Hybrid approaches to optimizing online transformation of master's programs: a complex systems case study in software engineering and cybernetics

Igor Kovalev[1,2*], *Anna* Voroshilova[1], *Alexander* Kuznetsov[1], and Yusuf Beshimov[3]

[1]Siberian Federal University, Krasnoyarsk, Russia
[2]Navoi State Mining and Technology University, Navoi, Uzbekistan
[3]Bukhara Innovative Education and Medical University, Bukhara, Uzbekistan

Abstract. This paper explores effective practices for transforming Master's programs into an online format, focusing on the Software Engineering and Cybernetics program at Siberian Federal University. The study's relevance stems from the rapid digitalization of education and growing interest in online formats, making Master's programs more accessible to working students. We present an analysis of successful practices for implementing online courses, including structural elements, design, content, multimedia, teaching methods, student interaction, assessment, and feedback. Special attention is given to the selection of an online learning platform, with Moodle being justified as the most suitable system for implementing the Master's program. The paper also presents a portrait of an online master's student, helping to identify needs and expectations, which aids in optimizing the educational process. The study emphasizes the importance of applying hybrid methods and complex systems approaches to create a high-quality educational experience and achieve program goals.

1 Introduction

The transformation of master's programs into online formats has become increasingly relevant in light of global changes in higher education. The COVID-19 pandemic has been a powerful catalyst for the transition to digital learning formats, leading to a sharp increase in interest in online master's programs. According to statistics, a third of registrations on leading global platforms for massive open online courses occurred in 2020, indicating significant demand for distance education.

In the context of a rapidly changing labor market and the rapid development of technologies such as artificial intelligence and big data, universities are forced to adapt to new requirements. Online education provides the opportunity to study from anywhere in the world and at any time, making it particularly attractive to students combining study with

* Corresponding author: kovalev.fsu@mail.ru

work. Moreover, distance programs allow students to obtain a state-recognized diploma with the same volume of knowledge and competencies as traditional full-time courses [1,2].

The study of effective practices for transforming master's programs into an online format, using the example of the "Software Engineering and Cybernetics" program implemented at Siberian Federal University (SFU), is not only relevant but also necessary to understand how modern educational institutions can successfully integrate digital technologies into educational processes.

In accordance with the demands of our time and with the support of the Vladimir Potanin Foundation, the transformation of the "Software Engineering and Cybernetics" Master's program, implemented at Siberian Federal University since 2021, aims to update course content in line with the latest trends in IT industry development and fully transition to an online format.

This article aims to identify the best approaches and methods that will help improve the quality of online education and meet the growing demand for qualified specialists in programming and cybernetics.

Online education offers significant advantages that make it attractive to students and educational institutions. One of the key aspects is flexibility, allowing students to combine study with work, which is a crucial factor for Master's program students, as most of them combine education with full-time employment. Thanks to the asynchronous learning format, students can choose convenient times for classes, which is especially important for those who are already working or have other commitments. This enables them to effectively organize their time and minimize stress from the need to adhere to a rigid schedule.

Moreover, online programs provide access to education from anywhere in the world. Students can receive quality knowledge without leaving their homes, which is particularly relevant for those living in remote or hard-to-reach regions. Access to learning materials is provided via the internet, allowing students to study at any time and place with a stable connection.

It is also worth noting the economic advantages of online education. It often proves more affordable compared to traditional forms of learning due to reduced costs for transportation and accommodation. Students can significantly save on educational materials, as many resources are provided in electronic format.

An important aspect is the ability to obtain up-to-date information. In the rapidly changing world of technology, students have access to the latest materials and research, allowing them to stay at the forefront of their field of knowledge. This is especially critical for such dynamic areas as software engineering and cybernetics.

Thus, the transition to an online learning format not only meets the modern requirements of students but also opens new horizons for educational institutions striving for innovation and efficiency in training specialists.

