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The Scalability of E-learning Platforms: The NAVOICA case

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Abstract

This article discusses the importance of scalability in e-learning platforms, using the Polish NAVOICA platform as a case study. Scalability adapts a platform's infrastructure to increasing numbers of users and courses. NAVOICA relies on container technologies, orchestration, microservice architecture, and cloud computing, which ensure its flexibility and security. This positions NAVOICA strongly to address the challenges of modern online education, such as the rising popularity of massive open online courses (MOOCs), expanding user bases, and the increasingly widening array of courses.

1 Introduction

Alongside widely-used technologies such as video conferencing and virtual classrooms, which rely on synchronous teaching, learning management systems (LMSs) maintain a central role in online learning. These include platforms that are dedicated to limited numbers of users, communities, or narrow groups of employees, as well as global, scalable platforms such as Edx, Coursera, and Moodle [8]. This article discusses the scalability of e-learning platforms, examining the definition of scalability, the advantages of its implementation, and the factors that impact its effectiveness.

2 What is scalability?

Scalability, in the context of e-learning, is a platform's ability to flexibly adjust to increasing numbers of users and their learning preferences, educational resources, and courses, without compromising its efficiency. Particularly among massive open online courses (MOOCs), which have seen a global surge in popularity due to the COVID–19 pandemic [6], [7], scalability has emerged as a fundamental element of remote education.

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Data indicates that the ready accessibility of MOOCs is responsible for creating increased interest in knowledge acquisition, as well as the honing of professional skills and personal interests [12], [13][*].

The scalability of a platform is based on the **interaction** between four factors (presented in Figure 1.):

1. increasing numbers of users
2. user preferences; their learning styles
3. the IT system
4. increasing numbers of resources (courses and functionalities).

These interacting elements make the platform increasingly popular.

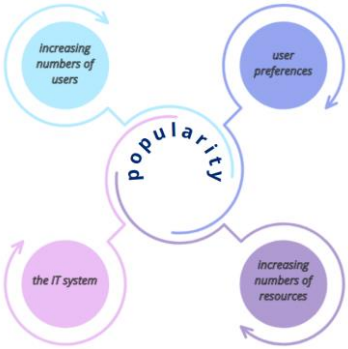

Figure. 1. All factors influence each other.

This means that:

- in response to a growing number of users, a system can:
  - generate the necessary number of user accounts (profiles)
  - generate the necessary number of certificates, which relates directly to the number of resources (i.e. courses)
  - gather and report the necessary amount of data
  - ensure the necessary response to/space for the increased user activity and the users' interactions with the platform (interactive exercises, messages, downloaded reports, additional space for forum discussions)
- a system is capable of creating space for new resources, such as courses and functionalities (multimedia, exercises, surveys, cohorts), enhancing platform diversity
- resource development, accessibility (Web Content Accessibility Guidelines (WCAGs)), attractiveness, and methodological correctness contribute to the expansion of a platform's user base
- users' opinions and suggestions regarding a platform and its courses, as well as knowledge on their learning styles, develops the IT system and enhances the quality of the resources.

[*] According to this report, the total number of global platform users (Coursera, Edx, Udacity, FutureLearn, Swayam) reached 180 million in 2019 and 220 million in 2021.

3 The technical aspects of platform scalability

From a technical perspective, scalability describes the capability of an IT system, software or infrastructure to adapt efficiently to changing requirements and workloads. This flexibility is often achieved by the use of **cloud computing**. The implementation of such a model in the construction of IT systems has effected a profound change in how IT tools are viewed, which, regardless of their complexity and design, become services that are utilised primarily by end users, independently of their locations [10], [1].

The key technical aspects of a platform's scalability are:

- efficiency, irrespective of the number of users
- flexibility: with cloud computing potential, the platform adjusts its resources—including computational power, memory, and network bandwidth—to accommodate changing demands, such as increasing numbers of users and courses
- resource adjustment, which facilitates the dynamic addition and removal of resources
- stability and resilience to malfunctions, which ensures operational continuity through recovery mechanisms in the event of a technical issue
- the parallelisation and distribution of computation and processing, which enable the efficient handling of a larger volume of simultaneous operations, ensuring seamless platform operation—even with a large number of active users
- efficient memory management, which guarantees seamless system operation with large data volumes
- process automation: resource scaling and configuration management enable efficient responses to variable system workloads, removing the necessity of human intervention in technical processes.

