



DOI: <https://doi.org/10.57125/FED.2022.10.11.2>

How to cite: Järvis, M., Tambovceva, T., & Virovere, A. (2021). Scientific innovations and advanced technologies in higher education. *Futurity Education*, 1(1). 15-25. <https://doi.org/10.57125/FED.2022.10.11.2>

Scientific innovations and advanced technologies in higher education

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Received: July 12, 2021 | **Accepted:** September 21, 2021 | **Published:** September 25, 2021

Abstract: The modern transformation of the role of education affects the consideration and improvement of the methodological principles of education. At the same time, the constant development of the educational sector entails the justification of the use of certain scientific innovations and advanced technologies in the system of higher education, which is the actual task of this pedagogical research. The object of the study is innovation and advanced technology in higher education. The aim of the work is to highlight innovative means, methods, and technologies in higher education, which are promising mechanisms for improving the university system of Estonia and Latvia. Pedagogical methods of research

(theoretical and empirical) are used in the work. Among theoretical methods of pedagogical cognition, we will distinguish analysis, synthesis, concretization, and abstraction, systemic and functional methods. The empirical methods of research used observation, experiment, and rating method, the basis of which formed the key recommendations for the implementation of the analyzed learning technologies. The results analyzed a number of problems, in particular, the issues of innovative changes in European higher education, modern advanced technologies of learning in higher education, innovative, methods, forms of development of higher education, the problem of STEM-education functioning in Estonia and Latvia. The scientific novelty of the research is the proposed synthetic analysis of actual innovative methods and technologies in the system of higher education. The practical value of the work consists in the formation of recommendations for further use of innovative methods of higher education development. In the conclusion, it is summarized that the use of innovative teaching methods is an important part of modern European education. At the same time, the main advanced technologies turn to the individual development of the student, improvement of his practical skills.

Keywords: innovation, technology, higher education, Europe

Introduction

The latest processes of modernization of training is a topical problem for research because the national system of higher education differs from the established practices of the leading countries of the world. For this reason, the use and borrowing of foreign experience will require further thorough reflection and consideration, because not all components of European or American systems of training specialists can be applied in Estonia and Latvia. At the same time, as the analysis of professional literature has shown, there is no single synthetic study devoted to the outlined range of problems. Thus, innovations in the university educational process have been studied unevenly, and based on the Estonian and Latvian experience, they need additional recommendations for implementation.

This study is formed based on the use of modern pedagogical literature, which reflects the key challenges of modern education and scientific innovations. In particular, Laufer et al. (2021) characterized the features of digitalization implementation in the learning system. Petrenko et al. (2020) investigated the impact of distance learning on the quality of education in general, in addition, these scholars also analyzed the main mechanisms of e-learning implementation. Downton (2017) characterized the problem of education of the future, where the leading role will play in e-learning. Kotyk et al. (2021) highlighted key innovations in today's education system. The researchers focused on the definition of the project method, which is widely used in modern education. At the same time, Cherif and Hasanov (2021) analyzed key theories and empirical evidence on the complex relationship between innovation, competition, and inclusive growth. They find that competition and innovation-driven growth are crucial for productivity gains. We believe that their reasoning is valuable for the development of an integrated education system. Fuad et al. (2020) characterized major innovations in education system development. Skvorcova et al. (2020) peculiarities of higher education system functioning in Latvia against the background of education internationalization. However, the problem of the effectiveness of innovative teaching methods, and dynamic renewal of trends in the European higher education system remains understudied. Besides, it is important not only to characterize certain types of innovative methods but also to analyze the main problems of system of European higher education.

Research Problem

Scientific innovations and advanced technologies and their application in university education remain important areas of research. Due to the shifting trends and methods of learning, there is a need for constant updating of empirical data and theoretical foundations of this process. So, the use of best practices will require active analysis and forward-looking work.

