

Article

Digital Transformation of the University as a Means of Framing Eco-Environment for Creativity and Creative Activities to Attract and Develop Talented and Skilled Persons

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Abstract: The purpose of this article is to present the results of the ongoing study of the University digital transformation on the basis of a comprehensive theoretical model. The article describes a conceptual model of the University digital transformation formed based on the comprehensive quantitative and qualitative analysis of potential ecosystem participants in line with the requirements of changing external conditions. The authors list the current results of the transformation and strategic plans considering any achievements adjustment. The National University of Science and Technology “MISiS” (NUST MISiS) has been used as an experimental basis for the research. The key achievement of NUST MISiS such as a digital ecosystem is described in this article. The digital environment of NUST MISiS considers the needs of the University staff and students and contributes to achieving the strategic goals.

Keywords: digital transformation; higher education; educational environment; eco-environment



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1. Introduction

Any breakthrough in education is difficult to make. Therefore, the four waves of fundamental transformations can be distinguished within the observable period of time:

- The first wave—foundation of first universities in Europe in the X–XIIth centuries;
- The second wave—establishment of the class and lesson system;
- The third wave—foundation of research universities in the XIXth century;
- The fourth wave—project and active teaching methods.

The strategic approach of Industry 4.0 doctrine includes the establishment of “smart factories” [1]. Introduction of innovative technologies and processes reduces the human labor involvement and boosts production automation. Therefore, consequently it requires qualitatively new human resources: engineering degree and state-of-the-art knowledge [2–4]. Numerous articles of Russian and foreign scientists prove the positive effect of modern technologies and digitalization processes on the economic development of countries and the global economy as a whole, such effects can be classified as synergetic. Digital technologies show most effect on the following three areas: education, science and inventions [5].

Digital revolution, pandemic, globalization and global economy multiple headwinds have resulted in the fact that the existing models of higher education, deemed as achievements of the second half of the 20th century, are currently losing their efficiency [6]. Just as globalization and technology have affected other huge sectors of the economy over the past 20 years, universities will face the need for fundamental changes in the coming 20 years [7,8]. Universities are challenged by digital transformation: profound re-engineering of business processes implying application of a wide range of digital technologies, and development of

new educational process models [9–11]. The University digital transformation processes are focused on shifting from formal teaching models to informal models, including through the innovation design of the educational process based on state-of-the-art technological and teaching solutions aimed at education efficiency enhancement, considering the changing demands of the HR market and the vital need to obtain competing advantages in attracting and retaining the students [12–14]. The COVID-19 pandemic period gave rise to a set of models for digital education transformation [15–17]. We think that the task of the university digital transformation is to smoothly and comfortably apply breakthrough technologies to give rise and boost advanced innovations in education [18–20]. It requires not only digitalization of the current processes by partial immersion into the virtual educational environment; it requires complete transformation through development of the University digital ecosystem [21]. The theoretical and methodological basis for the ecosystem development lies in the synthesis of theoretical concepts in the ecosystem economics and indicative coordination and values control, participatory culture of the organization theory, Kolb's cycle in teaching adults [22]. Moreover, requirements of the present-day employers and standards of education are considered. The environment transformation dynamics determines the need for business units self-organization and self-regulation that, in fact, contributes to the transformation of the units themselves. G.B. Kleiner [6] specifies various social and economic ecosystems as key factors in the future economy. The fundamental relations between the ecosystem components is based not on material and information flows exchange, but on the transfer of rights of access to the existential resources of space and time, as well as rights of access to energy resources—activity and intensity. Management of such conglomerates must be based on soft management principles. While the role of the state must be limited to the indicative coordination and values control. The ecosystem creates the environment which makes it possible for all subjects including students to be able to accept and get adapted to a wide range of new technologies (including, digital skills development) [23], to form and show pro-active behavior both in learning, research and development and professional activities [24].

In this respect, the basis for the university ecosystem development includes scientific research results in behavioral economics of education. By combining digitalization opportunities and achievements in behavioral sciences, it is possible to create a conceptually new educational environment, which is flexible not only in terms of external conditions change, but also in terms of needs and abilities of a student. Investigation of behavioral models, in particular, Fogg behavior model [25], and concepts of soft power (nudging) in general [26,27] based on big data in the educational system to create an innovative educational environment, which contributes to the development of a specialist of a different behavior, on the one hand, and allows for saving money due to enhancing the efficiency of educational programs mastering with the maximum possible students retention degree (until the end of their learning period), on the other hand, are deemed as critical under current conditions.

The pandemic, which preconditioned the applicability of blended learning and digital learning environment, encouraged the development and use of innovations in educational technologies. Contemporary challenges evoke the need for investigating the opportunities and efficiency of blended learning models of teaching students during the COVID-19 pandemic. M. Murata et al. [28] are currently studying the opportunities of educational platforms and modern online communications tools for digital learning. R. Miller et al. [29] highlight the problem of inequality in the access to education among different social strata (low accessibility of digital education for low-income family students). Y. Coiado et al. [30] describe the pandemic attributable innovative educational model based on implementation of the problem-based learning approach to a university digital learning environment. The generalized analysis of digital transformation in the higher education system during the pandemic is given in Castro et al. [31].

The purpose of this article is to present the intermediate results of the ongoing investigation on the University digital transformation (as exemplified by NUST MISiS) based

on the transformation comprehensive theoretical model, its adjustment as affected by the changing external environment, technological innovations as well as feedback from the basic participants involved. The article describes the conceptual University digital transformation model formed based on the comprehensive quantitative and qualitative analysis of requests from potential participants of the ecosystem and requirements of the changing external conditions. The article lists the current results of the University digital transformation and strategic plans considering any adjustment of achievements based on processing of quantitative and qualitative indicators of the feedback on the process in progress.