The effective scalability management of an e-learning platform ensures the delivery of high-quality MOOCs, of which global access is a key feature [3][†].

4 User preferences vs. scalability

Platform users exhibit various learning styles and utilise different senses to assimilate new information[‡]. The identification and integration of the wide spectrum of learning styles enables platforms to be customised and training materials to be adapted to the specific needs of participants; this, in turn, leads to improved knowledge acquisition and effectiveness of courses [4], [5].

User preferences can be explored through:

- usability testing (UI, UX)
- evaluation surveys that serve as comprehensive assessment tools, providing data insights that are crucial for understanding scalability. By responding to the questions in the surveys, users

[†] MOOCs are online courses prepared by academic lecturers or field experts. They can be accessed globally via dedicated platforms. Their structured design and expert-level content substitute traditional, in-person classes at universities or specialised corporate training sessions effectively. Completion of a MOOC is confirmed with the issuance of a course completion certificate.

[‡] There are four predominant learning styles: activist learners prefer learning through action; reflective learners evaluate consequences and observe others; theorist learners absorb knowledge from trainers and experts; and pragmatic learners learn by applying the knowledge they acquire in practice.

help administrators to identify the areas that require improvement and modification, contributing to the formulation of future development plans.

- discussion forums constitute an integral part of e-learning platforms and play a key role in facilitating interaction among users, and between users and administrators. In the context of platform scalability, discussion forums serve not only as tools for the exchange of views and experience, but also as drivers of effective communication. They enable users to establish integrated communities and develop ever-expanding knowledge bases. Administrators can leverage discussion forums to monitor discussions, respond to queries, and collect users' opinions on their platforms, enabling them to cater quickly to users' needs and optimise teaching processes [11].
- the analysis of feedback shared with the helpdesk, whose influence extends beyond the provision of support in collecting users' opinions. These are essential for platforms' scalability and in their adjustment to meet constantly-growing user demands.
- analytical reports (e.g. Google Analytics), which provide vital data on platform users.

5 The scalability-driven economic approach

Prior to the launch of an LMS, it is essential that a thorough business analysis be conducted. This approach should be adopted not only by firms that seek to develop customised training paths for each of their departments or clients, but also by academic institutions that offer semester-long programmes, postgraduate programmes, and language courses via platforms that hold accounts for numerous students.

In both instances, an LMS that adapts flexibly to an organisation's evolving needs serves as a valuable instrument for implementing training strategies, and yields considerable financial benefits. Various analyses indicate that financial outlays aimed at maintaining and enhancing IT infrastructure often account for substantial portions of the budgets at organisations that possess or utilise such systems [10].

Nonscalable platforms must be replaced shortly after their implementation, resulting in additional expenses on:

- the re-examination of the organisation's needs
- the implementation of the tool
- the commitment of the training team that is responsible for migrating courses to the new platform
- the redesign of courses and their adaption to the capabilities of the new platform
- the conducting of instructional sessions for prospective users.

Such costs can be avoided by the implementation of scalable platforms from the outset.

6 NAVOICA as an example of a scalable platform

NAVOICA (www.navoica.pl) is a Polish e-learning platform that is available to the public, expanding as its number of users rises and providing them with diverse educational resources. Owned by the Polish Ministry of Science and Higher Education, NAVOICA offers MOOCs that are delivered by universities and other educational institutions. The platform finds extensive use in education, serving as a valuable study aid in class and a flexible means to reinforce lecture-based knowledge [3], [6], [7].

NAVOICA grants users the freedom to pursue the subjects they find intriguing, and to delve into them at their own pace and in their preferred manner [7].

