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IMPACT OF NON-LINEAR PROGRAMMING AND TECHNOLOGIES ON EDUCATIONAL TRANSFORMATION

IMPACTO DE LA PROGRAMACIÓN NO LÍNEA Y LAS TECNOLOGÍAS EN LA TRANSFORMACIÓN EDUCATIVA

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ABSTRACT

This article explores the potential of non-linear technologies in transforming higher education in Russia with attention to their pedagogical value at both micro and macro levels. The research seeks to specify the main elements of non-linear educational practices including multidimensional course structures, path dependence theory and student-centered learning while also analyzing local examples of implementation in universities. The methodology is based on a combined theoretical and empirical review of literature together with a conceptual framework that enables a systematic understanding of these technologies. The findings indicate that non-linear approaches foster autonomy, responsibility and cognitive flexibility among students and encourage them to build personalized learning pathways. At the micro level non-linear education takes the form of creative tasks that promote independence and motivation, while at the macro level it supports multidimensional programs in which students design their own educational roadmaps. The study concludes that gradual integration beginning with micro practices can help Russian universities move from linear models toward flexible systems better aligned with the requirements of a digital society.

Keywords:

Non-linear education, Higher education, Student autonomy, Multidimensional learning, Educational innovation, Digital society.

RESUMEN

Este artículo explora el potencial de las tecnologías no lineales para transformar la educación superior en Rusia, prestando especial atención a su valor pedagógico tanto a nivel micro como macro. La investigación busca especificar los principales elementos de las prácticas educativas no lineales, incluyendo las estructuras de cursos multidimensionales, la teoría de la dependencia de la trayectoria y el aprendizaje centrado en el estudiante, a la vez que analiza ejemplos locales de implementación en universidades. La metodología se basa en una revisión bibliográfica que combina teoría y empírica, junto con un marco conceptual que permite una comprensión sistemática de estas tecnologías. Los hallazgos indican que los enfoques no lineales fomentan la autonomía, la

responsabilidad y la flexibilidad cognitiva en los estudiantes y los animan a construir itinerarios de aprendizaje personalizados. A nivel micro, la educación no lineal se concreta en tareas creativas que promueven la independencia y la motivación, mientras que a nivel macro apoya programas multidimensionales en los que los estudiantes diseñan sus propias rutas educativas. El estudio concluye que la integración gradual, a partir de prácticas micro, puede ayudar a las universidades rusas a transitar de modelos lineales a sistemas flexibles más alineados con las exigencias de la sociedad digital.

Palabras clave:

Educación no lineal, Educación superior, Autonomía estudiantil, Aprendizaje multidimensional, Innovación educativa, Sociedad digital.

INTRODUCTION

In recent decades, the landscape of higher education has undergone profound transformations driven largely by the rapid expansion of digital technologies and the growing need for innovative pedagogical models. Universities across the globe are facing the dual challenge of preserving academic traditions while simultaneously adapting to the imperatives of a digital society characterized by flexibility, constant innovation and personalized knowledge pathways.

Within this context, linear models of education, traditionally based on rigid curricula, standardized assessment mechanisms and predetermined trajectories, have become increasingly insufficient to meet the demands of twenty-first century learning. Students and educators are calling for approaches that emphasize autonomy, creativity and adaptability, thus prompting an exploration of non-linear programming and technologies as viable alternatives to reshape the higher education experience (Acosta-Servín et al., 2025; Casimiro-Urcos et al., 2025; Oliveira & De Souza, 2022; Timotheo et al., 2023).

The notion of non-linearity in education implies a break from sequential and uniform patterns of teaching and learning. Instead, it favors diversity of trajectories, multidimensionality of course structures and the possibility of building individualized roadmaps that recognize the complexity of cognitive development. Such an approach finds theoretical grounding in concepts like path dependence, which highlights how prior choices and contextual factors shape future learning opportunities, as well as in student-centered methodologies that prioritize agency, motivation and personal initiative. These elements converge in what can be termed non-linear educational practices, which encourage learners to take responsibility for their progress while allowing institutions to design flexible frameworks that accommodate a multiplicity of paths and outcomes (Crotti et al., 2021; Mhlongo et al., 2023).

