

## Developing Tasks Designed Test to Assess Professional Competencies at the Stage of Study at the University

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### Abstract

We aim to develop and test tasks designed to assess professional competence at the university's formation stage. The system of internal competency assessment utilizing the requirements of professional standards in the IT industry enables bachelor's degree graduates to assess their level of preparation for professional activities. Our study employed the R&D design proposed by Borg & Gall, M.D. The essence of R&D design in our case is that it is necessary to implement the following five steps: 1) conducting research, 2) developing a prototype, 3) a small-scale experiment to improve the prototype into a model, 4) a large-scale experiment to improve the model into a final product, 5) dissemination through publication. We defined a competency model to develop tasks: Competence = [Knowledge + (Skills and Abilities)] in labor functions. Labor functions are described in professional industry standards. Our formula is based on the definition of the competency model in Computing Curricula 2020, specifying the context concerning professional activity. A version of 20 tasks assessing the prerequisite knowledge, skills, and abilities to perform the labor functions of the Database Administration standard was prepared for testing. Our experience has demonstrated that preliminary work must meet professional standards. Some knowledge and skill requirements are formulated without considering the property of measurability. Cases of requirement redundancy also exist for graduates who do not have practical experience. The results were processed by classical test theory. The main indicators of task quality were the correlation of each task with the total score, the difficulty level, and the discriminativeness index of each task. Cronbach's alpha, an indicator of test reliability, was also calculated. The obtained values of quality indicators enable us to posit that the tasks can be used for assessment. However, some tasks require content correction and revision by distractors. Our findings can be employed to develop a competency assessment system based on the requirements of professional standards in industries other than IT.

**Keywords:** *Competency assessment, competency model, educational programs, professional standards, professional competencies*

### Introduction

Recently, the formation and assessment of professional competencies at the training stages in Kazakhstan universities have become increasingly relevant. This situation is attributed to the approval of professional standards (PS), specifying job applicants' requirements for knowledge, skills, and abilities in the labor market. Regulatory authorities guide all educational institutions in

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implementing these requirements in university educational programs (EP). The Guidelines for the Development of Educational Programs for Higher and Postgraduate Education (2023) are one of the main documents that set out the requirements for the design of educational programs. In particular, there are indications that the learning outcomes of the educational program should be focused on labor functions, on the future needs of the labor market (clause 20). In addition, clause 31 states that "In an educational program developed on the basis of the PS, the main labor functions are projected into competencies and learning outcomes." These requirements lead to the emergence of scientific and methodological problems associated with the need to correct the competence-based approach in higher education. Problems encompass general methodological issues of the competency-based approach, introducing the developed formation methods, and assessing the formation level of competencies into the educational process.

One of the important aspects of developing an EP based on the competency-based approach is considered in the work of Mukashova et al. (2023). The formation of competencies for designing an EP of higher education is declared based on the PS, but the labor functions described in the PS require structuring for the development of an optimal competency model for a graduate. The article presents an algorithm for structuring the PS in .xls format for developing intelligent design systems, formulating professional competencies, conducting an EP examination, and processing and analyzing data. The obtained structured PS data can be the basis for designing a competency model.

In the competence-based approach, the "competence" is defined as the core. The State Compulsory Standard of Higher Education (2024) describes "Competencies as the ability to practically use the knowledge, skills, and abilities acquired in the learning process in professional activities." Similar definitions are found in documents such as the National Qualifications Framework and the Law "On Professional Qualifications." Moreover, all industries' PS versions use a simple definition of competencies. None of these documents comprise scientifically substantiated concepts that would fundamentally allow the development of recommendations or approaches for implementing methods for forming and assessing competencies. In Kazakhstan, no generally accepted concept delineates a general methodology for implementing teaching and assessment methods in a competence-based approach in higher education. Therefore, universities face issues building a competency model with measurable components when developing EP and determining the content of disciplines (Orakova et al., 2024; Yelubay et al., 2022). These problems were especially evident when introducing the PS requirements into the university EPs' content. Due to unresolved general methodological problems, many universities can only formally indicate that their EPs' content

meets the requirements of industry-specific professional standards. We published a paper on the problems of reflecting the requirements of the professional standards in the contents of specific EPs in the Information and Communication Technologies (ICT) training program (Abdiyev et al., 2023).