Research Focus

The material focuses on issues of improving the quality of higher education about the requirements of the modern information society. Note that the analysis also addresses possible problems that will appear on the way to the use of best practices. This will contribute to the practical implementation of the results of the study.

Research Aim and Research Questions

The main purpose of this article is to investigate scientific innovations and technologies in higher education, which are promising tools for improving the university system in Estonia and Latvia. It should be noted that in the process of consideration of this issue a number of other important issues concerning the introduction of new individual methods, in particular, the effectiveness of STEM-education, project method, etc. will be elaborated and considered. The resulting recommendations will improve the organization of the educational process, taking into account the possible extension of the quarantine measures and the specifics of the national school, harmonize it with modern requirements for the preparation of highly qualified specialists.

Research Methodology

The study is based on the use of pedagogical research methods, which are divided into theoretical and empirical. Among the theoretical methods, we will distinguish analysis and synthesis. In particular, based on the method of analysis it was possible to divide the main subject of research (innovations and technologies of higher education) into several smaller parts (characterization of the phenomenon of innovation process in the education system, definition of key directions, and objects of innovation transformations in higher education, analysis of STEM-education in Estonia and Latvia and characterization of its prospects, etc.). With the help of synthesis methodology, the mentioned problems are combined, and specific considerations are formed. The study also applied systemic, structural, functional methods of research. Of the theoretical methods of pedagogical cognition, we will distinguish concretization and abstraction. Directly based on the method of concretization, the problem of implementation of STEM-education mechanisms was investigated. By means of abstraction, it was possible to characterize the general problems of innovative development of the higher education system in Europe and to form conclusions.

Among the empirical methods of pedagogical research, we will single out observation, experiment, and rating method. Based on the use of these methods of cognition, it was possible to approach the problem under study more thoroughly (in the practical plane). Note that the use of the predictive method reflects the problem of further development of scientific innovations and advanced technologies in the system of higher education. Note that this research is based on such methodological principles as systematicity, objectivity, retrospective, and scientific.

Research Results

The Problem of Innovative Change in Higher Education

The innovative process of education development consists in the fundamental transformation of its content and organization of the new. Consequently, the scientific literature considers the innovation process as a complex, systematic activity of creating (or developing), mastering, applying, and disseminating a variety of innovations (Cherif & Hasanov, 2021). The concept of pedagogical innovation refers to the phenomenon of innovation in pedagogical work, transformation in the content, methodology, technology of the educational process, the main purpose of which is to improve their effectiveness. At the same time, the term innovation in education means the process of formation, implementation, and dissemination of new theories, concepts, ideas, methods, practices, guiding technologies, the main purpose of which is to increase the indicators of achievement of certain elements of education (Fuad et al., 2020). At the same time, the current use of the concepts of “innovation” and “innovation” in pedagogical research is debatable. Some researchers strictly distinguish these terms, others consider their semantic definitions as identical. We believe that these concepts have different meanings. In particular, innovation is understood as a means (in particular, new method, methodology, technique, technology, etc.), at the same time, as innovation is a directed transformation, which introduces new steel elements into the plane of habitat, which entails the transition of the system from one position to another (Kotyk et al., 2021). In explaining the content of pedagogical innovation processes, it is important to highlight such important problems as research, generalization, and expansion of pedagogical experiences, and the problem of implementing the fundamental achievements of pedagogical science in the practical plane.

The main consequence of pedagogical innovation processes in the European education system should be the application of modern innovations of the theoretical and practical plane in a holistic educational process (Fuad et al., 2020). The teacher should play the role of researcher, user, author, and developer of modern pedagogical methods, theories, technologies, or concepts. At the same time, the management of such processes contributes to the preparation, evaluation, and use of new ideas in their work. The innovative orientation of pedagogical work also allows for the inclusion of teachers in the course of formation, mastering, and application of educational innovations in the practical plane of the learning system, the formation of some innovative environment in the higher education institution (Kotyk et al., 2021). The key areas and objects of innovative changes in the European education system are the formation of concepts and strategies of education development, the transformation of certain teaching methods or technologies, improvement of educational institutions’ management system, formation of psychological security, monitoring of learning, etc. (described in Table 1)