Russia offers a particularly relevant case study for this transformation. Its higher education system has long been rooted in strong traditions of linear instruction, with clear hierarchies and standardized procedures. However, the shift toward a knowledge economy and the growing internationalization of universities are pressing forces that require adaptation. The integration of non-linear technologies has the potential to support this shift by promoting new modes of interaction between students, teachers and digital platforms. At the micro level, these practices can be observed in classroom activities that emphasize independence, problem solving and creative tasks designed to enhance motivation. At the macro level, they manifest in multidimensional programs where students are encouraged to design their own educational trajectories, combining courses across disciplines and engaging in interdisciplinary projects that reflect real-world complexity.

The pedagogical value of non-linear approaches lies in their capacity to foster cognitive flexibility, responsibility and self-directed learning. By moving away from the rigidity of linear progression, universities can nurture graduates who are better equipped to adapt to rapidly changing professional environments and to engage with the uncertainties of contemporary society. Furthermore, the progressive integration of non-linear practices, starting from micro-level innovations and gradually expanding to institutional frameworks, can facilitate smoother transitions for universities seeking to modernize their systems. This stepwise approach ensures that experimentation and adaptation occur in manageable stages, allowing educators and students alike to develop the competencies required for more complex transformations at the institutional level.

Nevertheless, the problem of developing up-to-date courses for students remains a demanding task. Adjusting a course to students' personal needs is increasingly viewed as one of the primary goals of education, and many methodologists dedicate significant effort to constructing courses with carefully sequenced elements presented in the most efficient and timely manner. Yet the question arises: what would happen if students themselves were the ones to design courses according to their individual needs? This is precisely what non-linear programming and technologies in education propose. They encompass a set of methods that rely on students' autonomy and self-studying skills, thereby offering opportunities for personalization and flexibility in the learning process. Such approaches are particularly relevant in the Russian context, where higher education institutions are gradually shifting toward non-linear models, albeit at a slower pace than many scholars would anticipate.

This ongoing tendency has shaped the research agenda, emphasizing the need to review theoretical concepts and practical applications, to extract lessons from local implementations and to explore new possibilities for integration into the university system (Ambarova & Shabrova, 2016; Zborovsky, 2016). The present article addresses these challenges by examining the impact of non-linear programming and technologies on educational transformation in Russian higher education, while situating their pedagogical value within a broader framework that links micro-level practices to macro-level reforms in pursuit of more flexible and student-centered systems.

MATERIALS AND METHODS

The authors review and analyze research existing findings related to the problem of the development of non-linear technologies and programming in education in almost in every region of the country. The analysis reveals a number of critical aspects in the further development of non-linear technologies and programming.

The review has contributed greatly to the framework of this study and may be regarded as the first step towards the solution of the problem discussed in the research article. The conceptual framework identifies obstacles, which prevent researchers from developing a more specific and comprehensive definition of non-linear technologies and programming.

The research article relies on holistic systematic approach, which enables to review non-linear technologies as a comprehensive phenomenon. The structural and functional approach allows for examination of non-linear technologies as a part of non-linear programming, identification of its main functions, outlining further prospects for development and areas for improvement.

The transformation of educational system into a non-linear standard was hindered by economic and social changes of the 1990's. However, they drove the need for new goals in the educational system. Now free market economy defines which professions society genuinely needs. Therefore, teaching technologies should be adapted to new circumstances. Educational system must promote competitiveness among graduates, which makes them feel willing to land a decent job.

According to Jutsavitche (1989), new teaching methodology needs to be: (1) flexible which means responsive to changes on labor market; (2) democratic in the ways of presenting material to students; (3) promoting individual approach and customization of educational programs; and (4) willing to change when the teacher understands themselves the need and which implies freeing them from monotonous work. These four components are strongly fused in non-linear educational technologies. Non-linear method is perfectly suitable for free-market economy, as in addition to students' professional needs it deals with future occupational issues.

Self-directed non-linear programming is totally driven by the learner demanding and seeking personal learning solutions to the environment in which they will establish their social enterprise. It is fundamentally opposed to the linear, mass delivery methodology often associated with formal linear learning, says Pérez et al. (2023). The design of non-linear learning environments is inherently difficult and complex. In such designs, learners should be able to select any entry point in the subject (similar to opening a book to any page), and directly move to any other point in the subject at will, argues Härkki et al. (2021).

In non-linear programming, learners can choose learning contents according to their interests and browse learning resources according to their own ways of thinking. Non-linear one has characteristics of learning autonomy, cognitive flexibility and so on (Tian & Han, 2011). Non-linear programming plays quite an important role in forming such competences. It suggests a promising way of educating people non-linearly from many perspectives, but the issue of how to apply this new method to the Russian higher schools remains open.

