



Development of CytoAcademy: a new web- and mobile-based E-learning platform for cytopathologists and cytotechnologists by the Korean Society for Cytopathology in the post-pandemic era

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Since the late 1990s, online e-learning has offered unparalleled convenience and affordability, becoming increasingly popular among pathologists. Traditional learning theories have been successfully applied to web/mobile-based learning systems, with mobile technologies even enhancing conventional offline education. In cytopathology, hands-on microscope training has traditionally been paramount, complemented by real-case presentations and lectures. However, the coronavirus disease 2019 (COVID-19) pandemic disrupted regular academic activities, making online e-learning platforms essential. We designed a web/mobile-based learning platform to enhance continued medical education in cytopathology at various levels, particularly during the era of COVID-19 and beyond. Since 2021, we have integrated curriculum materials, virtual education files, and whole-slide images (WSIs) of cytopathology, submitted from over 200 institutions across Korea, with the support of numerous instructors. We develop a new e-learning platform named “CytoAcademy” composed of a basic session for each organ and level across the range of morphologic findings; on-demand lectures to enhance cytopathologic knowledge; WSI archives that allow users to explore various histologically confirmed cases; and a self-assessment test to help organize diagnostic knowledge acquired through the web/mobile-friendly learning system. The platform provides not just an opportunity to achieve a correct diagnosis, but also a learning experience based on problem-solving point. Members interact, identify their deficiencies, and focus on specific educational materials. In this manner, all participants can actively engage in creating and maintaining knowledge and foster a proactive approach to learning.

Key Words: Cytology; Education; Medical; Continuing; Self-assessment

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Cytopathology is a field of pathology that studies and diagnoses diseases at the cellular level [1]. For accurate diagnosis, cytopathologists require training with multiple cases that exhibit sufficient variability within and between diagnostic categories, along with continuous feedback throughout the training process [2-4]. In the field of cytopathology, hands-on training with the direct use of microscopes has traditionally been of great importance. However, traditional educational methods using optical microscopes (OM) and glass slides as teaching resources impose several limitations. For example, glass slides are prone to deteri-

oration, damage, or loss; most importantly, unlike slides produced using formalin-fixed paraffin-embedded tissue, it is not possible to produce a large number of identical cytology slides. Additionally, due to limitations related to OMs and space availabilities, the number of trainees must be restricted. Amid these challenges, the coronavirus disease 2019 (COVID-19) pandemic introduced unexpected environmental constraints, disrupting hands-on and professional training courses, and regular in-person academic activities. This further emphasized the need for a transition to online education in cytopathology and related fields [1].

In the field of pathology, virtual microscopes (VMs) for observing whole-slide images (WSIs) and learning management systems equipped with these technologies have been explored as solutions to overcome these challenges [5]. VM simulates the experience of an OM, allowing users to navigate scanned slides, adjust objectives, zoom in on areas of interest, and focus on various cellular components [5].

Learning is increasingly shifting toward more self-directed, open, and informal methods [6,7]. Learners are gaining more choices regarding the time, place, content, and path of their learning. The rapid increase in online learning resources is profoundly influencing ideas and beliefs surrounding education [8]. Over the past decades, the internet has revolutionized the field of education. Since the late 1990s, online e-learning platforms have offered unparalleled convenience and affordability. E-learning is currently receiving significant attention and is widely discussed in medical education. Due to continuous changes and advancements in information technology, as well as the introduction of more user-friendly e-learning methods, e-learning is continuously advancing in the field of medical education [9-12].

In cytopathology, hands-on microscope training has traditionally been paramount, complemented by real-case presentations and lectures. However, the COVID-19 pandemic disrupted regular offline academic activities, making online e-learning platforms essential. E-learning is also becoming popular in the field of pathology education. Therefore, we need web/mobile-based learning platforms to enhance continuous medical education (CME) in cytopathology at various levels, including during the era of COVID-19 and beyond. The rapid development of WSI-processing technology, the emergence of affordable platforms, and advances in high-speed networking have heralded a new era in the clinical and educational pathology workflow, including cytopathology worldwide.

METHODOLOGY

To keep pace with these domestic and international trends, the Korean Society for Cytopathology (KSC) formed a Task Force Team (TFT) composed of its executives and requested the development of a cytopathology e-learning platform in January 2021 to provide a convenient and efficient educational space. Accordingly, the TFT spent several months conducting literature research, reviewing various domestic and international CME programs, sharing development experiences with other academic society executives, and gathering expert opinions from external organizations before drafting their proposal. When developing

e-learning modules, we drafted the website from the user's perspective to ensure that it was as convenient as possible for members to learn. After several rounds of revision, we finalized the design. In addition, to ensure smooth program operation and secure data storage, we compared data from various server-related companies to evaluate the pros and cons of on-premises servers versus cloud-based servers. Ultimately, an on-premises server was used.

