THE ENGINEERING MASTER'S PROGRAM IN THE FIELD OF INFORMATION TECHNOLOGY " AL-AUGMENTED DIGITAL SYSTEMS ENGINEERING

DIDACTIC MODEL OF THE DIGITAL SYSTEMS DEVELOPMENT BASED ON ARTIFICIAL INTELLIGENCE TOOLS

The logic of the master’s degree educational program construction:

The Master's degree program is a set of thematic educational tracks built in accordance with the typical stages. The track is a set of interrelated educational disciplines aimed at the formation of knowledge, skills and abilities in a certain sector of tools in the field of information technology based on understanding. Consistency and stages in the educational process ensure an increase in the level of knowledge maturity for the subject context and readiness to use professional tools to solve popular problems in real production activities.

Training takes place in the following stages within the each educational track framework:

Stage 1: Basic familiarization with the basic concepts, methods and tools of the studied technological track. The theoretical foundations of the technologies underlying the technological track are studied in a lecture format at this stage,. Exercises are performed and elementary typical tasks are solved on demonstration educational examples in a given subject area at seminars and laboratory work. Students use the direct tasks for artificial intelligent assistants for almost each task. Interpretation and analysis of the results of solving typical tasks by intelligent assistants is carried out by student. The results of the tasks performed by the student and the assistant based on artificial intelligence are analyzed, interpreted and compared by professors. The methodology is mastered and the way of correct and effective task setting for intellectual assistants is practiced. Basic skills are formed to control the reliability and quality of the automation of intellectual activity results in accordance with the specifics of the technological track.

Stage 2: Practically significant in-depth and specialized knowledge, skills and abilities are formed in the areas of the technological track. The lecture material includes an in-depth and specialized theory, as well as an understanding of the development prospects of technology in the affected technological areas In practice, complex (but still model) problems are solved within the seminars and laboratory framework for the technology disciplines tracks. Skills in

decomposing complex tasks into elementary ones and building strategies for their sequential implementation and integration into complex solutions. Skills are practiced ensuring the interaction for group mode complex tasks solving, including with the roles division. The practice of solving complex problems at 2 levels is being worked out using intelligent assistants. We use decomposition and formation of a solution strategy at the upper level. And second step is solving elementary problems automation by agents and tools artificial intelligence for streaming mode work then.

Stage 3: Expansion of the knowledge and skills set acquired by students within the framework of the specialization. Approbation of the knowledge, skills and abilities set acquired by students in unique complex course projects, within the technological specialization framework. Formation and development of teamwork skills, with the inclusion in the circuit of interaction of intellectual assistants based on artificial intelligence technologies with a functional and role division between the members of the project group and specialized intellectual assistants. Artificial intelligence agents are enriched with a highly specialized professional context. Development of practices for quality control of execution and reliability of the results of the work of specialized intelligent assistants in the development of low-level components and private solutions, and then in the course of multi-level integration of components into a complex solution.

Stage 4: Complex unique practically significant project Implementation that requires interdisciplinary activities (obviously with some specialization). At the same time, there should be a project activities group interaction space within the of group formats framework, with role division and specialization and with the project groups self-organization experience acquisition. Large linguistic models must be used both for solving highly specialized problems and complex activities embedding. Educational and project cases implementation must have with forks and alternatives of both technical and engineering, methodological and organizational solutions. The skills of the activity are being worked out, during which goal setting is being worked out to form a matrix of criteria and a set of requirements for each student. Versatile erudition and some technical details are worked out by an intelligent assistant. The skills of planning, organization control, implementation quality and final result

obtaining for such projects are being developed, including cases with restrictions on the tools set and implementation resources.

Master's programs should be step-by-step, complex, design and engineering, interdisciplinary, digital and rich in artificial intelligence tools.

4 stages model is formed by semesters layers, with a shift.

Stage 1. Basic theory and elementary exercises in the first level disciplines subject tracks.

When: 1st semester (first 25% of the program)

Goal: leveling the foundation of information technology knowledge and forming the digital engineering thinking core.Classroom formats:

- 60% of the lecture

2. 40% seminars and digital labs: subject sandboxes and educational digital polygon.