The author Krezhevskyikh (2020) states that non-linear technologies and programming appear as a complex system organized in a highly complicated way. She believes that linear educational principles and strict institutional structure, including certain lesson time limits, audiences, and disciplines should be left out. She claims that changing the programs of higher schools is key to completion of the transition. Zborovsky (2016), is concerned about the decreasing role of Russian regional universities, which is reflected in his work. The statistics provided in the study shows that since 2000 the number of higher schools in Russia has dropped significantly. The study highlights that the need for transition to the non-linear standards is driven by the current situation.

A number of specific tasks, which need to be performed as the first step to committing the transition, are outlined and include as follows: "time investments" into human capital (teachers), rejecting authoritarian principles of university management, creating pedagogical conditions in which teachers will be willing to apply such technologies themselves, creating inter-university mobility (at the federal or regional level) that will allow for conducting projects together, establishing funds, etc. Ambarova & Shabrova (2016), claim that the new educational model of digital society must be built on universities' autonomy in the first place. It appears to be a challenging task to integrate this method into Russian educational system. Although the integration was proposed more than 20 years ago, there

have been a small number of changes in Russian higher education, including primary and secondary education.

The authors of the current research believe it may be explained by ***Path Dependence*** theory. Path dependence (Puffert, 2002) is when the decisions presented to people are dependent on previous decisions or experiences made in the past Praeger (2007). The path that was initially chosen will affect the future of the process. Soviet educational principles still live on in pedagogical staff, they have been absorbed by the walls of higher schools. It is stated that in Russian case higher education has strong features, which root from soviet educational system featured by a relatively low autonomy. In Soviet times higher schools lost their autonomy, which led to the formation of linear model of education. Russian education inherited this feature even though it is not very practical nowadays to use linear model of education. In monography under the editorship of Zborovsky (2016), authors hold the opinion that linear model in higher education is still dominating in Russian universities. Further, the authors will discuss the characteristics of a linear and a non-linear model.

A linear educational and programming model is strict, authoritarian managing system; university managers hold all the administrative power; no links with economic sphere; low interactional level among students, teachers and managers (administration); no democracy in choosing development prospects of the university.

Non-linear educational and programming model has a number of quite unique features, which distinguish it from the linear one. Firstly, the model rejects authoritarian principles of university management as it promotes high level of engagement among teachers and students in university management processes. Secondly, the model encourages creating partnerships between universities and major business participants on the market, which supports effective interaction among students, teachers and university administration. What is more, it enables universities to choose their development tracks.

To sum up, everything that was mentioned earlier, we need to highlight the pros of such methods – their orientation on multidimensional development of student's personality. These characteristics make it essential to highlight the advantages of the methods discussed with a focus on multidimensional development of student's personality.

Multidimensional courses

Difficulties in applying the non-linear educational model in Russia may stem from economic, social and cultural differences among the regions of the Russian Federation. For example, it is stated that in 2020 72 Russian regions out of 85 needed extra funding. Unstable economic situation results in lower salaries for teachers in Russian regions with budgetary gap, which, in its turn, results in their unwillingness to test and apply new technologies in their work. This problem may be identified as regionality.

When applying non-linear technologies to the educational system in Russia, it is significant to consider regionality. It means not to apply a certain educational standard to the whole country, but to develop approaches that will suit each region.

Russian experts say that the linear educational model should be replaced by the non-linear one (Grigoriev et al., 2021; Kolesnikov & Polyushkevich, 2012). However, how to do that? In addition to the ideas and within the scope of the new research stage of applying non-linear educational and programming model in Russia, this article introduces new terminology based on the empirical studies. The terminology is developed to simplify the process of classification of the steps to be taken in future.

Forming *multidimensional courses* and tasks is a significant part of non-linear technologies. Generally, such a course contains a certain number of modules, which are quite independent from each other. Each one has its own goals and tasks. Each one gives an opportunity to evaluate one's progress in the end of the course. The key point is that a student can change the order of the modules in accordance with their preferences. Therefore, a multidimensional course allows students to form their own learning road map, considering personal needs. Such a course is an embodiment of what is called "non-linear technologies on macro level" in this article. Long things short, non-linear technologies on *macro* level have the following functions: constructing an individual training road map; considering students' personal needs; engaging self-studying. As a result, students become more motivated to study hard. What is more, they feel responsible for their progress since they outline a specific roadmap. It contributes significantly to their level of motivation as their intrinsic motivation is activated. In other words, they are no longer forced to study subjects they do not need but rely on their internal needs.