At the time of development, we possessed more than 3,500 digital slides for quality control by the KSC that were accumulated through projects of the National Information Society Agency. We aimed to incorporate these into our e-learning platform to assist members in learning. To ensure optimal performance of the VM, we independently developed and implemented an image viewer program that allows members to conveniently observe WSIs (by Design JIU). After these extensive efforts, a web- and mobile-based e-learning platform named "CytoAcademy" was launched in time for the 36th Annual Spring Meeting of the KSC. During the development period, in an effort to garner interest from members, an event was held where all members were invited to submit suggestions for the platform's name, and prizes were awarded.

FEATURES OF CYTOACADEMY

Since 2021, we have integrated curriculum materials, virtual educational files, and cytopathology WSIs, submitted from more than 200 institutions across Korea with the support of numerous instructors. The CytoAcademy e-learning platform was developed with the following components (Fig. 1).

- Basic sessions: This menu provides an image atlas and descriptions of individual diseases organized by system.
- On-demand lectures: These provide the latest video lecture materials organized by each system.
- Digital slides: This menu provides WSIs of each disease, and members inspect the slides directly using a VM. An archive of more than 4,000 WSIs allows users to explore various histologically confirmed cases.
- Slide seminars: Obtained data have been continuously uploaded to the KSC website since 1989. A "slide seminar" is a case-presenting program of the KSC that has been held four times a year since the 1980s.
- Quiz: The quiz section consists of self-assessment tests and spot diagnoses. These tests help users organize and reinforce the diagnostic knowledge they have acquired.

The development of CytoAcademy started with a VM database of cytopathology WSIs scanned using a Panoramic 250 Flash III