Table 1

Key areas and objects of innovative change in higher education

The main directions and objects of innovative changes in higher education
1. Formation of theories, concepts, or strategies for the development of higher education
2. Development of concepts or strategies for the development of higher education institutions.
3. Transformation, improvement of new teaching methods or technologies
4. Improvement of the system of management of educational institutions
5. Improvement of the system of teaching staff training, professional development of teachers

6. Development of new models of the educational process
 7. Promotion of students' psychological, and environmental safety
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8. Formation of new technologies and teaching methods
 9. Organization of monitoring of educational processes in higher education
 10. Development (or improvement) of curricula, syllabuses, etc.
 11. Drafting, development (or improvement of existing) textbooks, manuals on new methods and programs.
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Source: Formed based on the author's analysis

The introduction of innovations can be done at different levels. In particular, the highest level includes those innovations that relate to the entire pedagogical field. For example, some progressive innovations appear on the scientific plane and support the advancement of practice. For this reason, an entirely new and important field has emerged in pedagogical science called the “theory of innovation and innovation processes” (Fuad et al., 2020). Reforming higher education is a structure of innovation aimed at fundamentally transforming and improving the functioning and development of higher education as a whole (Laufer et al., 2021). Consequently, it should be understood that the innovation process is a multifunctional process of formation, absorption, and application of certain innovations.

Modern Advanced Technologies of Teaching in Higher Education

Contemporary innovation processes in education are analyzed in three key aspects: socio-economic, psychological and pedagogical, and managerial. The general conditions under which innovative changes will take place also depend on these aspects. In particular, certain conditions can either facilitate or hinder the implementation of innovative processes in the higher education system. Thus, the innovation process has both spontaneous and knowingly managerial nature.

To thoroughly transfer knowledge and the formation of competitive specialists, the system of higher education in Estonia and Latvia should be focused on such modern technologies as person-centered, information and communication, integration, distance, modular-development, creative, etc. Various technologies should be used in the modern innovative education system (See Table 2).

Table 2

The main pedagogical technologies and features of their implementation

Pedagogical technologies	Features of the use
Structural logic	Consists in a step-by-step application, which promotes a logical sequence of didactic problem solving, taking into account the step-by-step monitoring of the process.
Integration technologies	Provides for didactic systems that ensure the integration of multi-subject knowledge and skills based on integrated courses

Professional and game technologies

Provide for the use of various kinds of “games” that form critical thinking skills. We are talking about business, role-playing, simulation games, individual trainings, etc.

Training technologies

Consists in introducing some algorithms of solving typical situations into the educational process. We are talking about psychological trainings of personality development, trainings

Information and computer technologies

for solving management problems, trainings contributing to the formation of leadership qualities, etc.

They are realized in the system of digital learning based on the dialogue “man-machine” However, the use of a variety of training programs is provided.

Source: Formed based on the author's analysis

We believe that in the system of higher education diversification of such pedagogical technologies contributes to their active and effective combination through the prism of the modernization process of traditional learning. As a result of using such an integrated approach, the main focus is on the personal development of future professionals.

Innovative methods, forms of learning activities in higher education

Among the training innovative methods, techniques, and forms most commonly used in higher education institutions are the following: analysis of own mistakes, mishaps, brainstorming (“brainstorming”), discussion, “decision tree”, business, role-playing games (taking place when students are in the role of experts, legislators, lawyers, clients, judges, etc.), method of a situation analysis and monitoring, project method, modeling, interview method (interview), PRES-formula method (Position - Reason - Explanation - Summary), public speaking, webinar, individual and group trainings, etc.

