separated its audio and video tracks (Figure 10). The original audio track was than replaced by a newly produced voice-over.

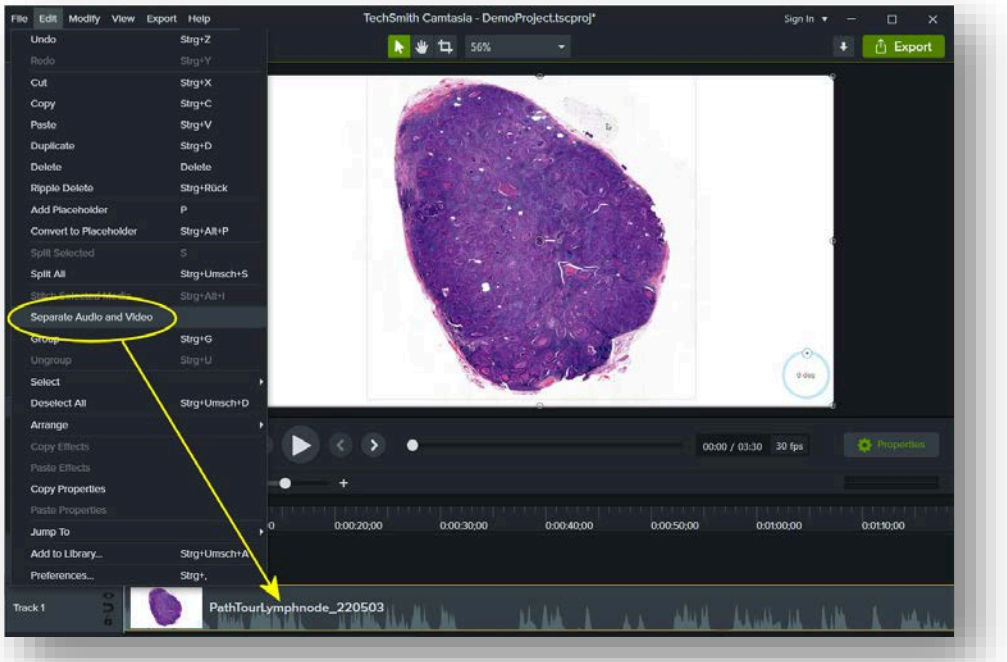


Figure 8. Camtasia: separation of audio and video tracks of the original screencast

Producing a final voice-over and videotutorial

We used the free, open source, cross-platform audio software ‚Audacity' to record the final voice-overs. Because it is difficult to record a long story in one go without slips of the tongue and well-timed with the images, we constructed the entire voice-over from several short sound recordings (Figure 11). This avoided the need to record long recordings in which a small mistake crept in all over again. In addition, fitting separate sound recordings onto an audio track made it much easier to keep them in sync with the image recordings on the video track.

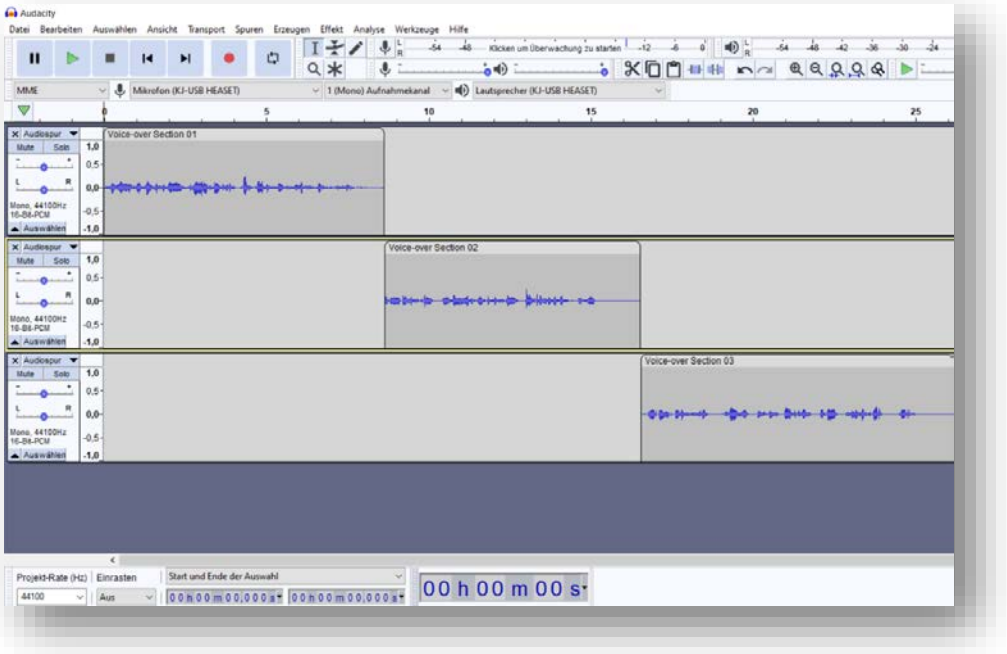


Figure 9. Audacity: several short sound recordings to build up the total voice-over

The voice-over sections in ‚Audacity' were exported as wav-files and imported in the software ‚Camtasia' to join the final video and other media files (e.g. images) to be compiled and edited into the final video tutorial (Figure 12). After the editing, in which for instance timing of the voice-over sections, transitions and annotations were settled, the videotutorial was exported as an mp4-file.