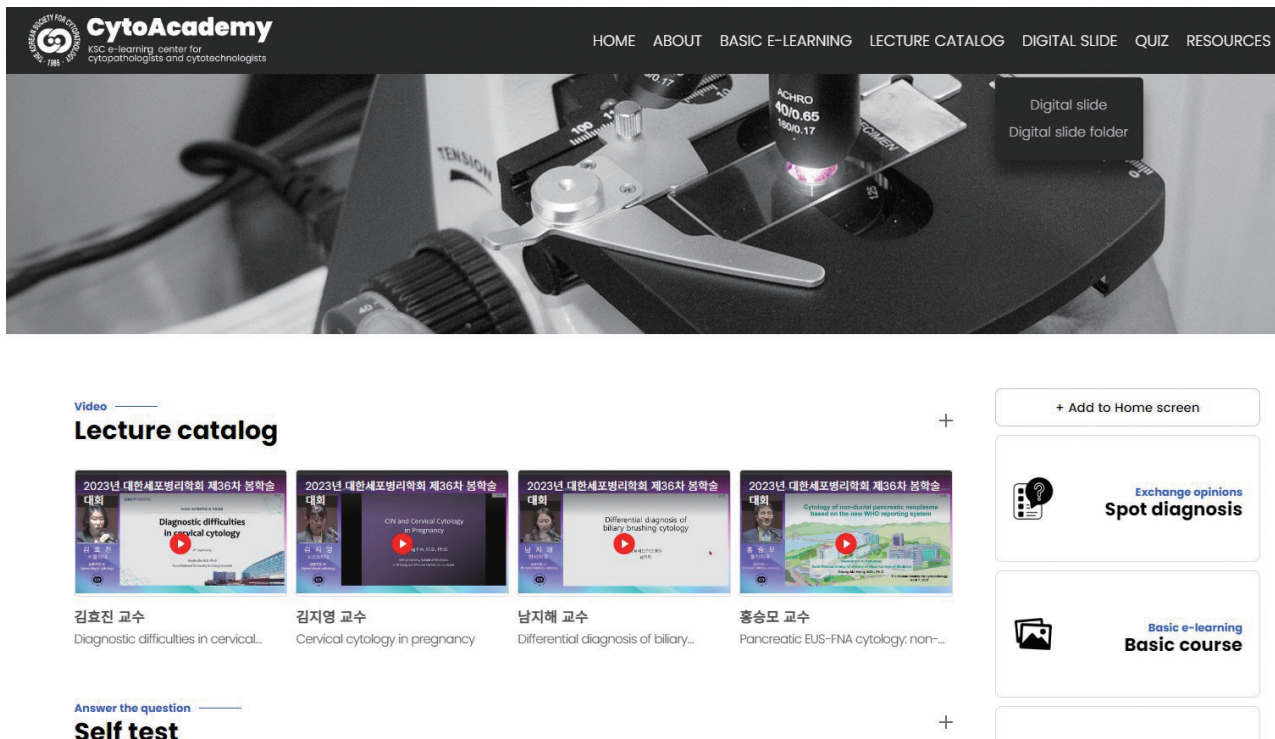


Fig. 1. Layout of the CytoAcademy website (<https://www.cytoacademy.or.kr>).

system (3DHitech, Budapest, Hungary). The WSI archives offer an extensive collection of histologically confirmed cases, providing essential features for in-depth study and reference. Even after its development, content in all areas continues to be updated regularly. Additionally, a paid lecture menu has been newly established for the management of specific lectures and to provide ratings for members of the KSC. The platform's interface is user-friendly, providing access to essential learning materials and resources. Users can navigate through different sections, such as on-demand lectures, WSI archives, and self-assessment tests.

PRACTICAL USE AND APPLICATION

CytoAcademy is being utilized as an individual educational platform for cytopathology by members of the KSC, and as a comprehensive learning experience in which problem solving is at the forefront. Moreover, it provides an opportunity to reach the correct diagnosis and effectively supports self-testing for quality control. It provides various training programs for cytopathologists and cytotechnologists organized by the KSC, as well as various workshops and seminars. Previous cytopathology training programs organized by the KSC have involved educating a small group of individuals using microscopes and slides. CytoAcademy offers the same level of educational effectiveness but without

the constraints of time, space, or number of participants. Learners can observe useful annotations on the slides, as recorded by the instructor, allowing them to learn faster than when using an OM. Most importantly, the ability for everyone to simultaneously observe and learn from the same image is a significant advantage compared to traditional cytology educational programs. CytoAcademy enables members to interact, identify their deficiencies, and focus on specific educational materials. This proactive approach to learning ensures that all participants can actively engage in creating and maintaining knowledge.

CURRENT LIMITATIONS AND FUTURE PERSPECTIVES

One of the key intentions when designing the online education platform was to ensure that it would not merely be a space where learners passively consume the provided content, but instead, a platform that is dynamically shaped and brought to life by the learners themselves. Such a platform should function as a participatory community where learners are not just consumers, but actively generate, share, and interact with content. Through this, learners can influence one another, expand their knowledge, and take on an active role in the learning process. To achieve this, it is essential to encourage active uploading of user-generated

content, facilitate collaborative interaction, and provide options for personalized learning pathways. However, during the development phase of the platform, it was challenging to meet all these requirements. Therefore, we first created a “spot diagnosis” section as a submenu under the “QUIZ” menu, where learners could freely upload content and communicate with each other. We hope that this space will gradually become more active, and by systematically updating the aforementioned features, CytoAcademy will evolve into an organic and dynamic platform.

Additionally, the TFT aimed to create a platform that could be freely accessed by cytopathology learners not only in Korea, but around the world. With this intention, a website was developed in English. However, due to various operational issues, the platform currently requires users to sign up and log in to access the content. Membership is restricted to the members of KSC as a protective measure for the vast amount of resources held by CytoAcademy. In the future, we will explore ways to allow open access to cytopathology learners worldwide. Through this, we hope that CytoAcademy will become a global platform for communication among cytopathology learners.

CONCLUSION

The KSC launched an e-learning platform named CytoAcademy in March 2023. Traditional learning methods have been successfully applied to web/mobile-based learning systems, with mobile technologies even enhancing conventional offline education. CytoAcademy represents a significant advancement in the field of cytopathology, leveraging technology to enhance education and professional development in the post-pandemic era. The development of CytoAcademy illustrates the integration of traditional educational methods with modern technological advancements, providing a robust platform for cytopathologists and cytotechnologists to continue their education effectively. As e-learning becomes increasingly vital, platforms such as CytoAcademy will play a crucial role in shaping the future of medical education.

For more information, visit the CytoAcademy website, “cytoacademy.or.kr.”

Ethics Statement

Not applicable.

Availability of Data and Material

The datasets generated or analyzed during the study are available from the corresponding author on reasonable request.

Code Availability

Not applicable.

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Conflicts of Interest

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