Virtual Microscopy
Histology and Histopathology

METHODOLOGY
OF PRODUCTION OF
VIRTUAL MICROSCOPY SLIDES

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General Presentation

Light microscopy sharing examination, in which the teacher/professor stands close by the student and alternatively examine the slides, using the same microscope in order to analyze each tissue/cell/organ, has represented traditional microscopy education. This method has been challenged during the pandemic and has forced innovation in order to continue teaching microscopy. Consequently, teaching via VM seemed an optimal alternative for histology and histopathology education. WSI has emerged as the digital pathology platform of choice for teaching in recent years, demonstrating its utility in both undergraduate and graduate medical education, primarily by leveraging stored teaching libraries, study sets, and individual cases to enhance didactic teaching, to monitor acquisition of new skills (e.g., stain interpretation), and to assess competency through slide examination/testing. Furthermore, VM software reproduces a high-quality image with meticulous clarity and added features that allow students and teachers to highlight, annotate, and pan and zoom. Thus, VM represents a modern tool, with increased quality and utility in microscopy education.

Several Medical Programs around the world have adopted the VM to compliment the effectiveness of competency-based education in medical education. Unfortunately, there is no study program of VM in Romania, and very few available in Europe. Therefore, it is imperative that medical students become familiar and proficient in the VM system applications. Thus, the project is addressing the need for students' skills improvement in morphological sciences. This project will also establish a dynamic virtual microscopy educational system in response to the need to increase the digital transformation of the educational systems. As a consequence, the implementation of this new technology is contributing to innovation in vocational education and training in Medical schools/universities. Considering that VM allow its application at a safe distance in between participants, it is increasing the flexibility of opportunities in vocational education and training, a necessary requirement in modern days.

The main project aim is the digital transformation of the microscopy teaching and learning, by setting a practical guide and steps to follow in order to achieve a successful use of virtual microscopy (VM) technology to improve the histology and histopathology curriculum.

The project objectives are: adaptation of the medical school curriculum of Histology and Histopathology at EU level, for innovative digital transformation by VM, digitalization of the teaching of microscopy in a Medical education institute, construction of a virtual microscopy library platform, decrease of the differences between education systems in Eastern EU countries, and increase in undergraduate and postgraduate students' vocational skills for new, modern Medicine domains.

The expected project results are: an improved EU curricula on histology and histopathology, set up by the researches of the partner Universities, a virtual slide library in histology and histopathology, a training guide for advanced VM teaching in microscopy for the extension of accessibility of undergraduate and postgraduate students to deep learning of microscopy, an Open online course on VM, to increase students' competencies in

VM3.0 - Digital transformation of Histology and Histopathology by Virtual Microscopy (VM) for an innovative medical school curriculum

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microscopy/morphological sciences, and the enhancement of students' interest for histology and histopathology.

The project is innovative because it is addressing to each participant's willingness or interest to adapt to new technology. By VM implementation, a modern tool in microscopy would be largely accessible to our students, providing special skills and competencies, and will enable the involved experts the innovative development of future histology and histopathology.

The project proposal is suitable for creating synergies between different fields of education, because it is addressing both to the Departments of Histology and Pathology, in order to implement a VM library. As it is addressing both to undergraduate and postgraduate students, it has an amplified effect in their education, creating synergies between different fields of training. The impact on the participants is in gaining digital skills and competences in VM, a domain of the future Medicine.

Moreover, considering different stages of partners of initiation digital microscopy teaching, there would be a fruitful exchange of expertise and knowledge between them, along with the expertise of the partner from Peloponnese University in digitalization, contributing to the implementation of the project in all Medicine universities involved in the project.

Nonetheless, **the target group** is represented by higher education sector, as the main project objective consists in increasing the accessibility of Medicine undergraduate and postgraduate students to microscopy data in order to allow the deep learning and increased skills, by raising the students' interest to virtual Medicine. The practical experience shared form the Gdansk universities to Iasi, Alicante, and Plovdiv Medical universities will ensure a professional partnership in which training approaches, strategies for modern, remote microscopy teaching will be an important learning experience with future impact on how the recipient countries will adapt the new methods to their national and institutional contexts.