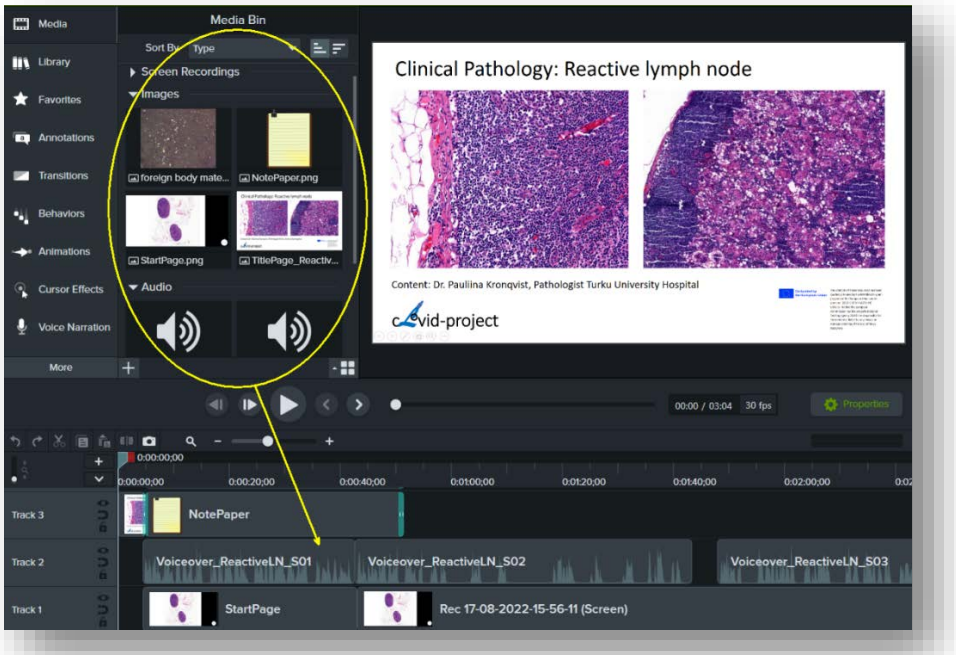


Figure 10. Compiling and editing the video tutorial in Camtasia

Making the videotutorial streaming and adding (multi-lingual) subtitling and chapters

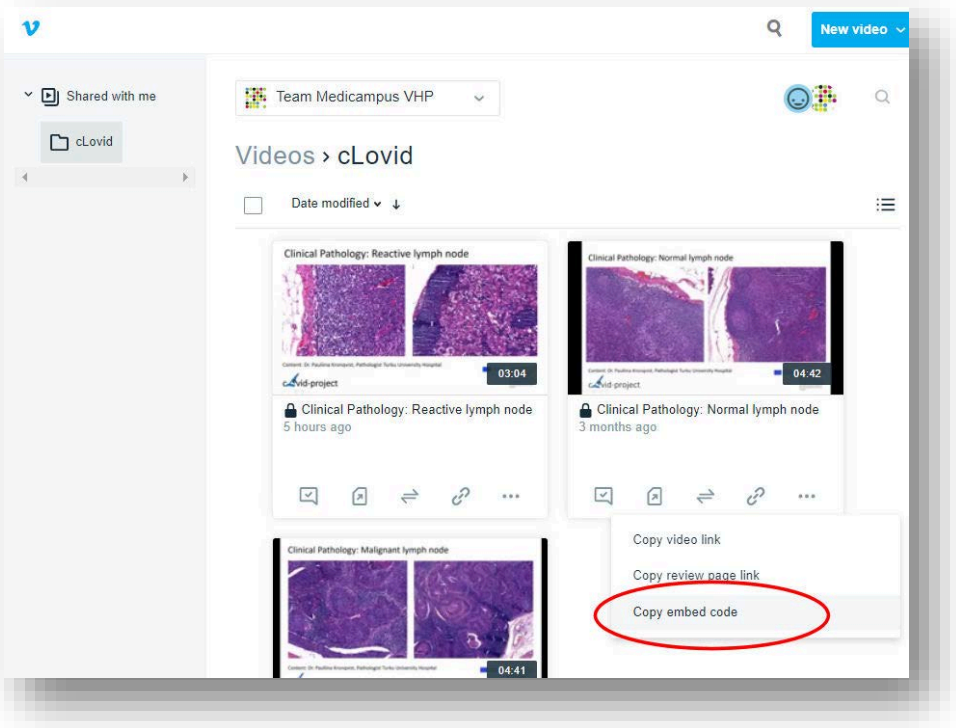


Figure 11. Vimeo-platform with videostreams that can be embedded in online learning materials

The Video-tutorials are uploaded on a streaming-video platform, in our case the ‚Vimeo' platform, so the URLs of the videostreams can be embeded in the learning materials (Figure 13) that are hosted in the Learning Management Systems used at a specific university. ‚Vimeo' gives the opportunity to generate ‚subtitles'and ‚chapters' for the videos. ‚Subtitles' provide viewers with a video's dialogue in written form and with ‚chapters' users can navigate to specific parts of a video.