6.1 NAVOICA's technological framework

NAVOICA utilises **cloud computing**, which enables the flexible allocation of resources to address current needs and evolving environments. The platform's database is categorised into various data types, which facilitates its effective management.

The platform was developed based on **a microservices architecture**. It comprises two main modules: LMS and CMS (*Studio*). The LMS module supports users and enables the generation of reports that detail their learning progress. The *Studio* module is used in the creation and configuration of new courses. A platform that relies on such an architecture enables the integration of additional functionalities, services (including upcoming additions like VR and chat bots to NAVOICA), and XBlocks, in response to the growing requirements from users and course creators.

6.2 NAVOICA's readiness to accommodate an unlimited number of users

NAVOICA's scalability allows for the registration of an unlimited number of users. Between 2018, when the platform was launched, and 31 January 2024, 167,666 accounts were registered, with this number continuously increasing. In response to user actions, such as their completion tests or quizzes, and their engagement in discussions, the platform adapts the discussion area, tracks course completion progress, issues certificates, and generates reports. This data includes:

- the number of users and their profile data
- the number of certificates issued
- users' course progress, including their exercise and test results.

The examination of such data helps in the identification of problematic areas on the platform and its courses, and determines what should be prioritised to ensure the optimal learning environment for the user.

The popularity of NAVOICA and the increasing number of its users relate directly to the technical and methodological quality of its courses.

Every new course that NAVOICA offers undergoes a technical and methodological evaluation conducted by an experienced team of specialists at the National Information Processing Institute (OPI PIB). Subsequent editions are subject to technical and methodological reviews performed by the institute's e-learning team. All components of the course, including graphics, videos, audio recordings, external links, exercises, and interactive elements, must function properly and adhere to methodological guidelines [7]. NAVOICA's courses are designed and delivered with the aim of ensuring accessibility for all users, regardless of their characteristics, needs, and potential limitations, such as disabilities.

NAVOICA's scalability is shaped by the quality of its education process, which is demonstrated through the verification of materials before their publication to a wide audience, consideration of feedback from participants of previous editions, the updating of the content, and the ensurance of full digital accessibility by adhering to the WCAGs.

6.3 NAVOICA's resource scalability

NAVOICA's scalability contributes to its diversity as an online environment [7], because:

- the course catalogue incorporates courses at various skill levels: elementary, intermediate, and advanced
- the course catalogue offers 208 MOOCs (as at 20 January, 2024) in twenty fields: biology; business and management; education; economics and finance; information technology; foreign languages; mathematics; nature and environment; humanities; pedagogy and didactics; politics; law; programming; psychology; personal development; sociology; science and higher education systems; arts; health; and engineering
- the platform is accessible in three language versions: Polish, English, and Ukrainian
- the course catalogue contains courses in the Polish, English, Ukrainian, Russian, German, Swedish, Norwegian, and Hungarian languages
- the platform integrates various content formats, such as video and audio materials, surveys, shareable content object reference models (SCORMs), and infographics
- the courses feature a variety of functionalities, including:
    - exercise libraries: a pool of questions used in generated tests
    - randomised test questions and answers
    - most exercises incorporate hints and feedback
    - a full-screen mode that enables users to view graphics in high resolution
    - a magnifying glass, which may be used to enlarge graphical elements to improve their visibility
    - forums: NAVOICA offers two types of discussion: in-line and course-wide: a discussion tool, which enhances courses with so-called ‘social learning’
    - a cohort system
- the platform supplements its courses with the following types of exercise:
    - open-ended questions with numerical answers
    - open-ended questions with text answers
    - exercises with drop-down lists
    - closed-ended single choice exercises—the order of answers can be randomised
    - closed-ended multiple choice exercises—the order of answers can be randomised
    - drag-and-drop exercises
    - questions for self-reflection
    - exercises that involve pointing to elements in an image
    - open response assessment (ORA) exercises
    - nested gap exercises
    - nested drop-down list exercises.

These resources hold the potential for expansion: courses can be offered in other languages, at different proficiency levels, and can explore additional thematic areas. From a technological perspective, it is also possible for other language versions of the platform to be deployed and additional functionalities to be implemented.