The impact for the Medicine undergraduate students, by participation in the project, would be their increased level of competencies, by gaining a better comprehension of microscopic features of human organs and diseases, by their involvement in an innovative, updated education and training in a safe environment, by user-friendly digital tools, leading to an enhanced self-confidence, efficacy and motivation, with the possibility of self-evaluation as a modern tool of learning.

The impact for Postgraduate students in Pathology training would be a better comprehension of microscopic features of human diseases, the acquirement of key competences for high-quality professional practice, with the possibility of self-evaluation as a modern tool of learning, with enhanced transversal skills, increased self-confidence, efficacy and motivation, gaining deeper insights into histological features significance for targeted therapy, by participating in the creation of an European VM Network of Centres/Departments as a point of reference for user-friendly digital tools.

The project concept is meant to gather the professional experience of all partners, to form a network of VM educational system. At local level, all partners have relevant experience in community level work with medical institutions and education and training, supporting policy development, EU projects and dissemination of outputs. According to their expertise, the partners will participate in online conferences, seminars, European Medical conferences and meetings, in order to promote their results to professionals, sharing their experience in VM

implementation. Articles that would be submitted to newspapers and medical journals will gain valuable feedback and support from stakeholders and professionals, which will contribute to the quality of the project outcomes. The experts involved in this project might have the possibility to share experience and to enrich their background, by application of advanced best practices, improved quality of professional performances and outcomes, by participating in interdisciplinary team-work and cooperation with other professionals. The Educational centers in Medicine may gain future oriented and modernized curriculum/ tools, with stimulation of a modern field of Medical education (digitalized microscopy), having an access to updated and international resources, with optimization of teaching, minimizing unnecessary on site classes and encounters, and for implementation of European VM Network of Centres/Departments as a point of reference for user-friendly digital tools.

Motivation

The new technology of virtual microscopy (VM) has been recently demonstrated as a reliable and valid pedagogy method for microscopy learning objectives and assessments. The implementation of the new technology in university education became a necessity during the pandemic. Moreover, the modernization of educational tools is contributing to innovation in vocational education and training in Medical schools/universities and may ameliorate the discrepancies between some Eastern and Western European countries.

Context

The medical education realized that moving the education in online during the pandemic, forced the microscopy education to be very much diminished, close to impossible to continue, especially for the practical laboratories. The loss of the classical methods has stimulated Medicine educational innovation in order to continue teaching microscopy. Alternatively, a shift toward teaching via VM provided a readily available, physically distanced, and cost-conscious alternative for histology and histopathology education.

VM has been progressively applied during the pandemic, by revolutionizing the learning of histology and histopathology worldwide, leading to digital transformation through the development of digital readiness, resilience and capacity. Whole Slide Imaging (WSI) technique involves digitization of glass slides to a high-resolution format, which can be easily viewed using specialized VM software on a tablet/computer/laptop, without the necessity to use a microscope for the examiners. This technology become more valuable as the COVID-19 pandemic has forced educational programs, including undergraduate and postgraduate students, to move to a physically distanced learning environment.

Considering that VM allows its application at a safe distance in between participants, it is increasing the flexibility of opportunities in vocational education and training, a necessary requirement in modern days.

By the acquisition of a VM platform, the didactical process is ready to face any other unprecedented EU or worldwide restrictions.

Modernization of all European universities

Currently, there are inequalities between Romania and other EU countries with regard to medical education platforms and specifically, in the field of normal and pathological microscopy. The need for implementation of WSI as a learning tool for the formation of microscopy competences in students, with the possibility to train at home, with the long term aim to generate a Romanian expertise in the field of histopathology at the EU standards in order to provide the means for an early, accurate diagnosis, prognosis, and tailored therapy to patients.

The development of a virtual slide library may contribute to the process of digital transformation, as a response to the pandemic situation. Moreover, the project would be an important tool to decrease the differences between education systems between Western and Eastern EU countries, in order to provide similar education quality.