An English voice-over of a video uploaded on the ‚Vimeo' platform will automatically be transfered into ‚subtitles' texts. Because speech recognition is not perfect, further manual refinement of these texts is usually needed. This was done by downloading the texts as a vtt-file and optimizing these texts in ‚Notepad'. The final English ‚subtitle' version was than translated with the online translation programme ‚DeepL' (https://www.deepl.com/) into other necessary languages and finally uploaded as vtt-file again on the ‚Vimeo' platform (Figures 14 and 15).

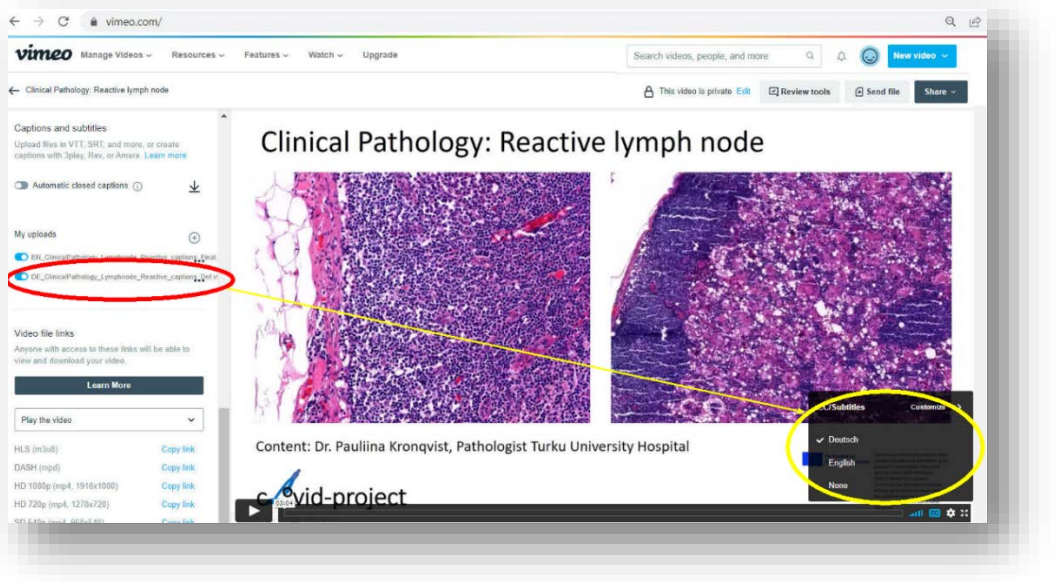


Figure 12. Vvt file with manually added German subtitles

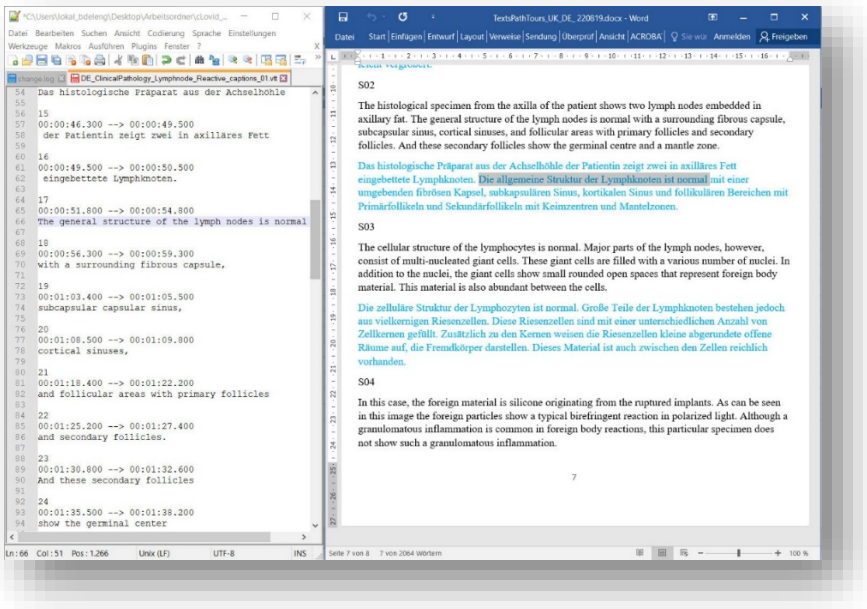


Figure 13. Vvt-file downloaded from the Vimeo platform and opened in Notepad (left). Wordfile with texts translated with DeepL from English to German, that is copied and pasted in a new vvt-file (right)

On the ‚Vimeo' platform, we manually added ‚chapter' headings for a video, which can be used in the videoplayer to jump to specific topics (Figure 16).