Independent students work is the work performance on the subject tracks main technologies, the basic skills and abilities formation.Features of practical work of students within the framework of the stage:

- Lightweight environment (Jupyter, Kubernetes sandbox, test bases, simplified models)
- Examples without end-to-end integration
- Problems of *the level "apply the concept on a simple case"*

Subject pool (focus on program thinking):

1. Algorithmic Foundations
2. Programming languages
3. Databases: concepts
4. Architecture: Patterns without infrastructure
5. Fundamentals of ML, DevOps, Networking, Systems Analysis

The artificial intelligence tools and large linguistic models use of in the educational process:

1. Solving basic subject problems through artificial intelligence tools.
2. 2. The subject dialogue basic skill formation in the educational process course: understanding formation, request explanations, examples expansion, quick

technologies demonstrations. Automatic formation of individualized pools of subject tasks based on a standardized core of exercises (variations of tasks)

3. Task control automation of (regular homework), problem tasks individualized consulting, illustrative generation, subject training topics demonstration and test examples. Generation of questions/tests to test knowledge and practical tasks for intermediate and final measures to control knowledge, skills and abilities in disciplines within the framework of subject tracks
4. Students individual profiles formation of within the subject track's framework.

Stage 2. Technological subject tracks advanced theory, model engineering tasks and projects implementation.

When: 2nd semester

Goal: the step to engineering maturity formation

Classroom formats:

1. 40% of lectures
2. 60% seminars, digital labs (on real digital instruments), project activities in disciplines.

Students independent work - the work performance for the subject tracks disciplines of in accordance with the stage level, the acquired knowledge application, model complex tasks and projects for skills and abilities.Features:

- Real tools are introduced: Kubernetes, Spark, Kafka, CI/CD, MLOps, hardware controllers
- Tasks and projects are complex, but model-based, as well as the initial study of end-to-end projects in accordance with the first and second stages level and disciplines.
- An individualized specialization is highlighted:
  - ✓ AI,
  - ✓ Big Data,
  - ✓ analysts and
  - ✓ information systems programming,
  - ✓ digital products testers,
  - ✓ DevOps,
  - ✓ IIoT,
  - ✓ information systems architecture.

Artificial intelligence tools and large-scale linguistic models are widely used in the educational process:

1. Various subject tracks learning environment generation.
2. Students and artificial intelligence agents as technological projects assistants collaboration.
3. Engineering solutions automatic verification of , assessment justification of the of the current result and an interactive refinement procedure.
4. Generation of complex laboratory and project scenarios, interactive immersion of students in the complex tasksformulation.
5. Development of the skill of subject dialogue in the course of the educational process: the formation of understanding, explanations on request, the joint work of a young specialist and an intellectual assistant on model complex tasks and projects
6. Automatic formation of individualized pools of subject tasks based on a standardized core of exercises in accordance with the level of the stage (individual `and group task variations).
7. Automation of task control (regular homework), problem tasks individualized consulting, generation of illustrative, demonstration and test examples on training topics in the stage level accordance.
8. Task, questions and tests generation for knowledge control and practical tasks for intermediate and final measures knowledge, skills and abilities in the subject tracks disciplines within the stage level accordance.
9. Students individual profiles support and filling within the subject tracks framework (portfolio based on the educational tasks completion and student project developments).

Этап 3. Track subjects in-depth specialized theory the in individualized course projects integration within the track, including research and development tasks master's students level.

When: end of the 2nd – the entire 3rd semester

Goal: the formation of in-depth knowledge, skills and abilities through an in-depth study of specialized theoretical aspects and the implementation of practical solutions for individualized practically significant engineering tasks within the disciplines of the subject track in accordance with the level of complexity and comprehensive understanding at the level of the third stage of training in the master's program.

Classroom formats:

1. 30% of lectures (special and advanced knowledge sections)
2. 70% seminars, digital labs and project activities (student project work, project consulting, milestone and final project presentations), project workshop

Students independent work - the development of in-depth knowledge, skills and abilities in the disciplines of subject tracks in accordance with the level of the stage, systematic and comprehensive project activities.

Projects type:

- ✓ AI track: Machine Learning Ops-pipeline, own large linguistic model (LLM-tonkern), computer vision (CV) system, real-time artificial intelligence.
- ✓ DevOps track: full GitOps + cloud stack, Observability, Security as Code.
- ✓ Big Data track: business showcase, streaming-pipeline, cluster modeling.
- ✓ IIoT track: digital twin, edge inference, automation and digital manufacturing, robotic systems.

The artificial intelligence tools and large linguistic models use for the educational process:

1. Students and artificial intellectual project assistants Collaboration with roles and specializations wide range.
2. Multivariate design engineering solutions study, the criteria and metrics for implementation project option assessing formation , the optimal option justified choice in the interaction together by students and artificial intellect assistants.
3. Gaining practice, developing a methodology and deepening the skills of a substantive dialogue between a human developer and an intellectual assistant during the target project development implementation at project various stages and various tasks types: theoretical development and design solutions justification, project hardware subsystems design, digital systems (software complexes and databases) creation and commissioning, design, development, launch and operation, automated mode routine tasks effective implementation using artificial intelligence tools, project documentation generation and implementation at project life cycle.
4. Engineering solutions examination (including digital engineering solutions). The current result assessment justification and finalizing design solutions interactive procedure.
5. Students' design solutions database accumulation. Solutions standard components decomposition. Standard solutions libraries formation with

annotations and metadata to build up the knowledge and solutions base within the technological tracks framework.