Among the innovative methods of scientific processes, the method called “race for the leader” is important. This method reveals the use of artificial competition, forms the skills of critical thinking and students. We believe that another innovative method for the full development of students' creative activity is intellectual games that promote the formation of critical and creative thinking (Chern & Davis, 2019).

The mentioned methods contribute to the complex development of the student, influence the formation of communicative, creative, media-educational competencies, which are now in demand in the labor market (Chern & Davis, 2019). In addition, students in practice in group teams must have the opportunity to solve typical situations in non-standard ways. Thus, students learn how to communicate in teams, make responsible decisions, and demonstrate their leadership skills.

The main stated goal of implementing the project method is the ability to independently solve problems or obtain and comprehend information, which requires the integration of knowledge from

different scientific fields (Protsyk, 2020). The implementation of this goal “autonomizes” the work of the student, trains him to act and work responsibly and with less control of teachers. Based on the analysis of the specialized literature, we can identify several main features that are inherent in the use of project methods. Let us form the results in Table 3.

Table 3

Key features inherent in the use of project methods

Action	Result
Setting a specific goal	Allows you to clearly define a problem, select ways to solve it and perform tasks, work through new and previously unknown material, and think creatively. Respond to the challenges of implementation
Group planning and implementation of projects by faculty and students together	Promotes teamwork skills in which students attempt to complete assigned tasks. The instructor acts as a definite tutor and advisor, providing advisory support for projects.
Involvement of potential employers in the project	Implementation and realization of independent student projects is an advertisement of their abilities and skills to potential employers. Therefore, when performing practical tasks, it is possible to involve stakeholders in this process.
Independent work and research by students	Provides the development of students' individual work skills, contributes to the formation of information competence, media competence, and other characteristics necessary to realize their creative potential in today's society.
Presentable result	Demonstrates concrete results of an individual, paired, or group project in front of a broader audience. Can be performed in different forms: presentation, report, posters, etc. Note that in today's educational environment, the ability to obtain a result and to present it in a dignified manner are important qualities. In addition, the presentation of project achievements may lead to a discussion, during which the weaknesses of the performed task may become apparent - the ability to discuss with the audience is also an important and demanded skill.

Source: Adapted from Protsyk (2020)

Consequently, the use of the project method in higher education has many positive aspects. For a long time in Europe, this method was used only partially - mostly through the preparation and writing of undergraduate or graduate research papers. However, the paradigm shift in the educational process has demonstrated that the teaching methods developed incidentally in the US back in the 1930s are effective (Protsyk, 2020). We believe that further integration of this method of teaching will allow expanding the educational potential of European universities.

At the same time, as it was possible to establish, the student environment is much more active in perceiving changes than teachers. The conservatism of university faculty (Howard et al., 2021) can be an important obstacle for the implementation of the project method (as well as other methodological innovations). Therefore, it is important to create clear evaluation criteria that also take into account some personal qualities of students (for example, the level of self-esteem, the ability to make conscious choices and comprehend their consequences, etc.). This will avoid subjectivism in giving final grades.

STEM education and its prospects

The modern information society needs a new type of specialists capable of quickly adapting to work conditions, complexity of tasks, social challenges, etc. At the same time, the activity of the education applicant's personality should not dissociate from the received knowledge, skills, and abilities (Downton, 2017). We believe that the main change in the vector of learning is in the paradigm of the attitude towards students and the results obtained on this basis. Learning should become more and more person-centered, allow the use of the latest techniques, form individual learning trajectories, etc. (Hamzah et al., 2021).

An important element of the new Estonian and Latvian higher education has been the introduction and implementation of STEM education ideas. The acronym STEM is used to define the current direction of modern pedagogy, which combines the topics of natural sciences (Science), technological education (Technology), technical creativity (Engineering), and mathematical sciences (Mathematics). An important aspect of the use of this direction in the educational process is a combination of the natural science component with the comprehension of innovative technologies. At the same time. The proposed approach is also used in the study of humanities disciplines (for example, STEAM - adding Art, i.e., art; STEMM - adding Medicine, i.e., medicine). The purpose of the unity of natural and mathematical educational fields is to form and develop students' personal competencies, to form a natural-science picture of the world, to expand worldviews and life values through the use of transdisciplinary approaches to education. An important element of such education is the emphasis on practical aspects of applying scientific, mathematical, technical, and engineering information that can be used to solve practical problems and improve one's skills.