With the transition to online format, universities are revising course design and learning approaches. Unlike traditional education, where the emphasis was on classroom lectures and seminars, online programs offer flexible schedules and the ability to study materials at convenient times.

The integration of modern technologies into the educational process also plays a key role. The use of digital learning platforms allows for the creation of interactive courses that include video lessons, webinars, and practical assignments. For example, programs can use simulations and virtual laboratories for practical study of software engineering and cybernetics concepts. This not only increases student engagement but also improves the quality of material assimilation [3].

Furthermore, modern teaching methods, such as project-based learning and case studies, are becoming standard in online Master's programs [4]. Students have the opportunity to work on real projects under the guidance of experienced mentors, which contributes to the

development of practical skills and critical thinking. This factor is important for attracting employer representatives to the learning process, as they get the opportunity not only to solve their current tasks through students and prepare the specialists they need but also to monitor processes in real-time [5].

Thus, the transformation of Master's programs into an online format not only responds to the challenges of our time but also creates new opportunities for learning in the field of "Software Engineering and Cybernetics," providing students with the necessary knowledge and skills for a successful career in the rapidly changing world of technology.

2 Materials and methods

The main objective of this study includes analyzing effective practices for transforming master's programs into an online format, identifying problems and barriers faced by educational institutions during the transition to online learning, and proposing improvements to the quality of education in the field of "Software Engineering and Cybernetics."

To achieve this goal, a comprehensive approach is used, including several methods:

- Conducting surveys among students and teachers to collect data on the perception of online learning formats, their advantages and disadvantages.
- Analyzing existing programs and literature on the transformation of master's programs to identify best practices and approaches used in other educational institutions.
- Qualitative analysis of data obtained from surveys and literature review, using content analysis methods to identify key trends and problems in the implementation of online programs.

These approaches and methods provide a comprehensive understanding of the current state of transformation of master's programs in the field of "Software Engineering and Cybernetics" and allow for the development of recommendations to improve their effectiveness.

3 Results and discussion

3.1 Successful Practices in Online Program Implementation

As previously noted, in the context of rapid digitalization of education and growing interest in online formats, Master's programs are becoming increasingly relevant for students seeking quality education without leaving their workplaces. Table 1 presents successful practices in implementing online programs related to the Software Engineering and Cybernetics program [6]. These examples illustrate the diversity of approaches to learning used by various educational institutions to prepare specialists in information technology and cybernetics.

Table 1. Successful practices in implementing online programs related to the Software Engineering and Cybernetics program.

Programme	University	Key features
Software Engineering and Cybernetics	Saint Petersburg State University	Experience in a full cycle of software engineering, creation of new software systems, application of the latest technologies.
Cybersecurity	Moscow State University	Preparation of masters in cybersecurity, development of new tools for solving problems.

Software for Cyber-Physical Systems	Siberian State University of Technology and Management	Skills in developing software for cyber-physical systems, management of software quality and the development process.
IT Product Development	MIPT (Moscow Institute of Physics and Technology)	In-depth study of programming languages, work on real projects with industrial partners.
Digital Product Management	Skillfactory	Practical training with an emphasis on real business problems, mentoring from industry experts.
Cybernetics and Control Systems	National Research University Higher School of Economics	Integration of theoretical knowledge with practical cases, use of modern technologies in training.
Data Analysis and Machine Learning	Netology	Training based on real data, use of up-to-date tools for data analysis and visualization.

3.2 Portrait of an Online Master's Student

To understand the needs and expectations of students and optimize the educational process, we have compiled an approximate portrait of a student in the online master's program "Software Engineering and Cybernetics" [7]. The main goals of creating such a portrait include adapting educational programs, allowing universities to adjust course content and teaching methods according to student characteristics, choosing relevant topics, class formats, and assessment methods.

The algorithm for creating a comprehensive student portrait in the online master's program "Software Engineering and Cybernetics" consists of four main stages: data collection, data processing, profile creation, and utilization of the student portrait, with a feedback loop integrated throughout the process (Fig. 1).