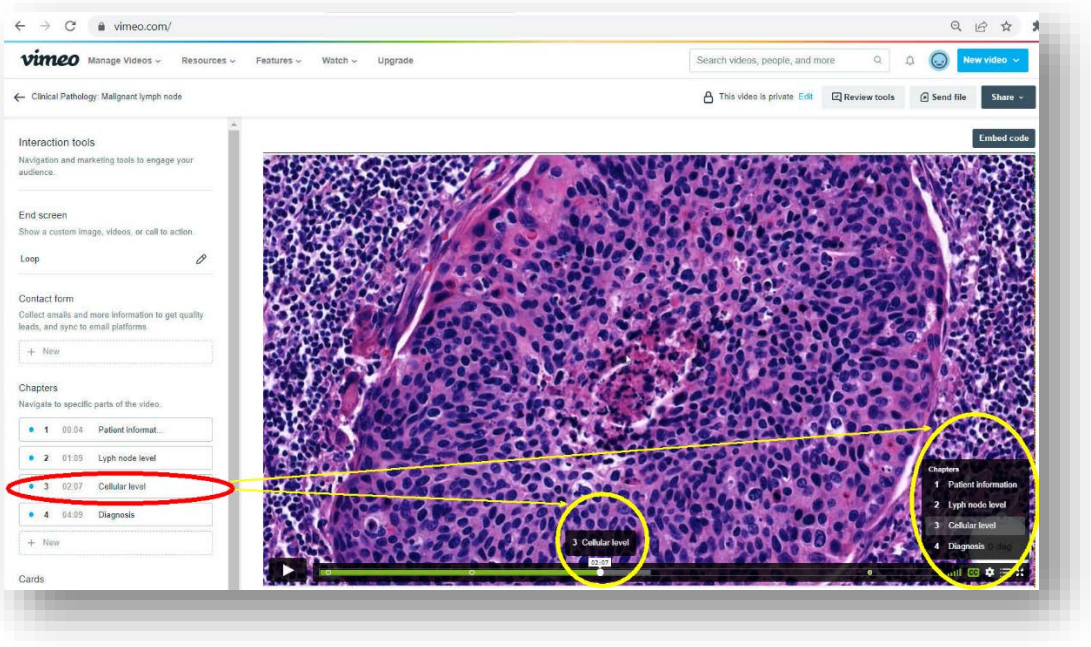


Figure 14. Vimeo platform in which chapters are manually added

Description online group sessions (in-class phase)

Many of the design elements Haidet e.a. formulated in the guidelines for reporting team-based leaning (TBL) in the Medical and Health Sciences Education Literature (Haidet et al., 2012) can also be well used to describe the activities in the (virtual) in-class phase of our flipped-classroom scenarios. Also their conceptual model, that depicts how teachers must constantly decide how content and group interactions can be shaped to engage students, is useful (seen figure below).

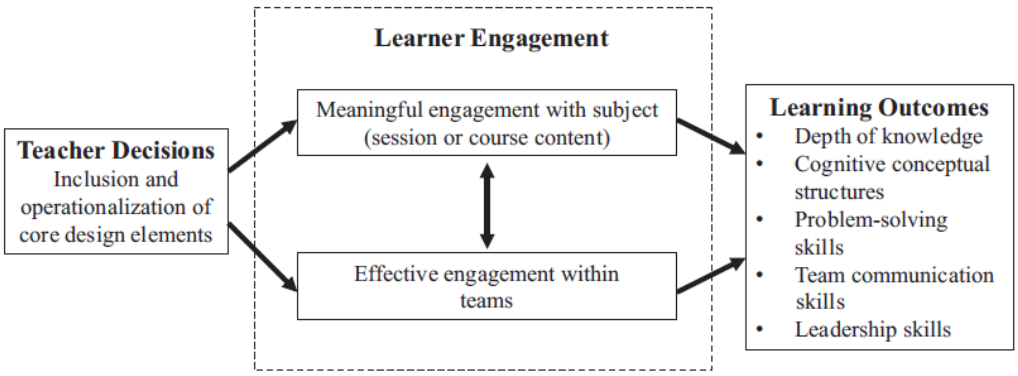


Figure 1 A conceptual model to describe the effects of team-based learning (TBL) design decisions on learning outcomes.

For undergraduate medical education

Scope

- A single online 90 minutes session, supervised by 3 teachers: 1 Finnish and 2 Dutch pathologists.
- Overall class size was 78 medical students: 48 Finnish third year and 30 Dutch second year.
- Unlike the Finnish students, the Dutch students had considerable experience with PBL. The Finnish curriculum probably pays more attention to the subject of pathology.

Team formation

- The students were assigned by the instructor to 11 groups of 5-6 students because fewer than 5 students carries the risk of insufficient critical mass and more than 8 permits ‚social loafing'.
- Five groups were heterogeneous in which gender and nationality were equally distributed among the groups. Heterogeneous teams promote discourse on the content as learners work out differences in their perspectives. Six groups were however homogeneous with respect to nationality (3 Finnish, 3 Dutch) for research reasons. This sorting process was not transparent to the learners.