2. Materials and Methods

NUST MISiS is used as an experimental basis for the research. NUST MISiS has transformed from the industry-based institution of higher education not listed on global ratings into the international research university included in top-500 of the institutional global QS rating and top-100 of QS subject ratings and ARWU over the past 10 years (Figure 1).

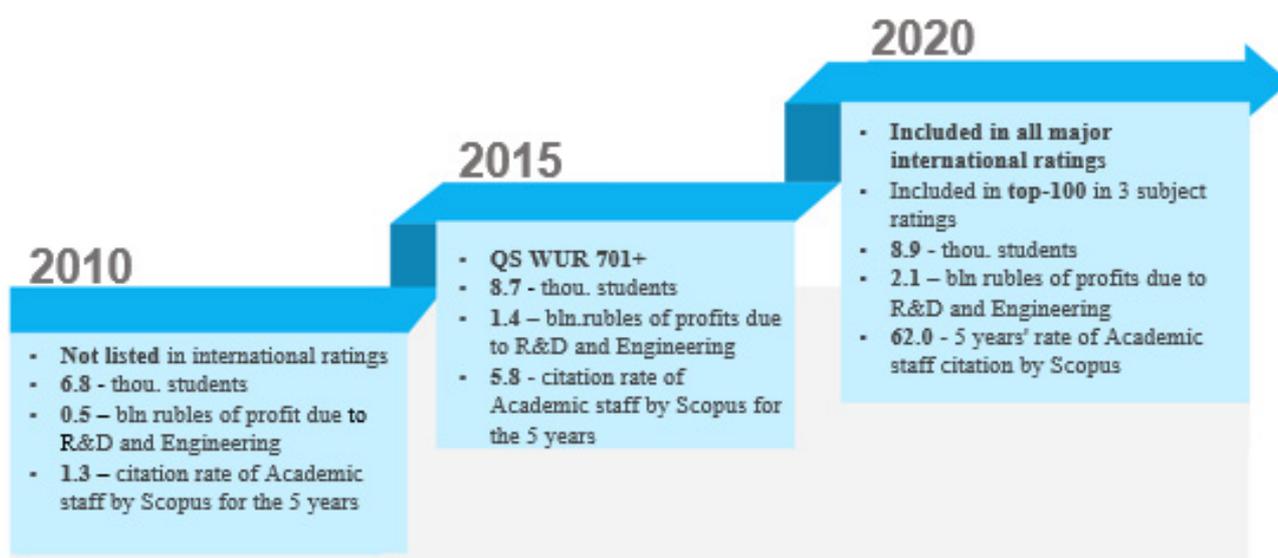


Figure 1. NUST MISiS transformation in 2010–2020.

For establishing an international research university that performs world-rated research and development, NUST MISiS has opened 40 laboratories and research centers. NUST MISiS has set up an Innovations emergence scientific complex due to investments into science infrastructure, and given rise to an enormous number of scientists: 89 of them are internationally experienced researchers with Hirsh index of over 15. Currently, more than 260 young researchers and academic staff under the age of 39 are involved into activities of the university. The university focuses on increasing the number of publications and improving the quality of publication activities by concentrating on breakthrough areas and front most research projects. The university has been structurally and qualitatively transformed due to update of educational programs, increase in computer sciences number and introduction of mandatory English language learning as per the Cambridge University Press curriculum. NUST MISiS has been the first in Russia to implement the 1C-based comprehensive University management system as well as to develop digital services for students, applicants and University staff as part of the University digital transformation. It has dramatically enhanced the efficiency of administrative functions due to formation of the students digital office. NUST MISiS has provided for students profound involvement in scientific research and has become leader in science promotion by introducing the following activities: Young Researchers Contest ScienceSlam (more than 100 thou. views in

social networks), Science and Education Forum “Scientists versus myths”, well-established “Public Christmas lectures”. NUST MISiS acted as initiator of the largest festival Maker Faire Moscow (50 thou. visitors in 2019), arranged for courses and workshops hosted by the super modern digital fabrication laboratory FabLab (including activities involving schoolchildren and preschoolers) as part of youth policy and young researchers support. The University participated in the Entrepreneurship Students Festival offering workshops and lectures by external experts. More than 15 thou. people visited the Festival in 2020.

The next stage of the University development within the transformed environment pre-determined the need to develop the conceptual digital transformation model of the University to achieve the strategic goals and generate the ecosystem that can contribute to such achievements. A special research was performed to justify and generate the model. The research was carried out according to the mixed methods approach (Figure 2), sub-type: triangulation, convergence model. The choice of the research design is determined by specific features of the data collected by the University as well as by the goal which is data-based decision making aimed to improve students collaboration experience with a particular university (single phenomenon).

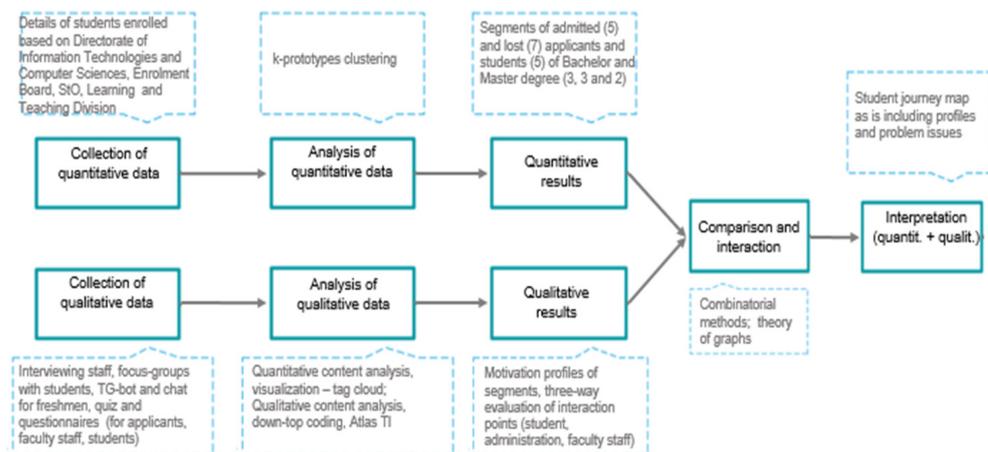


Figure 2. Research methodology.