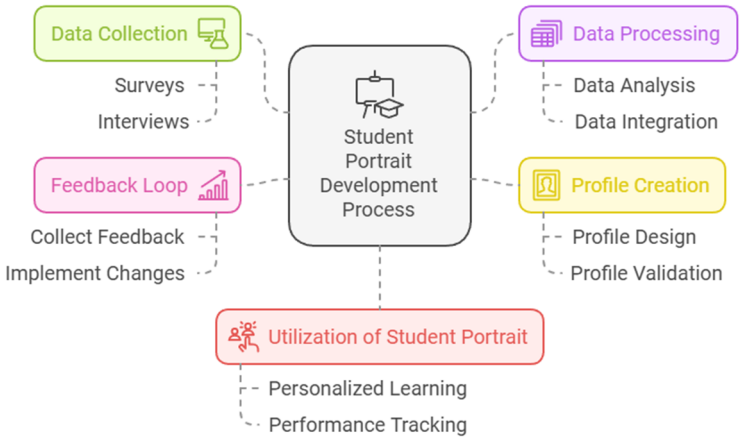

Fig. 1. Algorithm for Creating a Comprehensive Student Portrait in the Online Master's Program 'Software Engineering and Cybernetics'.

The first stage (data collection) involves gathering diverse information about the student, including personal details (name, age, gender, location), academic background (previous degrees, institutions attended, GPA), professional experience (current job title, years of experience, relevant skills), and course enrollment data (list of courses taken, grades received, participation in discussions and projects).

In the second stage of Data Processing, the collected data is normalized and analyzed. This includes standardizing formats for grades and degrees, categorizing skills into relevant domains (e.g., programming languages, frameworks), analyzing academic performance by calculating average grades and identifying trends, and assessing engagement through participation metrics in forums, group projects, and assignments.

The third stage “Profile Creation” involves creating a comprehensive student profile that summarizes personal information, academic history, professional background, skills inventory, and performance metrics (e.g., GPA, engagement scores). The algorithm incorporates a continuous feedback loop where students provide input through surveys about their learning preferences and career goals, as well as self-assessment of skills and interests. This feedback is used to update and refine the student portrait, adjusting the skills inventory and performance metrics as needed.

The final stage focuses on utilizing the student portrait to tailor educational resources, recommend courses based on interests and career goals, suggest mentorship or networking opportunities, and monitor progress by tracking changes in performance and engagement over time. This allows for the provision of personalized support and resources as needed.

By systematically implementing this algorithm, educational institutions can enhance the learning experience and support the professional development of students in the "Software Engineering and Cybernetics" online master's program, ultimately improving the overall quality and effectiveness of the educational process.

Recognizing that students value flexibility and practical orientation, educational institutions can implement more interactive formats such as case studies, group projects, and webinars, which contribute to deeper material assimilation and improved learning quality. The student profile also helps identify career goals, enabling universities to offer additional resources such as internships, mentoring, and professional events that foster skill development and experience acquisition.

Online master's students often seek networking opportunities and interaction with like-minded peers; understanding their preferences allows for organizing events and platforms for experience exchange and professional connection building. Comprehending students' expectations from online learning helps universities adjust their programs to minimize the gap between expectations and reality, potentially reducing dissatisfaction levels and increasing learning satisfaction. Thus, the student profile of the "Software Engineering and Cybernetics" online master's program not only assists educational institutions in improving their programs but also contributes to creating a more effective and supportive educational environment.

Students of the "Software Engineering and Cybernetics" online master's program represent a diverse group united by the pursuit of quality education in information technology and cybernetics. The majority of students are between 21 and 35 years old (about 80%) and have varying IT work experience (38% constitutes the largest group of students with 1 to 3 years of experience). Many already possess basic education in related fields and seek to deepen their knowledge or change professions to meet modern labor market demands (Fig. 2). Students appreciate the flexibility offered by the online learning format. The ability to study from any location and create their own schedule allows them to balance studies with work and personal life. This is particularly important for those already working in the industry and wanting to continue developing (74% of students work while studying).