Readiness assurance

- Readiness assurance tests, that are an integral part of TBL, were not applied in our scenarios. However by pointing out that in the follow-up discussions, each group's answers could be viewed by all and each team member could be asked to motivate the group-answer, a sense of team and individual accountability for task performance was stimulated.

Feedback

- Feedback was given during a plenary debriefing following the group work on a task. A learning dashboard, developed to facilitate complex in-class scenarios in radiology education (de Leng & Pawelka, 2020), was adapted for microscopy education and used by the teachers during the online plenary debriefing. Because learning dashboards are „application that captures and visualizes traces of learning activities in order to promote awareness, reflection, and sense-making" (Verbert et al., 2014)

all participants can simultanously see the specific choices made by the different groups. The aim was that with this awareness of everyone's contribution would encourage both the small-group collaboration and the plenary discussion. Controversy across teams could be used by the teachers to invite individual students to defend the points of view of their team. In this way students teach each other, often using language that is more accessible than that of the teacher.

Sequencing of in-class activities

– Intrateam activities in breakout rooms of the videoconferencing tool Zoom (Figure 17) were followed by interteam activities in an online plenary session in Zoom (Figure 18). This sequencing enabled learners to deepen their level of thinking and provided opportunities to discuss and elaborate course concepts in greater depth.