Even though the Law "On Professional Qualifications" was approved and implemented, the issue of confirming qualifications in IT professions upon entering the labor market has not been resolved. Qualification confirmation exams are only held for regulated professions in the "Healthcare" and "Education" industries. University graduates wishing to work in other industries receive diplomas without specified qualifications and cannot confirm their qualifications upon entering the labor market. Concurrently, a hiring decision is made but does not confirm the qualifications of applicants. Therefore, universities do not prepare their graduates for qualification confirmation. The final evaluation, conducted at the end of the training, assesses graduates' knowledge of the content of the studied disciplines without addressing the requirements of industry PS.

This research aimed to develop a system to evaluate the professional competence levels of undergraduate graduates using the PS requirements of the IT sector. Such a system can result in a more general system for preparing graduates for confirmation of professional qualifications, improving the quality of graduate training. Presumably, when implemented in universities, the student's participation in such training will become voluntary, enabling students to determine their readiness to perform work functions in specific professions in the IT industry. While developing a model for evaluating the level of professional competence at the stage of study at the university, the following questions arise:

- What should the competency model encompass to be used as a guide to develop tasks for assessment?
- What types of tasks should be employed to evaluate competencies in IT professions, and how should the quality of the developed tasks be assessed?

In this article, we demonstrate our approaches to solving the questions posed. Even though we have chosen the PS "Database Administration" and the EP "Computer Engineering and Software" (CE&S) for certainty, our approach can also be applied to other professions and EPs.

### **Literature Review**

In the literature review, we included sources describing approaches to solving three critical areas for our study: defining professional competencies, developing tasks for measuring competencies and their implementation, and conducting competency assessment.

**Approaches to defining professional competencies.** Competency models, including the Computing Curricula and Computer Science Curricula, are broadly used in the international IT community. These documents are distinct because they are an excellent presentation of models comprising measurable components. The Computing Curricula has become a de facto international standard described in (CC2020 Task Force, 2020) and formulates the concept of competence as a practical educational goal refining the Knowledge + Skills + Dispositions (K-S-D) framework first introduced in the IT2017 report. CC2020 expands on previous work and defines competence as comprising K-S-D dimensions observed during task performance. A competency specification contains knowledge, skills, and dispositions observed in performing a task specifying a goal in a work context.

Competency = [Knowledge + Skills + Dispositions] in Task

The document defines all four components, constituting a competency. Thus, knowledge forms a competency's "know-what" dimension as a factual understanding. Skills represent the ability to implement knowledge in performing a task, i.e., "know-how," and dispositions are "know-why." Dispositions are habitual inclinations of social-emotional tendencies, preferences, and attitudes (e.g., reliable, responsible) and are utilized to control whether and how a person is inclined to employ their skills. To that end, dispositions can denote the values and motivation guiding the application of knowledge while simultaneously displaying the quality of knowledge that indicates a standard of professional performance. A task is a construct that frames the knowledge's skillful application and makes dispositions concrete. Thus, it captures the goal-oriented context of a competency, revealing the integrated nature of knowledge, skills, and dispositions (Aimukhambet et al., 2024; Cahyaningrum et al., 2024; Marais, 2023).

The authors of the following two articles – Bowers & Sabin (2022) and Bowers et al. (2022) develop methods for assessing the competencies of IT professionals, defining competencies according to the IT2017 document (which is part of the CC2020 concept paper): Competencies = knowledge + skills + aptitudes, where aptitudes represent personal qualities desirable in the workplace. The author's main focus is assessing IT professionals' aptitudes (cognitive predispositions). The author's proposed method and assessment tool are based on evidence of task performance in real-life work settings demonstrating the SFIA (Skills Framework for Information Age) responsibility characteristics mapped to the CC2020 provisions.

Kumar et al. (2023) published the Computer Science Curricula 2023, describing competency as a point in a three-dimensional space with axes of knowledge, skills, and dispositions. A competency model of a curriculum forms a set of competency specifications:

Competency Model = {Competency Specifications }

Competency Specification = Task + Competency Statement + Knowledge + Skills + Dispositions

In a competency specification:

- A task is a statement of what someone in a given role and context should do and is expressed in layman's terms;
- The competency statement describes how a graduate might undertake to complete the task and is expressed in technical terms;
- Knowledge is specified concerning knowledge units in knowledge areas in the Body of Knowledge;
- Skills include one or more of Explain, Apply, Evaluate, and Develop; and
- Dispositions are one or more identified as appropriate for the necessary knowledge areas to complete the task.

