

# Implementing smart technology in engineering education

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**Abstract.** Engineering is an important field for the evolution of the world. Engineers build and create things that improve people's lives. In addition, engineers use innovative technologies in their academic and professional work. Consequently, it is important to train future engineers to use intelligent technology. Engineering is a complex field that uses many innovative technologies. Such technologies as CAD/CAM, 3D printing, and virtual reality are becoming increasingly popular in the engineering community. Engineers are using these technologies to create new prototypes and inform the public about new ideas. By presenting these intelligent ideas to the world, engineers are helping to create better products and designs. In addition, engineering schools are using smart technology to educate their students. Instructors use CAD/CAS software in the classroom to demonstrate practical applications. This helps students understand what they are learning and apply it to real-world scenarios. In addition, engineering schools use gamification and case studies to engage students in the classroom. These strategies help teach students relevant concepts and apply them to real-world situations. It is easy to see how smart technology improves engineering education and implementation in the field. Current and future engineers use these tools in their daily work. These changes improve learning and teaching tactics for instructors. Ultimately, this leads to better designs and applications of technology in the real world. It is also interesting to note how the adoption of smart technology affects engineering degrees. Many engineering colleges are introducing technology tools into their curricula as a graduation requirement. This allows their programmes to properly prepare their students for the workplace. Students are required to take technology implementation exams before entering college courses. This ensures that all graduates are well-prepared to work as engineers. Engineering is an exciting field, with many advanced technologies, both educational and practical. Future engineers learn by introducing and implementing new smart technologies in their classrooms. In addition, renowned engineers use innovative strategies to improve existing technologies or create new blueprints for inventions. Engineering is an integral part of the world; thanks to clever technological solutions, everyone can become an engineer!

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## 1 Introduction

Today, as a result of global computerization, intensive development of information technologies, which have become an integral part of modern man's environment, "classical" e-learning is gradually being replaced by education using smart technologies. The concept of smart technologies implies the widespread use of Internet resources and services in the learning process, providing students with the opportunity to achieve results in the study of subjects, taking into account their multidimensionality and continuous updating of content.

The use of smart technologies in the management of extracurricular activities of the educational organisation is a topical issue at this stage. This is due to the fact that extracurricular activities should be organized in such a way as to create conditions for activity and independence of students, to combine individual and group work, to provide flexible classes, variable composition of students, project and research activities, excursions, hikes, business games, etc. Smart technologies can help to implement the requirements mentioned above for the organisation and management of extracurricular activities.

Having analysed the degree of development of the research problem, we have identified three levels of contradiction: contradiction of sociopedagogical level, contradiction of scientific-theoretical level, and contradiction of practical-methodological level. The contradiction of socio-pedagogical level: between the urgent need of educational organizations in the organization of extracurricular activities management, including the use of "smart technologies" and insufficient experience of such organization.

Contradiction at the scientific-theoretical level: between the urgent need for theoretical justification of management aspects in the organisation of extracurricular activities and the insufficient level of this justification.

Contradiction of practical and methodological level: between the urgent need to develop a programme of extracurricular activities management in educational organisation through the use of "smart technologies" and unavailability of such a programme.

Research problem: insufficient study of the issues of extracurricular activities management in educational organisation with the use of "smart technologies".

The object of the research:

The process of managing extracurricular activities of an educational organisation through the use of "smart technologies" by the subjects of the educational organisation.

Subject of the research:

Forms and methods of using "smart technologies" in the management of extracurricular activities in the educational organisation.

The aim of the research is to theoretically substantiate the model of extracurricular activity management in educational organization with the use of "smart technologies".

Hypothesis of the research: the process of extracurricular activities management in educational organization with the use of "smart technologies" by the subjects of educational organization will be more effective in case:

- teachers will know the theoretical and methodological basics of using smart technologies in extracurricular activities

- teachers will be prepared to use and apply smart technologies in extracurricular activities

- a model for managing extracurricular activities through the use of smart technologies will be implemented

- the leading forms of using smart technologies in extracurricular activities will be: study groups, subject laboratories, competitions and Olympiads;

- systematic use of smart technologies in extracurricular activities.

## 2 Theoretical and methodological foundation of the study

Research in the field of information and computer technologies in the works of V.G. Bocharov, M.A. Galaguzova, I.A. Zimnyaya, A.V. Mudrik, and T.F. Yarkina.

Research in the field of socio-pedagogical methods of educating students in extracurricular activities in the works of G.E. Utegulov, Z.F. Kamaldinova, O.V. Lvova, A.L. Semenov, S.N. Sergeev, R.A. Shchukin, etc.