The consistent mixed method (including collection of both quantitative and qualitative data) was used in the completed part of the research. The same method is applied for the part of the research that is currently under implementation to triangulate the data as well as to obtain specific information from respondents. The quantitative data on the interaction problems within the digital environment, the degree of target indicators achievement as determined by the strategic tasks and objectives of the University, contributed to the basic problems identification and were used to compile quality questionnaires. Use of open questionnaires makes it possible to ensure individualization and specialization of emerging problems and expectations of the ecosystem subjects involved in the process. Sampling of subjects under investigation was purposive i.e., included determination and selection of persons or groups of persons that possessed some special knowledge or experience in terms of phenomena that were of specific interest for the researcher. In this case, information communication technologies integration into the educational and administrative processes is of specific interest. Therefore, the quantitative data collected across the entire multitude of the involved research subjects made it possible to achieve the target indicators and identify the problems and points of growth; while the qualitative research across the limited target samples contributed to the identification of the factors which formed the basis for the technological solutions to be implemented, as well as made it possible to come to some organizational conclusions used to adjust the development trend by accelerating and enhancing the quality of the digital transformation process and its significance for the subjects involved.

More than 20 expert interviews were performed involving the University staff; 6 focus groups of the University students, the total coverage of students interviewing was >500 persons (~21% of the total number of the students studying under some specific major track; academic staff questioning with the total coverage of >50 persons (~17% of the total number of the academic staff for the said major track), more than 20 thou. messages were received to the freshmen telegram-bot and chat. And the University social networking was subjected to analysis. The analyzed information made it possible to identify the most significant and essential issues that contribute to the formation of the interaction experience within the University as well as to select relevant and effective solutions for improvement. It should be noted that collection and processing of the data on all the aspects of the methods applied as given in Figure 2 are continuously ongoing for the quantitative data while data collection and processing is performed as per the established schedule for the qualitative data. Thus, it allows monitoring the development of the pre-determined model of the University digital transformation trend and to timely respond to the identified need for any activities adjustment.

3. Results

The target model of the NUST MISiS digital transformation developed based on the analysis results is focused on the ecosystem framing for creation and creative activities intended to attract and develop talented persons, as well as on the University transformation into the global center for engineering education and science including the following key parameters:

- the comprehensive concept of “digital first”—transformation into the digital format and integration of the entire educational and research content, services, internal and external interactions into the unified University digital environment;
- a new digital culture in the University: cancellation of outdated business processes and introduction of new business processes based on the data analysis;
- replacement of some specific functions within complicated activities with the artificial intelligence systems;
- decision making based on evidences, predictive analytics and big data analysis
- digital motivating educational environment: teaching/learning by digital technologies;
- digital literacy for all the University staff, teachers and students;
- online communication and formation of digital image of the University and its academic staff, teachers and students;

Therefore, the model of the NUST MISiS digital transformation includes the digital culture (of employees, academic staff and students), digital assets (artificial intelligence, e-platforms, and digital avatars), digital business models, and a digital company (Figure 3).

Below are listed the main items included into the culture of the NUST MISiS digital transformation model:

1. The key services and management business processes shall be reviewed and implemented using big data based digital technologies.
2. Each teacher shall be “digital” and continuously improve their digital literacy and competence.
3. Each student shall be “digital” and continuously study as per electronic (digital) economy competencies.
4. Each University employee shall continuously improve and update their digital competences and support others.
5. Decisions shall be based on “evidence-based policy” through big data analytics.
6. Transition to forecasting the future based on predictive analytics and taking proactive measures.
7. All the resources, activities, content and records shall be digitalized.

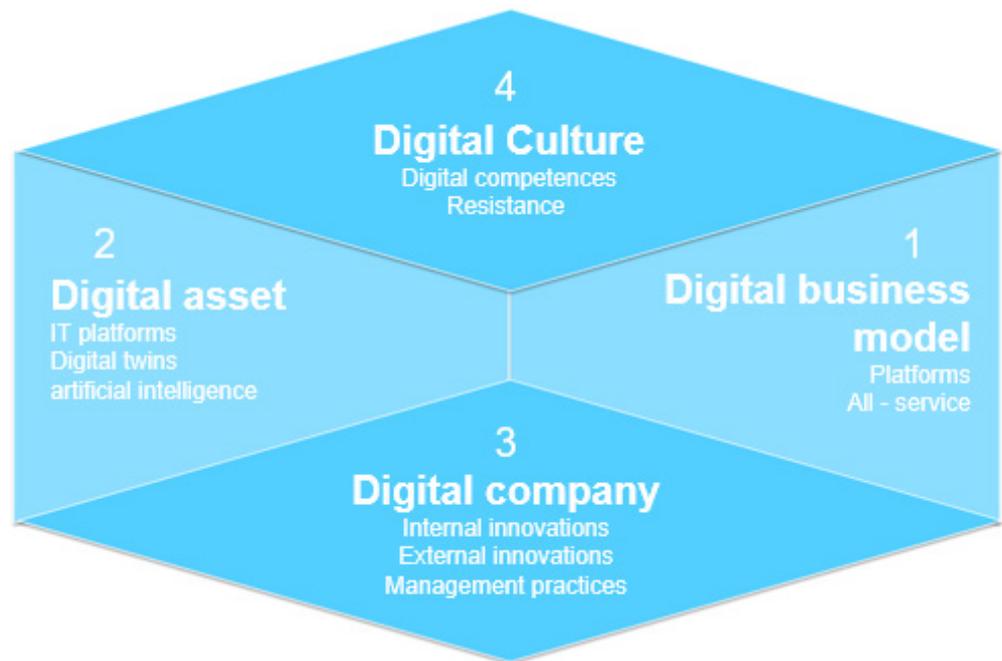


Figure 3. The NUST MISiS digital transformation model.