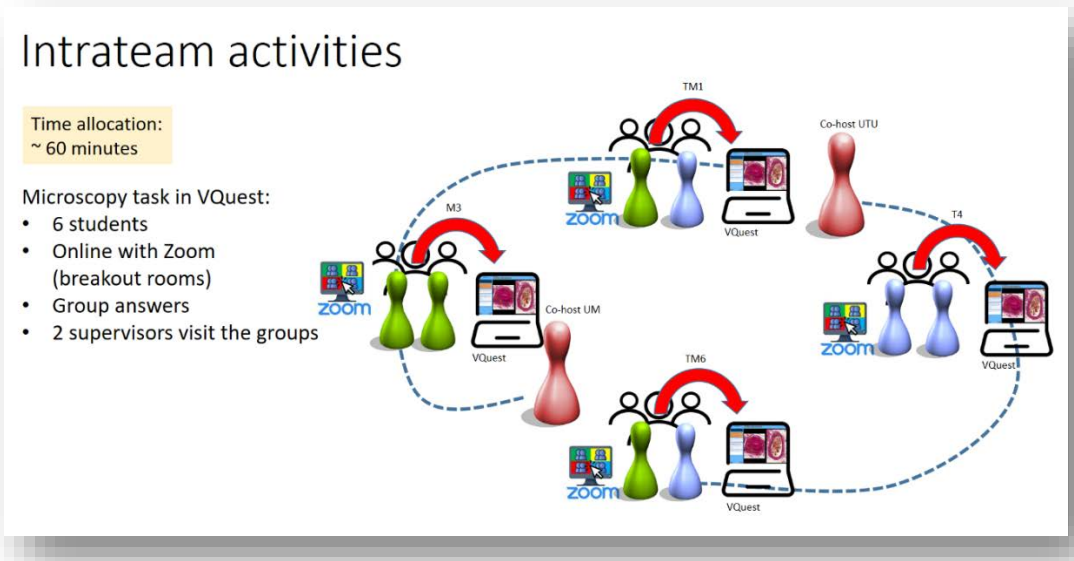


Figure 15. Intrateam activities in breakout rooms

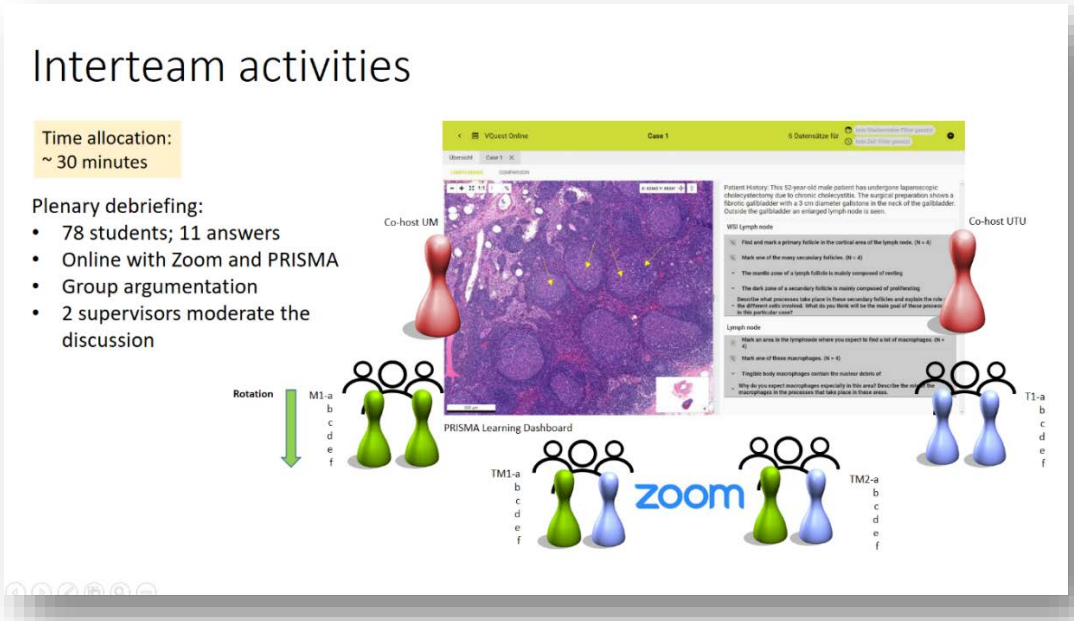


Figure 16. Interteam activities in main room

Four times S: significant problem, same problem, specific choice, simultaneous reporting

- During the intrateam activities all groups were assigned the same tasks with digital microscopy specimens (same problem). See figure 19. With a real patient case the students were introduced to the context of problems in the pathology domain and their relevance for medical practice (significant problem). Assigning a significant problem with realworld relevance increases interest during intrateam discussions.

Figure 17. Significant problem with authentic material in assessment program VQuest

- Assigning the same problem to all teams increases interest during interteam discussions. The tasks in the assessment program involved mainly multiple choice, longlist and marker questions (specific-choice). Together with the use of the learning dashboard during the plenary session (Figure 20), presenting back the selective responses of the groups in an aggregated overview (simultaneous reporting), provided a common frame of reference and made the differences between the groups visible. This was meant to enhance critical thinking and whole-class discussions.

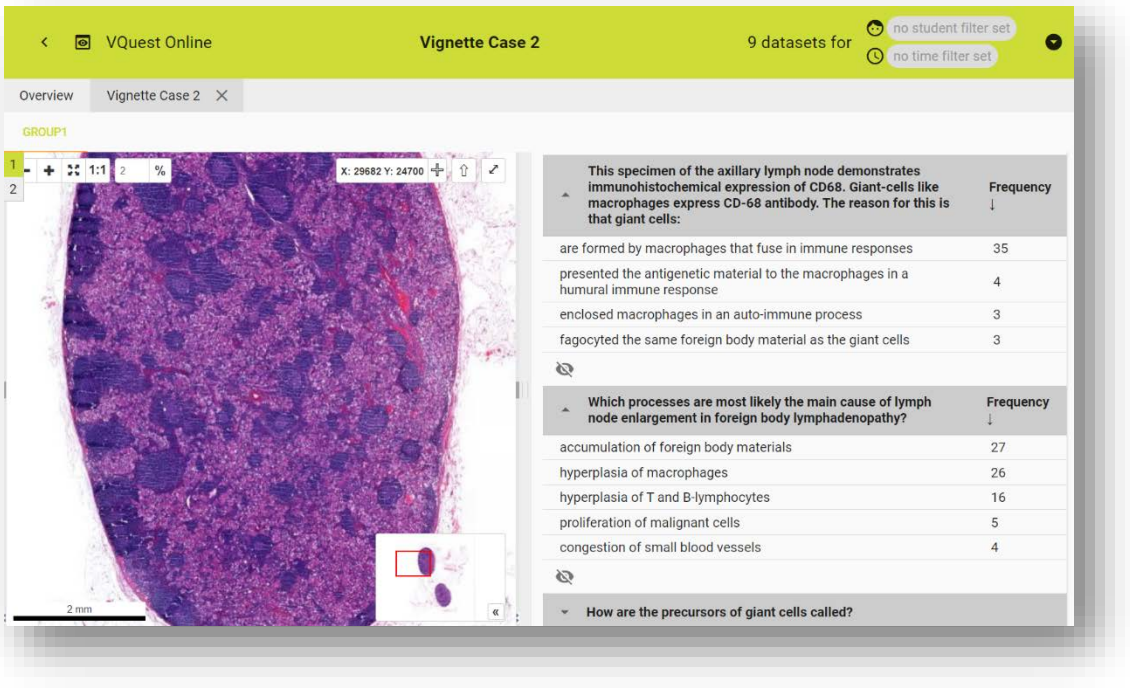


Figure 18. Simultaneous reporting of specific choices in learning dashboard

For postgraduate medical education

Scope

- The program with a total workload of about five hours was spread over a four weeks and was scheduled in the December month, during which the residents could potentially free up more time for study activities.
- Participation was voluntary and on invitation by the two supervising pathologists.
- Overall class size was eight residents: 3 first year, 2 second year and 3 third year trainees. And two pathology teachers.
- Domicile of the participating residents: three both from Turku and Kuopio, one from Helsinki and Oulu.

Team formation

- The eight residents were assigned by the instructor to one single group.

Readiness assurance

- Readiness assurance tests, that are an integral part of TBL, were not applied in our scenarios. Although the responses the individual assignments were annonymous the supervisors could see which year of training and which hospital the candidate was in.