Research on approaches to ICT application and "smart technologies" by A.P. Ershov, B.S. Gershunsky, E.I. Mashbitz, N. Wiener;

Theoretical justification of management ideas in the works of M.M. Potashnik, P.I. Tretiakov, T.I. Shamova.

In our work, we relied on the following key concepts of research:

Extracurricular activity, an integral part of the educational process of school, one of the forms of organisation of students' free time (Sh.A. Amonoshvili).

E-learning - organization and management of educational process in which a teacher applies ICT technologies. This process is governed by the use of electronic resources for information delivery (Internet, corporate networks of companies) (Novikov).

Smart education is an intellectual environment for continuous competence development of educational process participants, including the activities of formal and informal education process, which result in changes in demonstrated behaviour through the use of acquired new competencies (I. V. Shubina)

Smart technologies - technologies which are used in the educational process, with the help of unified educational content (created/acquired by an educational organisation), having technical, pedagogical resources underneath (E.S. Polat)

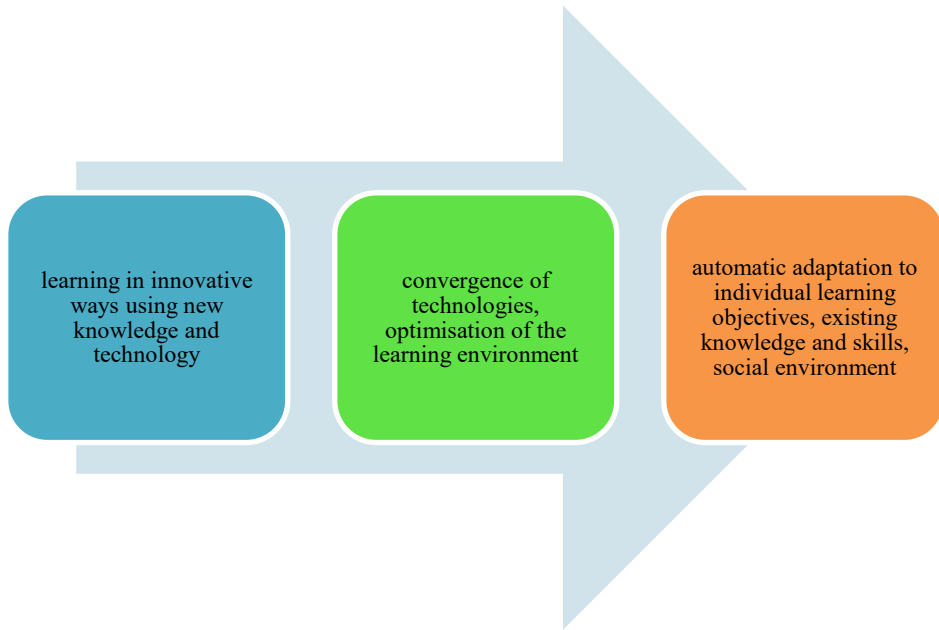
N.B. Borisova, believes that the new educational reality formed under the influence of smart technologies and its components lead to changes in the system of value and semantic orientations of an individual. There has been a socio-psychological change of the educator's role, since publicly available knowledge does not have subjective value any more and the educator is no longer a carrier of it, acting more as a consultant or tutor. But at the same time the teacher's role increases in terms of formation and development of such competences as self-education and self-development, acceptance, and awareness of these values.

A.V. Khutorskoy and P.V. Bakalov emphasise in their works that by "smart technologies" we mean educational content, which is openly available to all participants of the educational process, and there is feedback for all.

The process of using smart technologies in education is aimed at:

- eliminating a detected problem that creates an obstacle to activity change;
- programming a path for the development of ICT culture;
- creating an activity model that transforms the learning environment.

Providing the maximum level of education - is the goal of "smart education" [Busygina, 59].



**Fig. 1.** Organisation of the educational Smart Environment.

Based on the analysis of management experience of many educational organizations, the following components of smart technologies application in management practice in extracurricular activities of an educational organization can be highlighted [Baikov, Novikov]:

- Selection of the necessary material and technical support in the design of classrooms, thematic stands;

- Use of digital tools;

- Familiarization with methodical teaching aids, as well as analysis of the experience of other educational organizations;

- Use of the Internet in the educational process, in order to obtain information, scientific and technical support for the processes of study;

- Development of illustrative material of the educational institution;

- Maintaining the website of the educational institution, e-mail of the EI.