The NUST MISiS digital transformation shall result in establishing an open university, in management changing, personalization and practice-oriented approach of the educational process, enlargement of opportunities on educational formats (practices) that contribute to the formation of “ultra professional” skills, promotion of interaction among all the participants of the educational process at all the stages, formation of the single unified interface, Omni channels and logical consistency of the services that provide for the basic educational process. All these aspects will essentially contribute to the retention rate rise up to 80% as well as increase in the lifetime value of the client (LTV) (Figure 4).

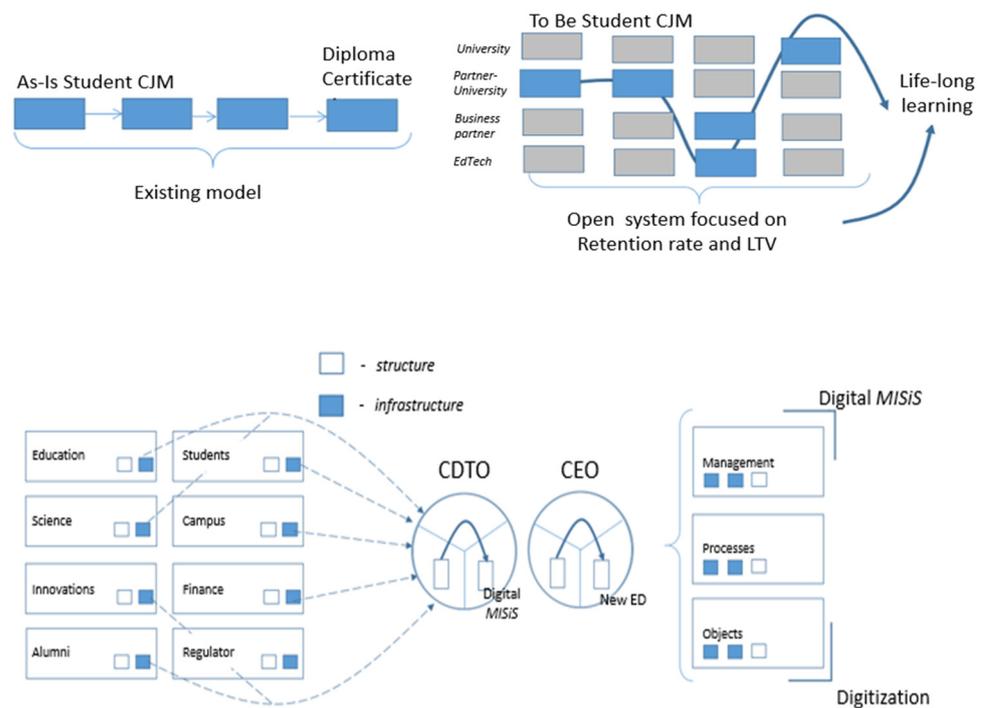


Figure 4. Model of transition to the Open University.

A new IT platform has been generated in NUST MISiS (Figure 5) to ensure transformation into the Open University.

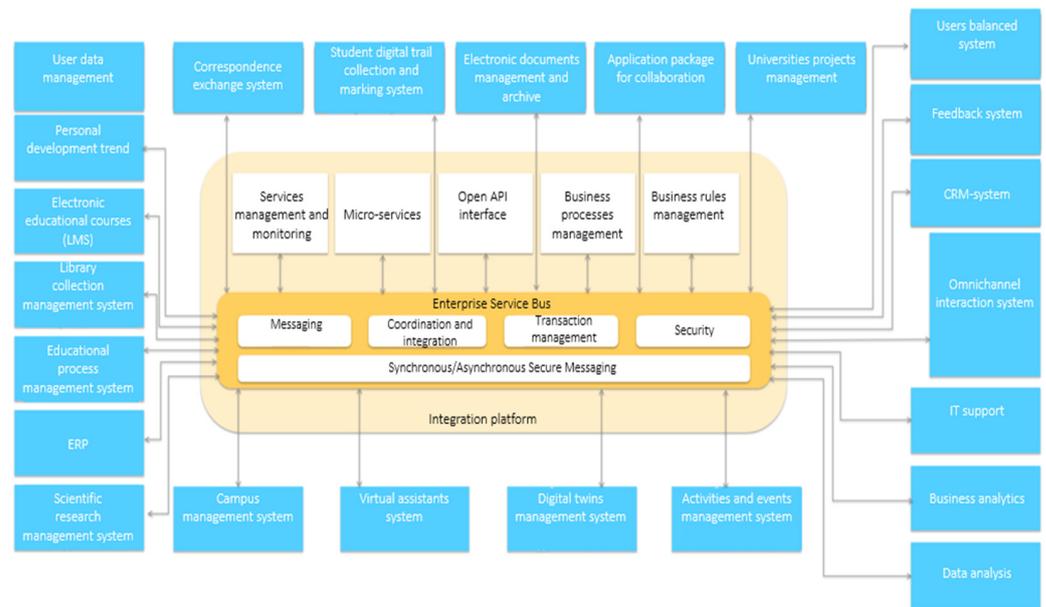


Figure 5. The new technological (IT) platform.

This integration platform includes the enterprise service bus and various procedures such as management of services, business processes and business rules provided they are continuously monitored, different micro-services and public interface. A large number of various operating packages will be developed based on this IT platform, such as ERP management systems for educational and R & D activities, CRM-systems including trends for personal development of the academic staff, students and employees of NUST MISiS, business analytics and etc.