This model slightly differs from the model described in CC2020 even though all components of the two models coincide. One should note that the earlier versions of international documents have only described IT knowledge models. However, all recent versions provide competency models. Frezza et al. (2018) describe a research-based approach to defining competencies in IT disciplines, which formed the foundation of CC2020. The authors developed a theoretical framework for teaching competencies based on the training programs that can be developed in various disciplines. International documents have substantial advantages because they include competency models defined in simple language in the form of simple models. Moreover, all components in the competency structure are measurable. For example, Sabin et al. (2018) discuss important aspects of the 2017 Curriculum Guidelines for Undergraduate IT Programs developed by The Association for Computing Machinery (ACM) and the IEEE Computer Society. The focus is not on IT knowledge transfer but on competency-based learning. The paper describes an IT curriculum that is structured to meet the growing demands of a changing technological world. It also describes ways in which undergraduate IT programs can be embedded into undergraduate curricula that equip graduates with the knowledge, skills, attitudes, and competencies that are important in the workplace. It is suggested that a focus on competencies allows academic departments to collaborate with employers and engage students in professional practice to gain work experience. Bowers & Sabin (2023) aimed to help educators assess students' achievement against the CC2020 dispositions by matching real-life experiences recorded in individual portfolios with the attributes of SFIA responsibility. Using a simple and consistent assessment algorithm, they describe a tool that matches the demonstration of SFIA responsibility attributes with the CC2020 dispositions.

The assessment process and results are illustrated using a fictitious student portfolio created based on one author's experience of the achievements of students completing placements.

In the article by Kazakh authors, Kassymbekova et al. (2021) note that implementing a competency-based approach requires adjustments to the educational process linked to changes in teaching and evaluation methods. The competency model should identify the planned levels of their formation and evaluation criteria. Because professional competencies cannot be observed directly, educational activities are employed to enable reliable conclusions about the level of formation of students' professional competencies. These authors posit that using situational and practice-oriented complex tasks to evaluate students is preferable. The paper describes a system for evaluating the levels of competence development, comprising principles, assessment tools, and assessment forms. The competency evaluation process encompasses a sequence of interrelated stages: development of a competency model, requirements for competency levels, assessment tools, and technologies. The authors' practical experience involves teaching students foreign languages. In their work, the authors do not accentuate the requirements of industry PS.

Naseikina and Tagirov (2015) describe the structural and functional model for forming the professional competence of future IT specialists, comprising four interconnected blocks that ensure its proper functioning: target, methodological, content-methodological, and diagnostic. The objective of forming professional competence during studies at a university should be specified by considering the requirements of modern employers in the IT sphere, reflected in the PS in IT. The content-methodical block of the model presents the author's understanding of the professional competence of future IT specialists: "an integrative quality of a graduate, characterizing their ability to successfully apply knowledge, skills, abilities and personal qualities in standard and changing situations in the IT sphere, reflecting their readiness to carry out professional activities..."

Thus, we note that Computing Curricula 2020 provides the most accurate description of the competency model. This model offers a notable advantage because all model components are measurable. Therefore, universities can conveniently implement it in the educational process. Therefore, we employed this model to define a new one based on the PS requirements. The model described in Kazakhstani authors' studies by Kassymbekova et al. (2021) is presented theoretically without professional standards. The authors specialize in teaching foreign languages, so the model will presumably be implemented in language teaching. Russian authors Naseikina and Tagirov (2015) must note such a feature as the presence of approved standards of specialties. In such standards, the types of future professional activity are also approved, among other things. This

approval enabled many researchers to develop an approach to evaluating professional competencies as an integrating assessment concerning applying knowledge, skills, and abilities. All the necessary components of competencies in this definition are covered in the content of disciplines and approved by educational standards.

**Development of tasks for measuring competencies and their implementation.** Baikina (2022) developed a competence-oriented system of assessment tools in the university educational program. It forms a vital subsystem of the educational program. It also guarantees an objective assessment of the step-by-step formation and development of competencies in a university graduate for external and internal stakeholders. The system implements diagnostic, cumulative, analytical, prognostic, and integrative functions. The system design process comprises four stages: the conceptualization stage specifies a set of requirements for a graduate and creating their holistic competence image as an object of evaluation; the detailing stage ensures the determination of the composition of each competence, the levels of its formation, the trajectory of formation and evaluation. At the design stage, structural elements of the assessment tools system are created; the examination stage is intended to evaluate the quality of the assessment tools system using the criteria developed at the university.