To determine the focus in our study, we analyzed the approach of Y.S. Baranovsky in identifying the most important directions in the use in the organization and management of extracurricular activities through "smart technologies". It is possible to highlight the following components [Baranovsky, p. 24-26]:

Experimental base of the research: Municipal Autonomous Secondary General Education Institution - Secondary General Education School №7, Tavda, Sverdlovsk region

In this article we have considered the essence concept of "extracurricular activities" in a scientific context, normative-legal basis of extracurricular activities management, and also highlighted the basics of organization and management of extracurricular activities through the use of "smart technologies". We have reviewed and described the models of organization of extracurricular activities: supplementary education model, optimization model, innovative and educational model. Management of extracurricular activities has its own specificity and includes the following main functions: predictive function, definition of levels of work organization, motivational function, implementation of control and coordination function. The result of applying smart technologies in extracurricular activities: changing the learning environment of innovative teaching methods, creating intellectual environment for

competence development of educational process participants. The management of the educational process with the use of smart technologies - covers the areas of management of pedagogical staff and the area of management of material values, financial flows, material values.

We conducted the ascertaining stage of the research in order to identify the readiness of the teachers of Educational Establishment No.7 to apply and use "smart technologies" in extracurricular activities.

The research period: 02.05.2021 - 01.01.2023.

The study involved teachers of school no.7, 1st and higher categories.

Number of participants: 43 teachers.

In order to study the level of use of information support in management, methodical and educational activities of the school a survey was conducted in the form of questionnaires among pedagogical staff of Educational Establishment School no.7.

43 out of 43 pedagogical workers participated in the survey.

The diagram shows the results obtained through the survey (Figure 4):

To question 1 "I know and understand why it is necessary to use information software" was answered by 65% of respondents; to question "I am actively involved in mastering of new information pedagogical technologies" was answered by 42% of respondents, to question "This year I have mastered new educational technologies (specify which) and actively use them" was answered by 52% of respondents, to question "I am able to work with information software tools, use them at lessons and in extracurricular activities" was answered by majority of respondents - 83 %.

Thus, we can say that in the school no.7 the need to use information support in the learning process is known and understood, but only some of them (65% of 100% of respondents) actively master new information and pedagogical technologies.

In order to identify the teachers' assessment and self-assessment of their readiness to use "smart technologies" in extracurricular activities we have conducted a survey of teachers (Figure 5):

Forty-three out of 43 educators participated in the questionnaire. According to the results of the survey, we can conclude that 30% of respondents are ready to use smart technologies in extracurricular activities. 37% of teachers have an average level of readiness to use "smart technologies". Low level of readiness is 32% of respondents. This percentage shows that educators are not ready to implement new technologies, techniques and methods in their activities.

Further, to determine the extent of application of information and "smart" technologies in teachers' work, a questionnaire survey of teachers was conducted.

When asked about the regularity of using smart technology 40% of respondents responded positively, to begin with it should be noted that regularity consists in the use of ICT tools. 60% of respondents noted that they use ICT, but not as often for various reasons. There are problems in the introduction and use of ICT in teachers' professional activities. Low ICT competence of teachers is also considered a problem: many of them know how to work with computers and other equipment, but outside work teachers do not use the equipment and, therefore, their work is done at a slower pace.

According to the results of the survey, we can conclude that teachers master and apply new educational technologies as part of extracurricular activities, and the vast majority of respondents know how to work with IT tools and use them in lessons and extracurricular activities.

We have conducted an interview with deputy principals for educational work in MAOU School No. 7. According to the results it was possible to determine the extent to which smart

technology tools are used to coordinate the interaction of participants in the management of extracurricular activities, especially when organizing extracurricular activities:

Respondents stated that they do not use smart technology tools in the educational institution.

Respondents believe that smart technology tools allow more effective and successful interaction with all participants of the process.

According to the survey results, the respondents believe that the extracurricular activities should be carried out only in the presence of local regulatory documents of educational organization. Also, the respondents noted that in school No. 7 the regulatory framework for the use of smart technologies in extracurricular activities has not been developed and approved.

In connection with the results of the study, the task of developing a model of organization and management of extracurricular activities when using "smart technologies" was raised.

The second chapter also describes the model of mechanisms for organizing and managing extracurricular activities with the use of "smart technologies": theoretical and methodological (target), structural and functional (content), design and technological (procedural), criteria and diagnostic (control and evaluation) stages.

The main components of pedagogical model construction:

1. theoretical-methodological (target): goal, objectives, principles, etc.

Purpose of the model, Object, Subject, Tasks, Functions of the model, Type of the model: Type of model, Target audience, Research base:

2. Structural-functional (meaningful): mapping of interrelations of model components.

3. Project-technological (procedural): general ideas about the model, its components, the process of implementation.

4. Criteria-diagnostic (control and estimation): monitoring of the model implementation efficiency.

We have also developed a program of extracurricular activities management with the use of smart technologies of Educational Establishment No. 7.