This system is supplemented with Omni channel communications and virtual assistants that make it possible to completely robotize all the routine business processes of NUST MISiS. Moreover, conditions will be provided to form a sustainable growth of the university’s lifetime value for a person throughout the entire life cycle of the latter (Figure 6).



Figure 6. Students’ through-University journey.

At the first stage of the “University Introduction” life cycle, a potential applicant may take a virtual tour of NUST MISiS, and arrange for educational programs of various higher educational institutions to be compared. It will make it possible for NUST MISiS to be included in the applicant’s universities list. And the applicant will be able to apply online (digital infrastructure developed before the pandemic allows for students online application: more than 90% of the applicants made use of the opportunity in 2019, and 100% of applicants made use of the opportunity in 2020) and monitor the entire process in progress in real time: from documents application to enrolment order issue. It takes 20 min for an applicant to apply. The digital trail of a student is generated when an application is filed to the Enrolment Board and is kept until study termination. The rating of applicants’ satisfaction with the enrolment system has been 100% for the past several years.

The university activities are focused on increasing the share of public socially essential services available in the e-format up to 95% in accordance with the national development strategy of the Russian Federation “Digital transformation”.

Digital solutions contribute to the improvement of interaction with the university at each of the stage of the students through-university journey:

- Discover and aware: introduction of tools to provide for applicants communication with the most motivated students, collection and processing of the contact data for further communication using CRM-system, assessment and evaluation of marketing tools efficiency and competitors analysis;
- Evaluate and compare: generation of tools for online support including those used for educational programs selection considering an applicants’ examinations results;
- Apply and enroll: generation of a system for students application tracking and personal information distribution;
- Introduction: integration of Canvas educational process management system, schedule and event management and control systems as well as apps to ensure a more efficient immersion into the educational reality;
- Retention: retention rate increase up to 80%, integration of LMS, electronic portfolio to set up a unified database for students level of success, participation in competitive examination and feedback.

4. Discussion

NUST MISiS performs the digital transformation of processes to ensure the maximum coverage of the needs of applicants, students and academic staff through identification of the most essential issues thus contributing to the generation of the university interaction experience as well as by selecting relevant and efficient solutions for each of them. The basic elements of the formed ecosystem are consistent with the ideas mentioned in scientific studies on the ecosystem approach, indicative coordination and values control, as well as the requirements of the present-day employers and standards of education under the conditions of the dynamic transformation of the environment [6,7,10,13,14].

Generation of a digital ecosystem, which includes the five basic tracks (Figure 7), is deemed as the key achievement of NUST MISiS.

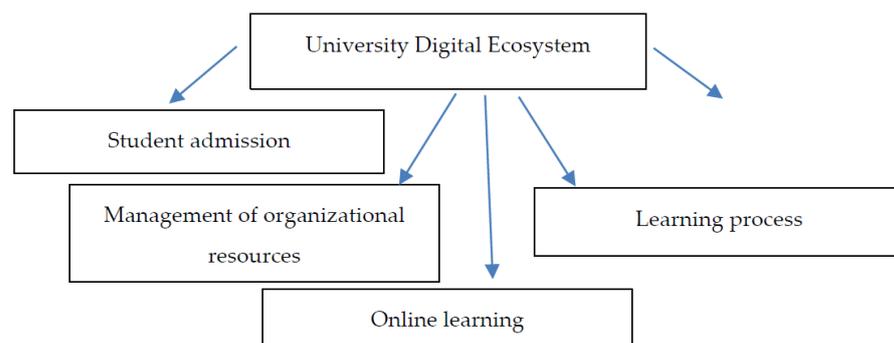


Figure 7. The key achievements of the digital transformation policy.

In terms of intending students admission track, the following can be distinguished as the key results:

- maximum clear and transparent process of admission to NUST MISiS provided that the entire process can be monitored in real time;
- digital trail of a student is generated when applicants file their applications to the Enrolment Board and is preserved until study termination;
- rating of student satisfaction with the admission system—100% for the past several years considering annual increment by 10% of the processed applications number.

As to the achievements in services generation for students, the following shall be noted:

- an innovative structural subdivision—Student’s Office (StO). StO runs via a “single window” principle thus providing an opportunity for each student and graduate student to receive information about their academic performance, request for the required certificates and statements online (through a personal account) or in person;
- submission of 95% of statements is made online due to StO;
- NUST MISiS was the first among Moscow universities to register with the Moscow Students Register; data on each student can be automatically transferred and updated within the city Students Register that makes it possible for the students to learn the information if their social cards are available and ready for use.

Digital achievements in terms of the educational process arrangement include the following:

- 100% of students study using the IT platforms-based blended model;
- 30% of the academic staff were re-trained in Teaching Skills School to ensure the efficient use of IT;
- Academic freedom of students: due to courses selection techniques students feel free to choose any courses and compile their individual and student-specific trends; this approach contributes to the motivation and involvement of students in the educational and R&D processes.

In terms of digitalization of organizational processes, NUST MISiS is the first university in Russia to implement 1C: University to make management decisions and ensure fast and timely interaction and cooperation of subdivisions on a number of issues: starting from compilation, distribution, agreement and approval of academic and extracurricular loads and ending in automated reporting and analytics; NUST MISiS won the international projects contest on management and accounting automation 1C: Project of the year in 2017; NUST MISiS implemented services of E-Credit Book and E-Report Card as part of their policy on abandoning paper versions throughout the documents management.

In terms of online study, the university digital environment is developed—it is a space for testing new technologies and experiments. In case of successful testing results, the innovations are introduced in the existing educational programs. These include creation of new educational digital systems, learning analytics and proctoring, integration of virtual and augmented reality into the educational process and gamification. The University has launched 40 online courses for more than 450 thou. participants and attracted more than 12 higher educational institutions as partners throughout Russia.