It has been proposed to comprehensively disseminate innovative STEM education methods, to combine the efforts of participants in the educational process (as well as employers) to form the necessary competencies of education applicants (González et al., 2020). The main objective of the implementation of the STEM system is the creation of skills to solve complex practical problems, the formation of critical thinking, the development of creativity and mental flexibility, the ability to communicate, and leadership. Among the last item, the researchers single out responsibility for the decisions made, conscious choice on mastering a profession in the future, development of financial literacy, cultural self-development, etc. (Kotyk et al., 2021). So, the proposed objectives correspond to the general strategies of modern higher education development, which consists in the all-around

development of an individual through finding out his/her abilities, mastering the necessary skills of work and education, formation of self-discipline, and desire to learn and develop during life.

Discussion

The basis for understanding any innovation is that it involves changing the old state of affairs. Sometimes change is required only for a certain group of individuals or organizations and can have a negative effect on the system as a whole. From this perspective, researchers have found that any innovation is frowned upon because students and faculty are equally obstacles to innovation because they will face immediate change. This dissatisfaction may depend on the radicality of the innovation, especially when there is no rapid positive change. Overcoming this phenomenon (resistance to the introduction of new modern teaching methods) requires extensive discussion with the public and potential employers. Stakeholders must independently consider the positive and negative elements of the transformation, accept or reject change. However, there is a downside to this democracy.

Researchers, based on the analysis of empirical data, have found that universities are rather slow to implement innovations and new technologies and methods due to complexity and bureaucratic sluggishness. Innovation tends to break old pedagogical routines and push teachers out of their “comfort” zone. For this reason, it is important to create special pedagogical conditions for the implementation of innovative changes (González et al., 2020). qualification level of teachers. At the same time, obstacles to new technologies in education come from traditional political notions, structural mechanisms of education functioning, labor market dynamics (where temporarily specialists with lower qualifications may be in demand). It is no secret that the dynamics of the market economy is determined primarily by powerful companies, and smaller firms or businesses (regardless of innovation activity) are inferior to them. The interest of employers can also be variable and based on the requirements of modernity. innovation is a rapid process of “aging” and changing its essence, educational programs may not keep up with the dynamics of transformation, and at the same time be in catch-up rhythm.

Thus, the demonstrated difficulties will inhibit the transformation of education. Note that some of them are optional, but the difficulties with the pedagogical conditions of increasing the role of higher education over time may become tangible.

Conclusions and Implications

Consequently, the use of innovative teaching methods, tools, and technologies contributes to the overall development of education in accordance with modern transformations and changes. The main advanced technologies are an appeal to the individual development of the student, and the improvement of his personal practical skills. Among such technologies, we would like to single out integration, training, and game-playing, which contribute to the formation of both critical and creative thinking in students, which will contribute to their future competitiveness in the labor market. At the same time, let us emphasize that the diversification of such pedagogical technologies contributes to their effective combination. Through the application of such a comprehensive approach (different technologies), the main attention is focused on the development of future professionals in one or another sphere.

Among the educational innovative methods most commonly used in higher education institutions are brainstorming, discussion, business, role-playing games, method of analysis and situation monitoring, project method, interview, webinar, individual and group trainings, etc. These methods

contribute to the personal development of the student, influence the formation of communicative, creative, media-educational competencies. It is important that students in practice in group teams can solve typical situations in non-standard ways. We believe that such experience is valuable for the development of personality as an important specialist in a particular field. Despite this, as it was possible to establish some difficulties in the way of innovative development of education Innovations tend to affect the elimination of typical ideas of pedagogical work and force teachers to leave outdated methods of teaching. For this reason, it is important to form special pedagogical conditions for the introduction of innovative changes. Despite some problems of introducing innovations and advanced technologies, their use demonstrates effective consequences.