6. Students competencies and preferences base formation by analyzing a set of completed educational tasks and participation in project activities, taking into account the quality of the proposed solutions and the educational program mastering pace at the disciplines and tracks context.
7. Students individual profiles support and filling within the subject tracks framework of (portfolio based on the completion of educational tasks and student project developments).

Stage 4. The final education set. Final qualification work (master's thesis) completion and defense.

When: 3rd-4th semester

Goal: Completing the knowledge, skills and abilities set formation across the entire educational technological tracks set. Real work skills formation and assessment in complex teams on real high-tech digital projects with scientific novelty and practical relevance and with the allocation of the individual contribution of a master's student in the format of a master's thesis.

Formats:

1. 80% practical work and project management
2. 20% targeted lectures and consultations on in-depth technological issues necessary for the graduate qualification works implementation within the complex high-tech projects framework.

Важные элементы:

- Ролевое разделение в комплексных проектах:
  - ✓ System Architect
  - ✓ ML / LLM Engineer
  - ✓ DevOps
  - ✓ Data Engineer
  - ✓ IIoT/embedded engineer
  - ✓ System analyst
  - ✓ Workgroup project coordinator.
- Interdisciplinarity of the tasks to be solved, specialized technological tracks integration.
- Solutions step-by-step monitoring and public protection.

- Master's Student's Work with AI Assistants as a Natural Part of Competence as Part of Work on a Personal Master's Thesis.
- Group work implementation with intellectual assistants LLM based within the project team competencies division.

The artificial intelligence tools and large linguistic models type of using for the educational process:

1. Students and artificial intellectual assistants joint work for wide range of roles and specializations projects and with a the preparation of a master's thesis.
2. Multivariate engineering solutions design. The criteria and metrics formation for assessing the option for the implementation of the project. The optimal option justified choice in the interaction of students and artificial intellectual assistants.
3. Gaining practice, developing a methodology and deepening the skills of a substantive dialogue between a human developer and an intellectual assistant during the implementation of target project development at various stages of the project for various types of tasks: theoretical development and justification of design solutions, design, creation and commissioning of hardware subsystems in the project, design, development, launch and operation of digital systems (software complexes and databases), effective implementation of routine tasks in an automated mode using artificial intelligence tools, generation of project documentation and implementation of its life cycle.
4. Engineering solutions examination (including digital engineering solutions). The current result assessment justification of and finalizing design solutions interactive procedure.
5. Accumulation of a database of students' design solutions, decomposition into standard components, formation of libraries of standard solutions with annotations and metadata to build up the knowledge base and the base of solutions within the framework of technological tracks
6. Students' design solutions database accumulation. Solutions standard components decomposition. Standard solutions libraries formation with annotations and metadata to build up the knowledge and solutions base within the technological track’s framework.
7. Student’s individual profiles support and fills within the subject tracks’ framework. Portfolio based on the educational tasks completion and student project developments.
8. The use of artificial intelligence tools for peer review and opposition at the stage of preparing a master’s thesis for defense

Addition: at all stages, starting from the second stage of the master's degree program, cases with forks in engineering solutions are considered. General approach (life cycle and phased solution) of digital engineering tasks:

- ✓ Problematization
- ✓ Goal-setting
- ✓ Formation of a system of requirements
- ✓ Management of requirements
- ✓ Formation of criteria and integral metrics
- ✓ Analysis of technological alternatives and technological forks
- ✓ Configuration management
- ✓ Development of product solutions and
- ✓ Formation product digital twins
- ✓ Analysis, evaluation, ranking, identification of non-conformities and management of non-conformities
- ✓ Simulation on digital twins, full-scale testing and testing of digital engineering systems
- ✓ Trial operation
- ✓ Modification based on the results of trial operation,
- ✓ Version and release management,
- ✓ Product customization.

The use of artificial intelligence tools and large linguistic models in the educational process: ,

- ✓ Development of solutions in collaboration and collaboration.
- ✓ Generation and exploration of alternatives.
- ✓ Automatic time and quality control.
- ✓ Modeling the behavior of digital systems.
- ✓ Scenario development based on foresight.