According to the current results of the University digital transformation monitoring, the basic trends of the digital transformation at the present moment are: change in students expectations (total experience), technological progress, request for Omni channel environment and external factors effect (Figure 8).

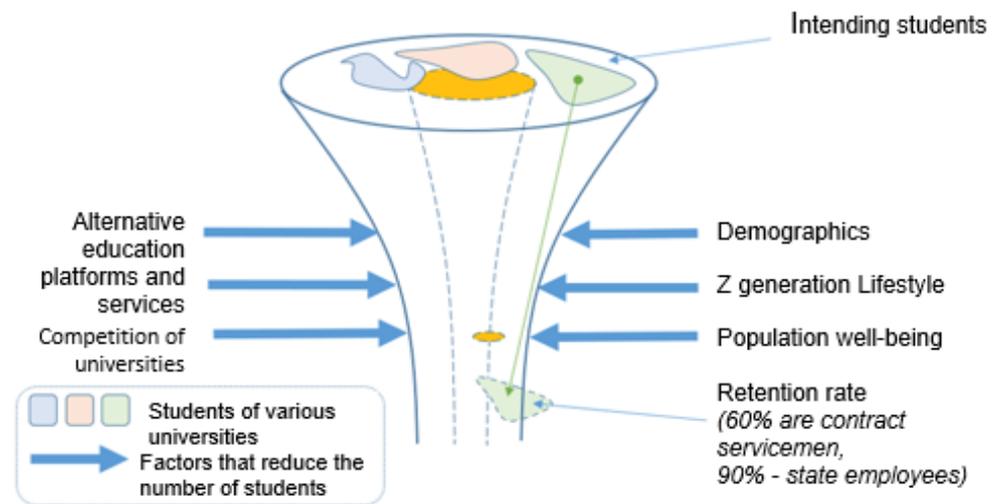


Figure 8. External effect.

The Omnichannel environment (Figure 9) is based on the established culture of using a variety of communication channels.

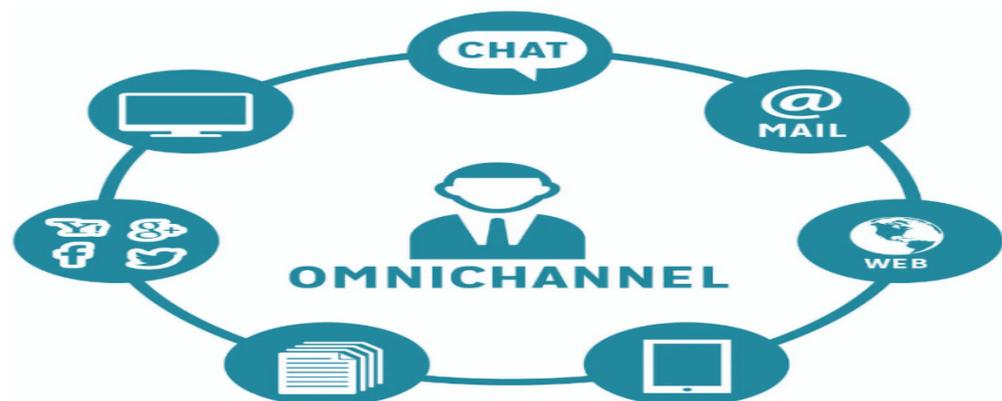


Figure 9. The Omnichannel environment.

Teacher-student interaction is executed through the set of channels by their mutual agreement, including LMS Canvas, CHAT, WEB, and e-mail. Interaction of NUST MISiS staff within the university is implemented by various communication means: 1C: UniversityProf, student/University employee personal account, creation of a single account in various systems (LMS Canvas, corporate e-mail, Google G Suite, Office 365 and etc.). The unified system of the documents management DIRECTUM has been implemented and the information portal is used in the University. The management system for scientific activities ISUNTP has been built in the University: the entire process of scientific projects management starting from participants applications preparation, issuing scientific research information control cards and ending in report forms uploading is performed in the system; the Project Management information system, platform visualization system, cloud file storage, videoconference system and etc. are implemented in the University.

By boosting the existing drivers for the digital transformation, the University goes deeper with its comprehensive activities in developing the established ecosystem including through technological solutions integration in the unified electronic information and educational environment LMS Canvas (lms.misis.ru). It is definitely the basic linking element and main working platform for the entire multitude of the University operation processes.

LMS Canvas delivers access to curricula, academic courses and practice working programs, learning and teaching materials and tasks provided by the academic staff. LMS

Canvas provides for recording the progress of the educational process as well as interaction between students and teachers.

In addition to LMS Canvas, students and the University academic staff may make use of the University e-library web-site <http://elibrary.misis.ru/login.php> (accessed on 4 July 2022), this resource grants access to the electronic teaching and learning publications. The e-library is a different specific service which is also used by the University students and staff.

The number of students registered with LMS Canvas is 6361 (parent OO). The number of teachers registered with LMS Canvas is 545 regular teachers, and 31 teachers who are external part-timers.

The digital educational environment is developed based on integration of the electronic teaching and learning management system LMS Canvas (<https://lms.misis.ru> (accessed on 4 July 2022)) and the automated information system 1C: University Prof in NUST MISiS, special services for the educational process planning and management, webinars arrangement sub-systems based on Adobe Connect Pro Meeting, library and information resources. The teaching and learning platform LMS Canvas of NUST MISiS is a technological basis for the educational process implementation and is widely applied to manage students independent activities and blended learning.

Development of the digital environment of NUST MISiS as a friendly and comfortable ecosystem of the University takes the needs of all the staff and students of the University into account and provides for automated and efficient management of the University key processes.

The NUST MISiS information system creates opportunities to access the personal and reference information posted in students and University staff personal accounts, as well as to receive services in the single-window mode.