Improved relationships between didactic staff and students

The VM library may be used as an alternative pedagogic method, considered as more attractive for students, by using the new technologies and methods. Moreover, it provides a platform for exchange of information, questions & answers, annotations, quizzes, online lectures and seminars, with the possibility to improve the relationship between teachers and their undergraduate and postgraduate students.

Methodology of production of virtual microscopy slides

Step 1 - Project curricula

The project curricula has been debated, according to P1 proposal, in the second transnational meeting, in June, in Alicante, and the final 18 sections have been established, in order to comprise major topics in Histology, Histopathology, and cytology, according to tissues, organs and/or systems, with an added section for miscellaneous findings.

Step 2 - Standards chart

In order to prepare the adequate slides according to the requirement of the scanner, a Standards chart has been made, containing the slides preparation standards, which is crucial to the quality of the scan, including the coverslips mounting, labelling, slides size and specifications (24.6mm to 26.5mm in width, 73.6 to 76.6mm, in length, 1.48mm, in thickness, with coverslip, with a scanning area of 54.9 x 22.9mm), and the slide transfer protocol, according to a transfer agreement.

Step 3 - Collection of Whole Slides Images (WSIs)

Our Histology Department achieved a collection of histology digital slides, meticulously curated to support the educational needs of our students. This collection adheres closely to the VM3.0 Curricula proposal, a collaborative effort by our project partners. It comprises a growing number of slides that are in a constant state of renewal and expansion to ensure that it remains current and aligned with the evolving field of histology.

Each scanned slide in our collection is thoughtfully organized and easily identifiable thanks to a coding label specific to a particular chapter in the curricula. This coding system simplifies navigation for students, enabling them to access slides relevant to their coursework swiftly. Furthermore, to enhance the learning experience, each slide is accompanied by a concise yet comprehensive description. These descriptions highlight key words and concepts essential for organ diagnosis, providing students with invaluable insights into the histological structures they are studying.

Our digital slide collection is structured to align with the VM3.0 Curricula proposal, which covers a wide range of histological topics. These topics include the histology of epithelial tissue, connective tissue proper, special connective tissue, muscular tissue, nervous tissue, blood, cardiovascular system, immune system, endocrine system, digestive system, glands associated with the digestive system, respiratory system, urinary system, female reproductive system, male reproductive system, mammary glands, integumentary system, nervous system, and miscellaneous histology, histopathology, and cytology (optional).

Step 4 - Digital slide scanners

Digital slide scanners advantages are that they represent closed systems, do not require eyepieces, or position and focus control, and are controlled by a PC, as our Aperio AT2 Slide Scanner, designed by Leica Biosystems, which has been used in our department for the last few years.

Step 5 - Image analysis system/software and functions

ImageScope is a free software for digital scanned slides viewing, with a web viewer version that eliminates the need for software installation, with an optimal scanning capacity. Our Histology Department has used the Aperio ScanScope AT2, which employs a lineal scanner and achieves precise focus adjustment from one line to the next at a high frequency rate. Each uncompressed tagged image file format (TIFF) file with a scanned image stripe is 200 megapixels in size when Aperio ScanScope is used at a ×20 objective. The software seamlessly assembles the digital slide squares through adjustments and stitching between the images, ensuring continuity and accuracy.

Step 6 - Storage and WSI viewing

Digital scanned slides viewing was achieved by a software called ImageScope. During the pandemic, this software, coupled with e-learning platforms and video conferencing, played a vital role in enabling us to prepare and examine our students using dynamic whole slides rather than static imaging, significantly enhancing the educational process. ImageScope and its online web viewer have been instrumental in our project as well, with the possibility to access digital

slides, pan across them, make annotations, and share these annotations between students and their peers. Students can utilize tools such as the pen tool to mark specific structures or regions of the tissue and employ the ruler to measure the thickness of a region on the slide. The software also enables users to save annotations as HTML files, facilitating easy sharing with others.