Example of applying (macro level)

Moscow school No. 1296 can be set as a prime example of an educational institution which attempted to implement home education for students of 11th form (Solovova, 2010).

This was due to students' inability to study full-time at school for a number of reasons, which included preparation for university exams, willingness and readiness to study new material at their own pace and occasional conflicts between them and teachers. Thus, the administration, the parents and the students mutually agreed to apply home education. The parents signed a contract with

the school, which included schedule and types of distant classes, forms and frequency of progress reports and payment procedures.

At the beginning both parties (parents/students and teachers) faced difficulties applying this form of education. The most challenging issues were planning and agreeing the syllabus from the students' side and controlling the progress on the teachers' part. However, both parties had managed to reach alignment. This form of education revealed a set of new roles for the teacher, which implied not only transfer of knowledge and monitoring of academic achievements but being a manager, counsellor and life coach. As for the students, they had become independent and free to choose their educational path. That provided them with better understanding of their roles and responsibilities within the educational process and gave them an opportunity to draft personal road maps based on their educational goals. The mandatory tasks for the students included planning their daily schedule, checking the deadlines, reaching alignment with their teachers by avoiding any open conflicts. They could select disciplines or classes based on their needs and preferences and set different scales or performance indicators, which they could use to measure their success.

At the end of the experiment, most students reported that they were generally satisfied with the opportunity to study at their own pace. The majority of students reported that home education triggered faster growing-up through a clear understanding of their personal roles and responsibilities within the educational process. Many students noted that they encountered a small number of problems during the first year at university. The experience helped them to pass their exams successfully and they did not find themselves disappointed studying at universities. This overall success can be attributed to non-linear technologies and programming.

To conclude, on macro level non-linear educational technologies imply providing an opportunity for each student to create his/her own educational road map. Then they should be introduced to the materials contained in each module, which they can replace or reschedule in accordance with their own needs. Although students select different ways to study the material, the final goal remains the same. The main idea is to give students more freedom and create a comfortable working environment.

On *micro* level non-linear technologies stand for using techniques that encourage students' creative thinking. It is worth mentioning that these tasks can be integrated into a linearly scheduled course. In other words, it is possible to integrate non-linear practices on micro level in a traditional linear course but with a rather limited number of activities.

It means giving students some tasks, which they do by themselves. This activity does not require detailed instructions from the teacher. By contrast, a teacher only needs to set some goals at the beginning and (not necessarily) to provide the students with some materials.

Example of applying (micro level)

What do students need to commit to a non-linear educational model and take the most from it? Obviously, they need to know what to learn. Another important factor is the ability to work independently with a minimum guidance from the teacher. At this stage, it seems necessary to give examples of tasks, which aim at developing confidence in learning and independence.

The authors would like to describe a lesson that they took part in last year. The students had to read a text about gold in the course book and answer the questions, but the teacher went beyond the scope of the book and gave them a task to search for some additional information and make a presentation. The task included finding the most popular sayings with the word "gold" and their meanings; the role of gold on the global market; and spiritual sense of gold in different cultures. The teacher did not provide any specific instructions. Therefore, the students were free to choose the way to complete the task. They agreed to get into three small groups and share the questions in the task.

Further suggestions

The research on gold was done with the help of the Internet the students managed to create a well-developed presentation to support their ideas. After completing the assignment, the students gave their feedback. The majority of students approved of the task and reported that they felt inspired to work in a team and at the same time having the freedom of choice. The authors consider this example to be crucial for the article as it supports the ideas underpinning non-linear technologies and programming. It demonstrates clearly how non-linear technologies work in practice. This task not only encouraged the students to learn new information, but also gave them an opportunity to act independently and as a team to solve a professional task which was realistic and achievable.

Using this model may lead to broadening the ideas related to shaping of multidimensional courses. Nevertheless, it might appear impossible to apply such technologies on a macro level in real life. For this reason, this article only proposes making an attempt).

There is a number of other examples which reflect the application of non-linear technologies and programming on a macro level.