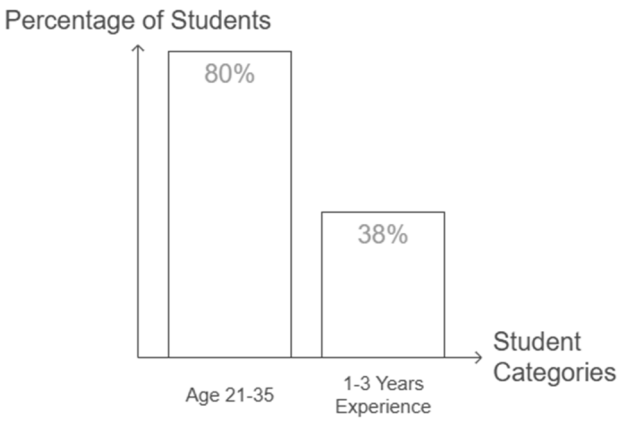

Fig. 2. Demographic and experience profile of students.

Many students expect online learning to be as effective as traditional education, but some express concerns about the lack of interaction with instructors and peers. Nevertheless, most actively participate in webinars, group projects, and discussions, helping them establish connections and exchange experiences (Fig. 3).

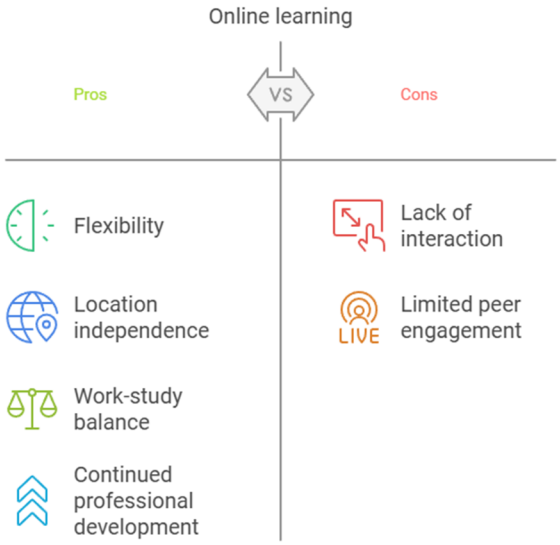

Fig. 3. Online learning: advantages and disadvantages.

In their free time, online master's students often engage in self-education, take additional courses, and participate in professional events (76% of students). Their core values are associated with career growth, skill development, and a commitment to continuous learning. This profile emphasizes the importance of adapting educational programs to student needs and highlights the role of online formats in preparing qualified specialists in software engineering and cybernetics.

3.3 Key Elements of Online Course Creation and Management

For the successful transformation of the master's program "Software Engineering and Cybernetics" into an online format, it is necessary to apply advanced practices in the development and implementation of online courses [8-10]. The main elements of creating and conducting online courses for the master's program include the following.

The structure and design of an online course play a crucial role in its perception and effectiveness. A clear course structure with logical division into modules and topics is essential to help students navigate the material more effectively. Intuitive navigation and a user-friendly interface contribute to a positive learning experience. A visually appealing and minimalist design based on UX design principles enhances student interaction with the course.

Content and multimedia are fundamental components of online learning. A diverse range of content, including video lectures, presentations, textual materials, and interactive elements, helps maintain student attention. High-quality multimedia resources (video, audio, images) make learning more engaging. Interactive elements such as tests, surveys, and assignments involve students in the learning process. It is also important to ensure content accessibility for students with special needs.

Teaching methods and student interaction should incorporate active learning approaches, such as project work, case studies, and group discussions. Regular online meetings (webinars, video conferences) facilitate synchronous interaction between instructors and students. Creating opportunities for feedback, consultations, and student support is a crucial aspect of successful online learning. The use of modern communication and collaboration tools (forums, chats, cloud services) improves interaction among course participants.