Name of the program: Program of extracurricular activities management with the use of smart technologies

Programme developer: Vera Mikhailovna Dyatlova

Grounds for the development of the program:

- National Project of the Russian Federation "Education";

- The Law of the Russian Federation "On Education";

- Decree on the Approval of the Federal State Educational Standard for Basic General Education;

- The Charter and local acts of the school;

Program goal: the need to increase the competitiveness of School no. 7, the most important factor for the successful and sustainable development of which is the ability to adapt quickly to modern conditions and requirements.

Hypothesis of the programme implementation:

Formation of a model of extracurricular activity management mechanisms using "smart technologies", provided:

- Creation of a set of conditions for the implementation of extracurricular activity programmes using information and communication technologies to ensure students' full mastery of educational programmes in school No. 7;

- application of modern information technologies in education, assuming formation of a modern type of thinking in teachers on the basis of growth of pedagogical competence and professional skill.

Programme objectives:

- To increase teachers' motivation in using smart technologies in extracurricular activities;

- to develop teachers' skills in using smart technologies in extra-curricular activities;
- developing educators' skills in working with computers and other means of communication;
- developing educators' skills in working with and finding relevant information on the Internet; participation in online educators' communities;
- teaching teachers to use smart technologies in their extra-curricular activities.

The programme ran from October 2022 to January 2023. The programme consisted of 3 stages.

Timeline and phases of the programme.

Programme implementation stages:

1. Preparatory stage:

Activity content:

1. Assessment of compliance of the existing material and technical base with the requirements of FSES is carried out.

2. Planning for the replenishment of the material and technical base of Educational Establishment No. 7

3. Planning of school staff training.

4. analysis of the level of information competence of teachers of school no. 7

5. Development of local acts aimed at implementation of the programme.

6. Selection of software when using "smart technologies" in the management of extracurricular activities of Educational Establishment No. 7.

2. organizational stage:

Content of the activity:

1. studying the experience of applying smart technologies in the educational process.

2. Making a list of equipment used in classrooms.

3. Drawing up a work plan: conducting master classes, open classes with the use of smart technologies.

4. Involvement of teachers in the implementation of the programme.

5. Acquisition of some equipment for the implementation of the programme.

6. Draw up criteria for evaluating the efficiency of using smart technologies.

3. Final stage

Implementation.

Activity content:

1. Development of mechanisms to verify the effectiveness of the application of smart technologies in extracurricular activities.

2. Summarizing and finalizing the system of criteria for evaluating the effectiveness of interactive educational Smart environment in an educational institution.

The implementation of the model and programme of extracurricular activity management through the use of smart technologies shows us the following results:

"The level of teachers' readiness to use "smart technologies" in extracurricular activities"

Forty-three out of 43 teachers participated in the survey. According to the results of the survey, we can conclude that 56% of respondents are ready to use "smart technologies" in extracurricular activities" (initial indicators are 31%). 34% of teachers have an average level of readiness to use "smart technologies". Low level of readiness is 10% of respondents. This percentage shows that educators are ready to introduce new technologies, techniques, and methods in their activities. The indicators have improved: the high level has increased, and the low level has increased.

The model was implemented in the following steps:

1. Diagnostic stage: Active interaction of the deputy director for educational work with teachers was organised to identify problems and difficulties in the use of smart technologies.

2. Theoretical stage: jointly (deputy director for educational work with teachers) developed programmes of extracurricular activities with the use of "smart technologies".

3. Implementation stage: joint activity of administration of EI and teachers is organized with the purpose of implementation of the model and rendering real, effective and timely assistance to teachers for successful application of "smart technologies" in extracurricular activity.

4. Assessment and adjustment stage: joint analysis and summarizing of the model implementation in the practice of extracurricular activities of EI, making adjustments to the model and activities for its implementation, if necessary.

During the implementation of the programme of extracurricular activities management with the use of smart technologies we came to the conclusion that the electronic infrastructure of the school should work, using a modern comprehensive information system which will provide: objectivity of the received information; comparability of the system data, due to the need to track results not only as a statement of facts, but also to study changes. Thus, during the conducted formative experiment our hypothesis was confirmed: the process of management The use of smart technologies contributes to the implementation of personality-centered approach, students' awareness of the holistic picture of the studied subject, allows providing independent learning of the material, individualizing learning, improving control and self-control, increasing the effectiveness of the learning process.

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