Students' personal accounts contain personalized information about the educational process (schedule, announcements, access to educational materials). Students can remotely request for the required statements, control the University subscriptions, and monitor the current events.

Subsequently, implementation of the developed digital transformation of NUST MISiS running based on big data will make it possible to review and change the approach to the educational activities arrangement and implementation, namely to enhance the efficiency of interaction with employers, prepare university graduates of some unique competences, develop the progressive culture available for innovations, set up conditions for continuous professional and personal growth and development (Figure 10).

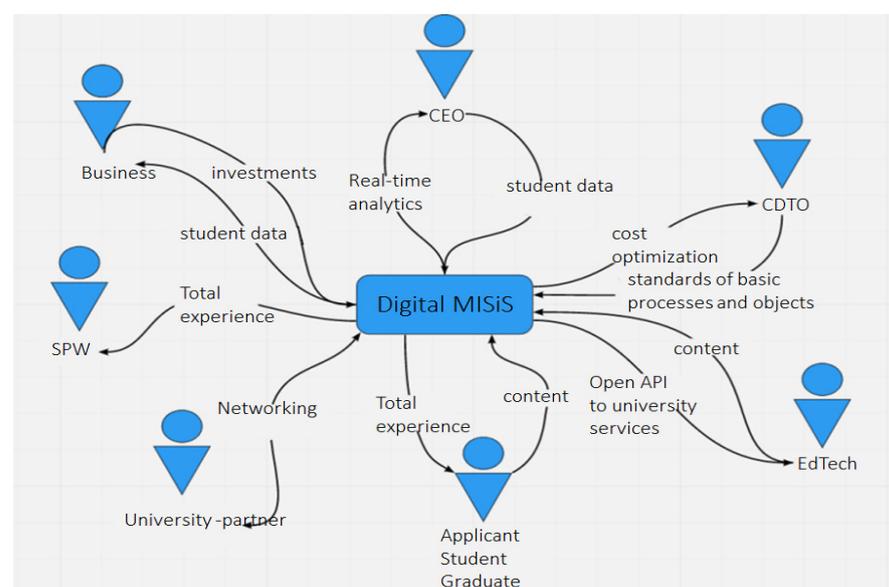


Figure 10. New interaction culture.

Priorities of the digital transformation are shown in Figure 11.

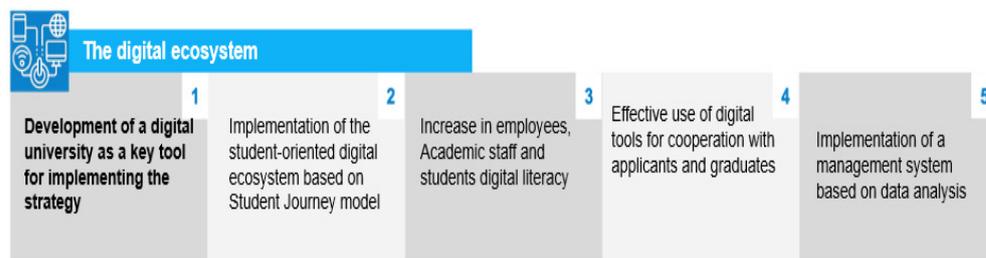


Figure 11. Priorities of the NUST MISiS digital transformation.

Therefore, priorities of the NUST MISiS digital transformation include:

1. Development of the digital university implies transformation into the digital format and integration of the educational and research content, services, external and internal interactions, including those made with the tools of virtual and augmented reality; creation of the unified digital environment of the university that combines internal information resources as well as information and software complexes; and provides for timely expeditious and safe data transfer between sub-systems and services of the digital environment, interactive access to all the sub-systems and services of the university for various users groups.
2. Personification includes application of any recommended systems and services according to the individual specific features, needs, interests, knowledge level and other parameters of the students in the implementation of educational programs at all the stages of learning; implementation of individual disciplines based on adaptive learning; implementation of educational programs based on personal educational tracks.
3. Implementation of the students-oriented digital ecosystem as per Students journey model implies creation of a new digital culture in the university: cancellation of the outdated and introduction of new business processes based on data analysis and/or using artificial intelligence systems.
4. Improvement of the digital literacy of the university staff, teachers and students includes development of the university digital platform to support students' activities on development results commercialization.
5. Effective use of the digital environment in activities involving applicants and graduates will allow ensuring support of gifted students and involvement of young people into research and development, design and experimental and innovation activities.
6. Introduction of the management system based on data analysis includes application of tools of predictive analytics, machine-aided learning and artificial intelligence.
7. External integration includes integration of information and software complexes of the university unified digital environment and external digital services (IT Systems, IT platforms, and etc.).
8. Planning and management includes planning, management of all the university activities (educational, scientific, innovation and extracurricular) as well as big data based decision making using predicative analytics tools.

The listed priorities are in line with the general trends of the digital transformation identified during the research investigation; please see the review at the beginning of the article [1–31].

Concept-based computations will not work and give appropriate results in achieving the set targets unless they are transformed into specific steps of actions on model implementation in practice. Below is the list of planned activities on digital transformation of a higher educational institution and their brief characteristics.