Assessment and feedback play a key role in the learning process. The development of an evaluation system should include various forms of assessment, such as tests, assignments, and projects. Regular feedback from instructors and experts helps students understand their progress and areas for improvement. Implementing self-assessment and reflection mechanisms for students contributes to their development. Collecting and analyzing student feedback allows for continuous course improvement based on real data [11].

Technological infrastructure forms the foundation for implementing an online course. Selecting an appropriate platform (LMS or MOOC platform) ensures reliability, security, and scalability of the educational process. Integration with other systems (libraries, databases, external resources) expands learning opportunities. Training instructors and technical support staff to work with online tools is also necessary for successful course implementation.

To choose a suitable platform (LMS or MOOC) for the online Master's program "Software Engineering and Cybernetics," it is important to analyze various platforms, considering their functions, advantages, and disadvantages [12-15]. Table 2 below summarizes the key characteristics of popular platforms.

Table 2. Key characteristics of popular platforms for implementing online Master's courses.

Platform	Type	Advantages	Disadvantages
Moodle	LMS	- Free software - Wide range of supported formats (SCORM, AICC) - Access from a mobile application - Built-in editors for creating tests and lectures - Adaptive interface	- Need for interface refinement and customization - Expensive add-ons for normal operation
Open edX	MOOC	- Cloud-based open source solution - Impressive selection of courses in various areas	- Complexity in setup and management for new users

		- Multilingual support (32 languages)	
Canvas	LMS	- User-friendly interface and ease of use - Support for mobile devices - Integration with other systems (CRM, CMS)	- Limited customization options compared to other LMS
Coursera	MOOC	- Access to courses from leading universities and companies - High quality content - Possibility of obtaining certificates from renowned institutions	- Some courses are fee-based, which may limit accessibility for students
Skillbox	LMS	- Focus on practical skills and real cases - Support for mentoring and career growth - Flexible training schedule	- Limited choice of courses compared to international platforms
Edutoria	LMS	- Specialization in higher education and postgraduate studies - Integration with banking services for students (preferential loans)	- Less known compared to international platforms

The selection of a platform for the online Master's program "Software Engineering and Cybernetics" depends on the specific needs of the program. If the emphasis is on flexibility and content accessibility, MOOC platforms such as Open edX or Coursera may be preferable. Conversely, if integration with educational processes and the ability to create individualized courses are important, LMS platforms like Moodle or Canvas should be considered [16,17].

Siberian Federal University chose the Moodle platform for implementing the online Master's program "Software Engineering and Cybernetics" for several key reasons:

1. Cost-effectiveness: Moodle is a free, open-source application, allowing SFU to significantly reduce costs associated with implementing and operating the distance learning system, which is crucial for the university in optimizing its budget [18].

2. Flexibility and adaptability: The platform can be customized to meet the specific needs of the "Software Engineering and Cybernetics" Master's program. Moodle supports integration with various services and plugins, expanding functionality in accordance with changing educational process requirements. For instance, courses in popular formats such as SCORM and AICC can be easily added, and various multimedia resources can be utilized.

3. Mobile accessibility: The Moodle educational platform is available on mobile devices, allowing students to study at convenient times and locations. This is particularly relevant for students combining work and study, as they can access materials and assignments through a mobile application.

4. Interactive content creation: The platform offers a wide range of tools for creating interactive content. Instructors can upload video lectures, presentations, and text materials, as well as create tests and surveys to assess student knowledge, including interactive elements and H5P assignments, which contributes to increasing student motivation and overall learning quality [19].

5. Analytical capabilities: Moodle provides powerful analytical tools for tracking student performance and analyzing their progress. Instructors can receive reports on attendance and test results, helping them to promptly respond to issues and adjust learning materials.