Feedback

- Feedback was given during a plenary debriefing following the four weeks period of individual work on webbased patient cases with digital microscopy specimen. During the online plenary debriefing in Zoom the two supervisors used the learning dashboard for microscopy teaching (described before). All participants could simultanously see the specific choices made by their peers.

Sequencing of in-class activities

- The in-class activity in the videoconferencing tool Zoom followed the individual work on the patientcases in the assessment program VQuest.

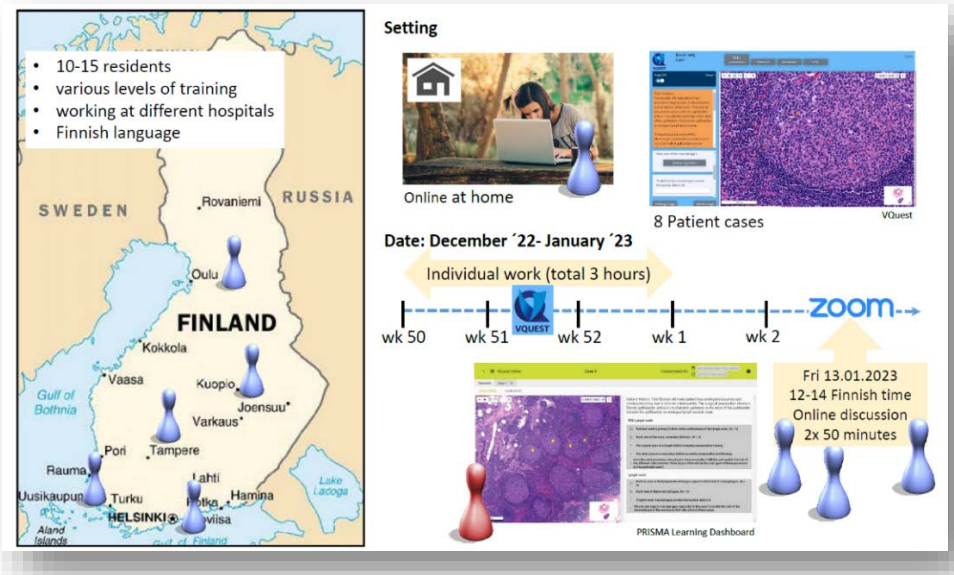


Figure 19. Out-of-class and in-class activities in the scenario for residents

Four times S: significant problem, same problem, specific choice, simultaneous reporting

- During the individual out-of-class activities all residents were assigned the same tasks with eight digital microscopy specimens (same problem). See figure 21. Similar as the real national exam, residents were asked to respond with histological descriptions, reports, pathologic-anatomic diagnosis, differential diagnosis, additional and follow-up examinations (significant problem).
- The tasks in the assessment program involved many multiple choice, longlist and marker questions (specific-choice). To prevent cueing in answering the questions on pathological-anatomical diagnoses, stains or studies and differential diagnoses, longlist with anwers were developed and presented as select responses (Figure 22) . Together with the use of the learning dashboard during the plenary session (Figure 23 and 24), presenting back the selective responses in an aggregated overview (simultaneous reporting), provided a common frame of reference and made the differences between the candidates visible. This was meant to enhance critical thinking and whole-class discussions.

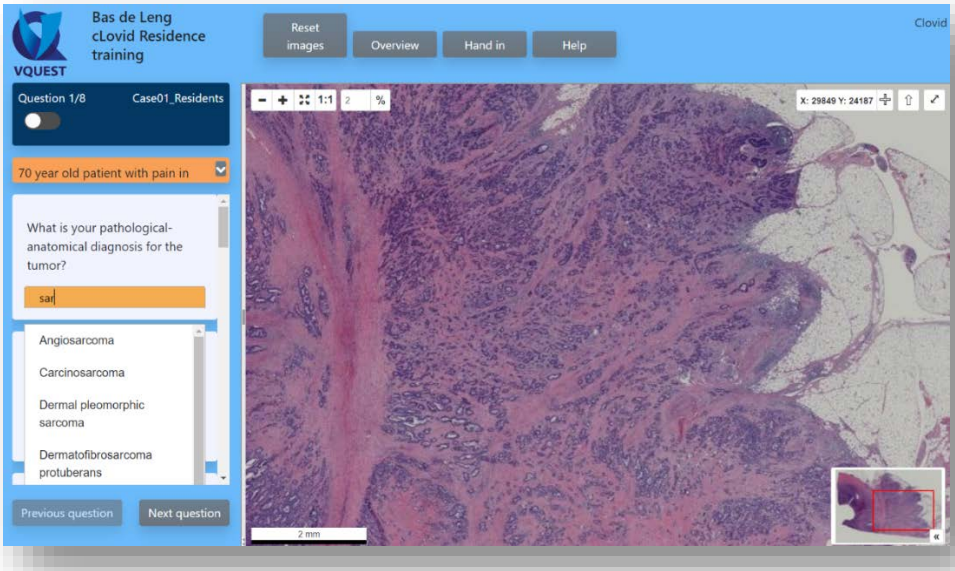


Figure 20. Longlist with pathological-anatomical diagnosis filtered based on entry of 'sar'