1. Creation of Personal learning tracks service within the corporate information environment. Implementation of the educational program that allows modeling of its content, evaluation of economic indicators, generation of portfolios of possible educational

- tracks based on data analysis for external and internal educational environment of the University.
2. Creation of the students-oriented digital ecosystem as per Students journey model. It implies generation of a new digital culture in the University: cancellation of the outdated and introduction of new business processes based on data analysis and/or using artificial intelligence systems.
 3. Updating proprietary educational standards of NUST MISiS as per the key digital economy competences. Analysis of the requirements of the reference documents (including programs of the Digital Economy of the Russian Federation, Federal State Educational Standards of Higher Education, occupational standards and etc.), proposals and recommendations of the expert community regarding the possible content of the digital economy, as well as identification of the solution to be subsequently integrated into the educational system of NUST MISiS. The results are the updated educational systems of NUST MISiS and guidelines for educational program elements development related to the formation of the digital economy competences.
 4. Development of methods for the main data based curriculum life cycle management within the educational environment of NUST MISiS. Creation of a digital model of the educational program that allows modeling of its contents, evaluation of economic indicators, generation of sets of possible educational trends, based on analysis of the external and internal University environment data.
 5. Integration of epy basic educational programs digital twins into the educational process planning system. Development of digital models of educational programs that allow management of their life cycle based on the design approach. The model contains content-type and economic characteristics of the program and makes it possible to upgrade its structure.
 6. Development of the system for students digital trail collection and marking. Development of the logical structure of the collected data and their marking. Development and implementation of data collection, storage and analysis system to build a student's profile.
 7. Digital portfolio. Introduction of tools for student's success data collection and storage into the key processes of the University in the digital portfolio format.
 8. Digital supplementary vocational education. A package of actions to develop and use supplementary vocational educational programs in the University in the digital format.
 9. Generation of the system to manage activities and events. The system that can provide for the arrangement, performance, accounting of activities and events performed as part of such activities (creation of activities, control of sessions and reports schedule, evaluation and assessment of presentations, reports). Based on evaluations and feedback received, both activities and reports rating and students' competence portfolio are generated.
 10. Business analytics systems shall be implemented to perform data analysis and visualization. The system that allows collecting data from different external sources into the unified standardized form; reports compilation and their visualization in different tracks with different degree of detail.
 11. Introduction of artificial intelligence-based tools and data collection system. Introduction of tools for big data analysis based on expert systems and artificial intelligence elements into the key university processes to perform expert assessment of decisions making based on predictive opportunities.
 12. Updating of a student's personal account and university IT portal. Modernization and development of tools using virtual assistants for navigation within a student's personal account as well as through the University IT portal. Development of the mobile application to provide for interaction with the University.
 13. Creation of the safe environment system. Implementation of a set of actions to ensure safe and easy access to the University facilities, including: campus map, biometric

- control, vehicle passage control and visitor entrance control. Availability for students and teachers shall be ensured 24/7.
14. Re-design of the corporate information system shall be performed. Restructuring of the university processes as part of the digital university modeling. Review of the university regulatory acts. Modernization of the established corporate information system. Development of new tools for the unified information system.
 15. Creation of the system for several university data resources communication and interaction. A package of programming tools for data synchronization within the corporate information system units based on the event model.
 16. Scaling of the data center to the cloud shall be ensured. Scaling of all the data center sub-systems to cloud systems shall be made.
 17. Implementation of the information security threats and incidents monitoring system. Expanding of the context of the information to be analyzed, introduction of incidents classification methods, automatic identification of interaction between incidents, events archive analysis.
 18. Creation of selection diagnostics system (teaming). The system that allows collecting, processing and diagnosing the university database including detailed reporting.
 19. Creation of a secure electronic documents management system through electronic digital signatures. Secure documents management shall be established to include documents approval (agreement) using electronic digital signatures that ensure automatic application of protection mechanisms and storage of users operating scenarios. Access to the documents management shall be provided through the mobile application.
 20. Creation of a unified video-service. The unified video-service controlling the video contents to inform students and the university staff through self-service terminals and feedback.

The listed steps fully implement the conceptual model of the university transformation and are consistent with the results and recommendations of the scientific research results in behavioral economics of education [25–27].

Therefore, by 2030 two vectors of the digital transformation will be implemented: education and clients experience improvement [32].

In terms of transformation of the educational activities, it is planned to achieve the 5 basic vectors:

1. Practice orientation: training of graduates based on employers' competences profile.
2. Personalization: generation and management of individual educational trends.
3. Expansion of opportunities in educational formats contributing to the formation of "ultra professional skills".
4. Access to the best content within the major (training track) and sound and seamless network cooperation.
5. Profound interaction with all the educational process participants at all the stages.

As part of the clients experience improvement, it is planned to reduce paperwork for teachers, administration staff and students as well as to implement the unified interface, omnichannel and logical consistency of services that provide for the basic educational process, that is absolutely consistent with the general trends identified in research investigations [33–35]. Besides, it is planned to increase the retention rate up to 80% and shift to the open model.

All these actions will make it possible for the university to reach a decent level of competitiveness in the constantly changing external environment and become attractive and appealing for all the interested parties through showing the high performance.

5. Conclusions

Based on the comprehensive quantitative and qualitative analysis of requests from potential participants of the ecosystem as well as based on the analysis of the requirements of external changing conditions, a comprehensive model for the university digital transformation including the digital culture, digital content in the university digital transformation,

digital business models and digital company, has been developed and is being implemented in NUST MISiS. Updated state-of-the-art educational management systems provide an opportunity for promoting teachers and students' collaboration to an absolutely new level developing future graduates' competences which can be in great demand at the HR market. The blended learning and e-learning can be successfully implemented provided that following conditions are met: the academic staff shall have appropriate information and communication competences and project-specific expert knowledge; application of electronic educational courses (with advanced functions) shall be encouraged and supported by the university administration; and new science-based pedagogical practices shall be introduced. The increasing number of committed learners is an incentive for updating the content of academic courses programs, for transforming and improving collaboration as part of learning and research activities in compliance with the changing requirements of the labour market and technology opportunities of the contemporary digital economy. The scope of research is limited by the limited number of respondents selected for the investigation—participants of the NUST MISiS ecosystem. However, the experience gained can be of some help for other universities that are just at the outset of their digital transformation. We consider a comprehensive comparative study of the transformation processes of the universities combined by different features, including their size, status, geographic position and etc., as a prospective for our further investigation to identify the characteristic features of the digital transformation processes management and control.

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