In conclusion, the choice of the Moodle platform for the online Master's program "Software Engineering and Cybernetics" at Siberian Federal University is justified by its cost-effectiveness, configuration flexibility, mobile accessibility, and extensive capabilities for creating interactive content. The application of these practices allows for the creation of

a high-quality and effective online course that meets the needs of students and employers, ensuring the achievement of the Master's program objectives in "Software Engineering and Cybernetics".

4 Conclusion

The successful transformation of the master's program "Software Engineering and Cybernetics" into an online format not only meets the needs of students but also contributes to the preparation of qualified specialists ready for the challenges of the modern world. The application of hybrid approaches and complex systems methodologies in this transformation process has proven to be effective in creating a high-quality educational environment that meets the requirements of the modern labor market.

The analysis of successful practices presented in the article shows the diversity of approaches to learning used by various educational institutions to prepare specialists in information technology and cybernetics. Understanding student needs and their expectations from online learning contributes to the adaptation of educational programs, allowing universities to adjust course content and teaching methods, choosing relevant topics and class formats.

The choice of the Moodle platform for program implementation is justified by its cost-effectiveness, flexibility of configuration, and wide possibilities for creating interactive content, ensuring the accessibility of learning for students and allowing them to study at a convenient time and place.

Future research should focus on further developing hybrid methods and complex systems approaches to optimize the online transformation of master's programs, particularly in the rapidly evolving fields of software engineering and cybernetics.

The project is being implemented with the support of the Vladimir Potanin Foundation.

References

1. E.A. Opfer, Higher Education in Russia **1,** 36-48 (2021).
2. L.A. Parshukova, D.S. Leontiev, News of Higher Educational Institutions. Sociology. Economics. Politics **1,** 98-100 (2024)
3. E.O. Vlasova, Domestic and Foreign Pedagogy **2(4),** 125-128 (2022).
4. I.B. Stukalova, Modern Education **3,** 1-8 (2018).
5. E.A. Opfer, Higher Education in Russia **5,** 45-51 (2017)
6. V.A. Sukhomlin, International Journal of Open Information Technologies **11(7),** 143-148 (2023)
7. M. Mironova, Forbes Russia Education (2024). https://education.forbes.ru/authors/portret-studenta-online-magistratury
8. C. McAndrew, Educational Studies Moscow **4,** 60-80 (2018)
9. A.S. Loginova, A.V. Odinokova, V.E. Gavrilova, Proceedings of Voronezh State University. Series: Law **4(43),** 317-331 (2020)
10. G.D. Mamatova, T.S. Kuchkarov, Informatics. Economics. Management **3(1),** 0101-0158 (2024).
11. D. Shikhiev, G.A. Ashirova, M.Y. Ilamonova, Symbol of Science **9(2),** 91-94 (2023)
12. S.E. Kushnareva, Scientific Notes of V.I. Vernadsky Crimean Federal University. Philological sciences **2(68) 2-2,** 209-213 (2016)

13. V.Y. Shurygin, L.A. Krasnova, Baltic Humanitarian Journal **10(4) (37),** 185-189 (2021)
14. N.B. Teslya, D.Y. Tomshin, Eurasian Integration: Current Trends and Promising Directions **7,** 184-192 (2024).
15. L.O. Denishcheva, I.S. Safuanov, Y.A. Semenyachenko, Bulletin of the Moscow City Pedagogical University. Series: Informatics and Informatization of Education **2(60),** 72-85 (2022)
16. I. Brezgunova, S. Maksimov, Science and Innovation **10(128),** 50-52 (2013)
17. M.S. Shumikhina, I.A. Yashina, Actual Problems of Aviation and Cosmonautics **3(14),** 803-804 (2018)
18. O.N. Zaitseva, Education and Upbringing: Methods and Practice **2,** 59-64 (2012)
19. E.S. Kalashnikov, Forum of Young Scientists **1-2(29),** 143-147 (2019)