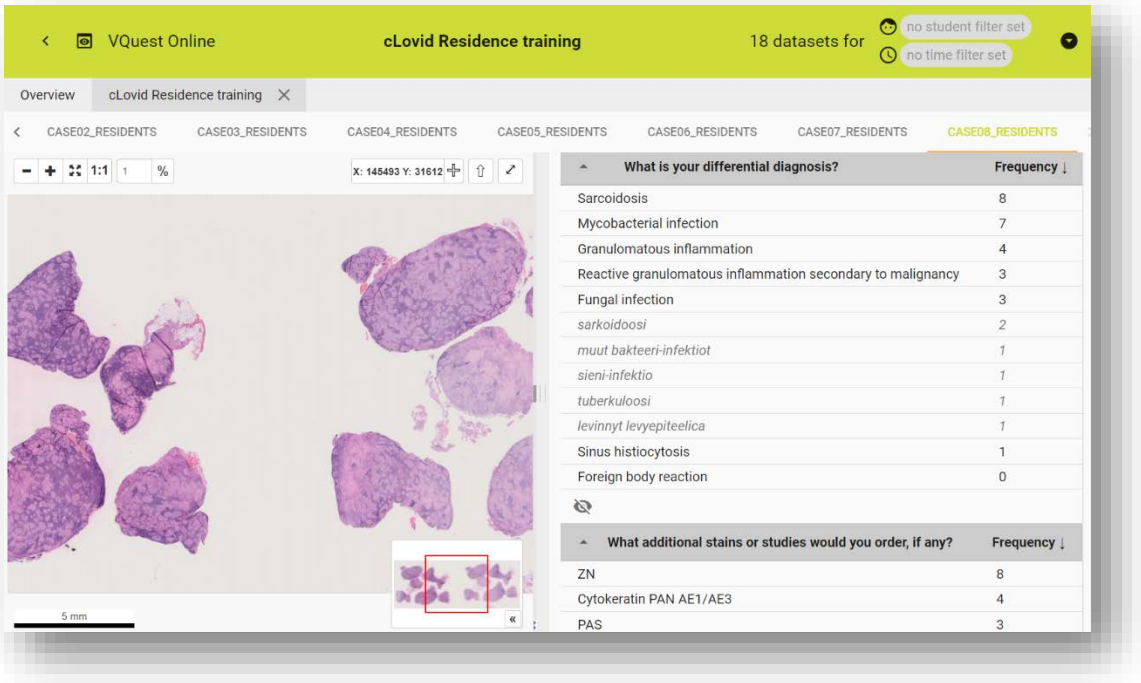


Figure 21. Learning dashboard showing the distribution of the select responses over the candidates

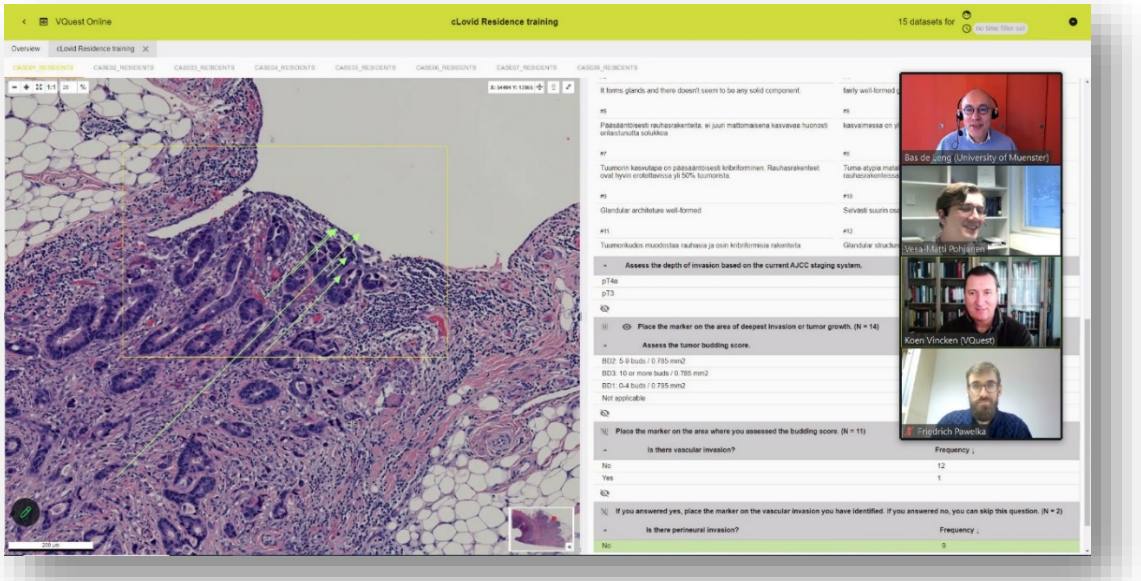


Figure 22. Learning dashboard showing arrows as select reponses in marker-questions

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