6.4 NAVOICA's user preferences

The NAVOICA team values the opinions of users on the platform’s functionality, appearance, and resources highly. Feedback is collected through usability testing, evaluation surveys that pertain to particular courses and user experiences with the platform, and the analysis of tickets reported the helpdesk. Users also post their opinions on course discussion forums.

The team places focuses on users' learning styles, their sensory preferences, and the needs of disabled users. That information enables it to develop the platform and enhance users’ remote learning experience.

6.5 Usability testing

In February 2022, OPI PIB conducted quality studies with the objective of gathering students' feedback on NAVOICA [2]. The researchers sought to understand users' experiences with other online course platforms, their motivation to learn online, and the importance they placed on course completion certificates. The studies also sought to gather opinions on the design, layout, and usability of the new interface project, which is scheduled to be implemented in 2024.

The overall appearance of the new interface was unequivocally rated as "modern," "clear," "aesthetic," "visually appealing," and "accessible." The color scheme was described as "pleasant," "nice," "subtle," "not too bright," and "easy on the eyes." The graphics were praised as "nice," "modern," "attractive," with "consistent visual elements," "not evoking negative emotions," "not flashy," and "eye-catching" [2].

Figure 2 presents a screenshot of the homepage featuring the new interface. Figure 3 presents a sample course description.

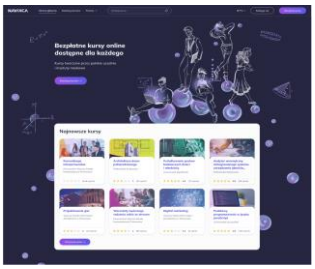

Figure 2. A screenshot of the NAVOICA homepage featuring the new interface

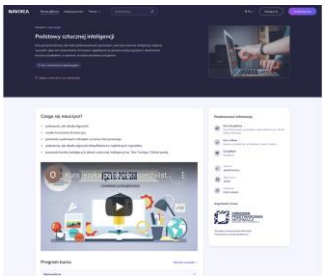

Figure 3. A screenshot of a course description on NAVOICA

6.6 NAVOICA evaluation surveys

NAVOICA's evaluation surveys comprise a variety of question formats, including open-ended and closed-ended questions, as well as evaluation scales. Thoughtfully formulated questions enable the collection of essential data that contributes to the further development of the system. NAVOICA users can complete evaluation surveys regarding the platform itself and the courses they have completed.

The platform evaluation survey includes the following questions:

- Did you have difficulties accessing the course materials?
- How would you rate the performance of the platform when using it?
- Have you experienced any problems with the platform?
- Was your use of the platform consistent and undisturbed?

- Did you notice any limitations when using the platform?
- Are there any features that you found particularly useful when using the platform?
- How would you rate the accessibility and performance of the platform when using it?
- What would you improve to make the platform even better?

Figure 4 illustrates a screenshot of the user–platform interaction survey.