Example 1

General task. Think of your future job

Key objective. Think of a profession which appeals to you and gives opportunities for development

Context. In modern educational environment students need to develop their ability to acquire professional knowledge. Therefore, this task perfectly fulfils two needs: decreasing the lack of professional knowledge and building confidence in students, which will eventually lead to applying non-linear education technologies on a macro-level more easily.

Objectives that will help to find the solution.

- Think of your interests and decide, whether it is possible to monetize them or not.
- If not, then read about the most prominent jobs
- Then, visit digital resources which provide such vacations, like headhunter
- Finally, decide on 2-3 professions that you think are the best for you.

Example 2

General task. Create a plan for your personal development.

Key objective. Form a detailed plan for personal development, consisting of three parts: gaining knowledge, physical development, psychological development.

Task's context. Such unusual, though extremely important, tasks are rarely given at school. The main idea of this task is to develop students' learning confidence through gaining knowledge. Other components of the task are auxiliary and serve as tools to make it more engaging and encourage students' independence.

Objectives that will help to find the solution.

Think of the knowledge that you need to fulfil your educational and professional goals. You may ask the teacher about the useful sources. Note down the results.

Think of your physical shape and how to improve it. Note down the results.

Take psychological tests on the type of your character and find areas for improvement. Note down the results.

Finally, analyze the results and create a daily plan of what to do in order to close the gaps.

Compare the results with your partner's.

This leads to the assumption that "non-linear technologies in education" can be divided into two close but separate terms. "Non-linear technologies in education" on a ***macro*** level are creating the course, which will encourage students' autonomy. "Non-linear technologies in education" on a ***micro*** level are using specific techniques in teaching that provoke students' independence. It is important to understand the difference between students' autonomy and students' independence at this stage. "Students' independence is an ability to solve tasks without the help of the teacher, whereas students' autonomy is an ability to choose how, when and what to study for achieving the goal". In other words, macro level technologies can be used in the long term, while micro level technologies can be regarded as spontaneous activities.

CONCLUSIONS

This article proposes some new terminology that clarifies people's perception of the concept of ***non-linear technologies and programming*** in education. It divides this concept into 2 levels: ***macro level*** (encouraging students' autonomy by creating long-term module courses); and ***micro level*** (encouraging students' independence by using certain techniques at a specific lesson). This diversity may help solve the problem of the application.

The idea is that implementation of macro non-linear educational technologies into universities may only be possible in those universities, which receive regular financing. Otherwise, the attempt is likely to fail due to reluctance of the academic staff to take action. In addition, the reluctance can be caused by previous teaching experience and unwillingness to accept changes, even if teachers realize the effectiveness of the model (see Path Dependence theory). Similarly, students who are not used to non-linear studying could feel confused if they were put in such conditions, including both the ability to solve non-linear tasks and the unawareness of own needs. This is to underline that applying non-linear technologies and programming is a gradual process, which requires sufficient time to adjust to the new reality.

Thus, it is better to start the adjustment process with using non-linear technologies and programming on a micro level, which means postponing development of module courses and giving the right level of autonomy to students. Additionally, the present level of autonomy in Russian higher schools is relatively low, especially in small or remote regions, where higher schools tend to merge into single educational organizations, which does not support transition to non-linear principles.

To conclude, the authors consider it essential to outline a set of practical steps that may facilitate the transition toward a non-linear educational model in the Moscow region of the Russian Federation. Before implementing significant adjustments to the educational system, both pedagogical staff and students should be given sufficient time to adapt to new learning methods. This can be achieved through the gradual introduction of micro-level

non-linear technologies and programming into the educational process. Teachers should be encouraged and trained to apply these approaches, while students need to be guided to understand the benefits and opportunities that such methods provide for their personal learning trajectories.

All participants in the process must be psychologically prepared for the forthcoming changes. University autonomy should be granted progressively, allowing institutions the time to monitor, evaluate and adjust to the transition. Autonomy in this sense implies a gradual departure from authoritarian management principles and the inclusion of students' voices in the governance and daily life of the university.

The integration of the non-linear model into higher education should be carried out smoothly and incrementally. At the initial stage, it is advisable to combine elements of both the linear and non-linear systems, creating a hybrid structure. This overlapping of approaches would provide students with sufficient time to adapt, while enabling them to select courses within the broader framework of a general program. Such a strategy ensures that the transition is not only feasible but also sustainable, leading to a balanced and student-centered educational environment.

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