Thus, innovative pedagogical methods of teaching and forms of work are gradually superseded by traditional ones. In this case, European higher education institutions should develop optimal approaches to the organization of the educational process, taking into account the local specifics of higher education systems.

References

- Cherif, R., & Hasanov, F. (2021). Competition, innovation, and inclusive growth. *IMF Working Papers*, 2021(080), 1–28. <https://doi.org/10.5089/9781513574172.001>
- Cherng, H.-Y. S., & Davis, L. A. (2019). Multicultural matters: An investigation of key assumptions of multicultural education reform in teacher education. *Journal of Teacher Education*, 70(3), 219–236. <https://doi.org/10.1177/0022487117742884>
- Downton, M. P. (2018). Preparation for future teaching: Authentic activities in a teacher education classroom. In D. Polly, M. Putman, T. Petty, & A. Good (Eds.), *Innovative practices in teacher preparation and graduate-level teacher education programs* (pp. 293–305). IGI Global. <https://doi.org/10.4018/978-1-5225-3068-8.ch016>
- Fuad, D. R. S. M., Musa, K., & Hashim, Z. (2020). Innovation culture in education: A systematic review of the literature. *Management in Education*, 36(3), 135–149. <https://doi.org/10.1177/0892020620959760>
- González, M. J., Surikova, S., & Pigozne, T. (2020). Adaptation of a teacher training programme for character education to the Latvian context. In L. Daniela (Ed.), *Human, Technologies and Quality of Education* (pp. 7–18). University of Latvia Press. <https://doi.org/10.22364/htqe.2020.01>
- Hamzah, N., Ahmad, M. F., Zakaria, N., Ariffin, A., & Rubani, S. N. K. (2021). Technical and vocational education students' perception of using learning videos during Covid-19 pandemic period. In *2021 IEEE International conference on automatic control & intelligent systems (I2CACIS)* (pp. 346–351). IEEE. <https://doi.org/10.1109/i2cacis52118.2021.9495895>
- Howard, S. K., Schrum, L., Voogt, J., & Sligte, H. (2021). Designing research to inform sustainability and scalability of digital technology innovations. *Educational Technology Research and Development*, 69, 2309–2329. <https://doi.org/10.1007/s11423-020-09913-y>
- Kotyk, T., Romanyuk, S., Bogush, A., Rudenko, Y., & Nepomniashcha, I. (2021). Innovative and project activities of future education. *Laplace em Revista (International)*, 7(3B), 213–219.

- Laufer, M., Leiser, A., Deacon, B., Perrin de Brichambaut, P., Fecher, B., Kobsda, C., & Hesse, F. (2021). Digital higher education: a divider or bridge builder? Leadership perspectives on edtech in a COVID-19 reality. *International Journal of Educational Technology in Higher Education*, 18(1), Article 51. <https://doi.org/10.1186/s41239-021-00287-6>
- Petrenko, L., Kravets, S., Bazeliuk, O., Maiboroda, L., & Muzyka, I. (2020). Analysis of the current state of distance learning in the vocational education and training institutions. In *E3S Web of Conferences*, (vol. 166, Article 10010). EDP Sciences. <https://doi.org/10.1051/e3sconf/202016610010>
- Protsyk, H. M. (2020). Project method: Past and future. *Medical Education*, (1), 67–71. <https://doi.org/10.11603/me.2414-5998.2020.1.10996>
- Skvorcova, O., Stavicka, A., & Odiņa, I. (2020). Subjective well-being of international students in Latvian higher education institutions. In L. Daniela (Ed.), *Human, Technologies and Quality of Education* (pp. 196–207). University of Latvia Press. <https://doi.org/10.22364/htqe.2020.18>