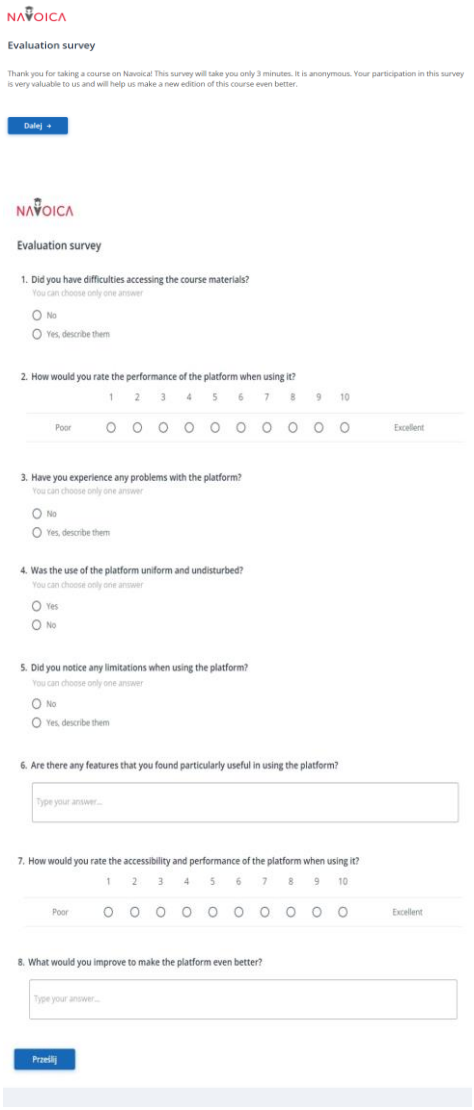

Figure 4. A screenshot of the NAVOICA user–platform interaction survey.

When competing NAVOICA courses, users are encouraged to complete surveys on their satisfaction with the didactic process. It contains the following questions:

- What was your main reason for taking this course?
- Has this course helped you achieve your primary goal?

- Please rate your satisfaction with the instructor(s)
- Please rate your satisfaction with the videos
- Please rate your satisfaction with the readings
- Please rate your satisfaction with the exercises/tests
- Please rate your satisfaction with the NAVOICA platform
- In my opinion, this course is...
- This course is interesting.
- There were enough exercises to master the content of the lessons.
- Contact with the course staff was possible.
- Contact with other students was possible.
- I would recommend this course to my friends.
- Space for your comments (optional).

The responses they provide in both surveys position NAVOICA's users as significant contributors to the platform's development. Completion of the surveys serves as a means of communication between the users, the administrators, and the course creators. Following examination of users' responses, administrators and course creators can implement suitable solutions to enhance the quality of the services and improve user satisfaction. To assist users in diagnosing and resolving technical issues, the NAVOICA helpdesk contacts them via email.

7 Summary

This article outlines the concept of scalability in e-learning platforms, as well as explaining its significance and benefits. It presents four primary factors that impact the scalability of e-learning platforms: increasing numbers of users, user preferences, IT systems, and growing numbers of resources. The interactions between these elements are also presented.

From a technical perspective, scalability describes the effective adaptation of an IT system to changing requirements and workload, the key factors of which include performance, flexibility, resource allocation, data security, stability, parallelisation of computations, and process automation.

From an economic perspective, scalability can mitigate extra costs related to the implementation of e-learning in organisations such as higher education institutions and commercial firms.

Illustrated through the example of NAVOICA, a Polish MOOC platform, this article explains how microservices architecture and cloud computing can support scalability. NAVOICA exemplifies effective scalability implementation, enabling it to address the complexities of the modern educational environment, such as the rising demand for MOOCs, expanding user bases, and the widening variety of course options.

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8 Author biographies

Aleksandra Kołodziejczak, Ph.D. — she was awarded her Ph.D. at the University of Bialystok. She has completed courses on web development, and has worked in e-learning for over thirteen years. She established a website that offers Russian language courses, which she created herself, and has participated in many commercial e-learning projects. She works currently at OPI PIB in Warsaw as a leader team on the NAVOICA project, where she brings her experience as a Moodle platform administrator, a frontend developer, an editorial manager, and a foreign language educator. aleksandra.kolodziejczak@opi.org.pl


Ewa Wojciechowicz — her e-learning career started in 2019 at the Faculty of Remote Education at the War Studies University in Warsaw, where she worked in the capacity of remote teaching educationalist and conducted workshops and training sessions for lecturers on how to use e-learning platforms and remote education tools. As an e-learning specialist, she is currently part of the team on the NAVOICA project at the OPI PIB. She supports online course creators in the theory of and technical solutions for e-learning. ewa.wojciechowicz@opi.org.pl


Piotr Grabias — he graduated from the University of Life Sciences in Lublin, where he earned an MEng degree. His journey into e-learning began with several education projects, including some conducted on behalf of the Polish Ministry of Education, related to early childhood education. Through his involvement in these projects, he acquired proficiency in Articulate Storyline, as well as audio and video editing. He is currently an e-learning expert responsible for the NAVOICA project at OPI PIB. piotr.grabias@opi.org.pl