Dalim et al. (2023) present the results of determining the framework for measuring numeracy and digital skills in universities in Malaysia. The Malaysian Qualifications Framework encompasses these skills and is implemented as a learning outcome at all education system levels. Furthermore, the authors tested the developed tasks. First, experts strictly evaluated the content of the assessment tool, and then, based on the testing results, the internal reliability of the test was determined using Cronbach's alpha. The testing involved 218 students from various disciplines.

Urra et al. (2022) discuss the adaptation, application, and analysis of the psychometric qualities of the information competence assessment tool developed by R. Marshall. The participants included 381 senior students from Chilean universities. The tool for measuring students' information competencies comprises 27 questions grouped into five sections defining the various stages of creating and using information. The adaptation of the original tool encompassed clarifying the content of these sections. Based on the results of testing the questions, the tool is recommended for evaluating the information competencies of university students.

The approaches to developing and testing tasks in the above articles are well-known and form standard cases. However, differences exist in the content of the tools and some indicators. The above articles were helpful because they present the new experiences of colleagues from different countries. The situation in Russia is peculiar because they have approved standards of specialties. These standards require that the university develop a fund for assessment tools. Therefore, many

articles address universities' experience in this matter. Such experience helped us use different methods for finding funds.

**Conducting competency assessment.** Yeltunova (2015) specifies an approach to developing a model of a system for evaluating the professional competencies of college students majoring in "Programming in Computer Systems." One component of the model system is the graduate's competency model, which is described as a set of professional competencies approved by the educational standard and developed technological maps. The authors assert that technological maps have been developed addressing the requirements of consumers in the region. Nonetheless, the description of the technology for implementing the model excludes references to the industry's PS, indicating that the requirements of consumers' educational services are analyzed and the specifics of the region are provided.

Vasilieva (2017) describes a method for assessing the learning outcomes of the EP within the competence-based approach. The author's method is based on the model and profile of competencies accepted in the professional environment and adapted to educational practice. The content of the EP disciplines is adopted as a foundation to form competencies at the university, and scientific qualimetry is used to formalize the educational results. According to the author, in developing a graduate's competence model with the employer's participation, the form of intermediate results presentation allows for balancing the volumes, list, and sequence of disciplines and practices that develop individual competence and groups. The model enables the balance of competencies in the interests of the industry's professional community to change. The method for calculating the indicator of mastering the EP is considered an algorithm. The algorithm's first steps substantiate a holistic understanding of a company employee's and a university graduate's competence. Concurrently, a hierarchical decomposition of achieving the primary goal of professional activity within the PS is described. The decomposition of the competency model due to mastering the educational program is also described as the following fragment: a block of competencies → a single competency → an academic discipline → knowledge, skills, and abilities. The described method suggests that the author conducted calculations for a specific educational program.

Zakharova (2018) remarks that the processes of coupling the educational program's requirements and educational standards of higher education regarding a graduate's evaluation reveal specific problems. The main task involves developing competency maps and creating adequate funds for assessment tools, enabling evaluation of the competence development level. The article displays the experience of Russian universities in developing educational programs in ICT, considering the

requirements of the educational program. A list of optimized general professional competencies (GPC) for graduates in bachelor's and master's programs is proposed for the specialty "Computer and Information Sciences." An example of implementing one GPC (to be able to apply knowledge in fundamental and applied mathematics in software development) is provided; the stages of mastering the competence are illustrated: Stage 1 - first and second years, Stage 2 - third and fourth years, and Stage 3 - Master's degree. The following control procedures evaluated the GPC development level: oral and written survey, written problem solving, checking laboratory and independent work, and final qualifying work. Because approved standards for university specialties are enforced in the Russian Federation, an important task involves identifying the compliance of the LF from the PS with the general professional and professional competencies from educational standards. The article presents a fragment of the LF's table of compliance with competencies in training "Fundamental Informatics and IT."

Russian authors Zakieva et al. (2023) report that measuring competence (possession of competence and readiness to perform professional actions in the competence) differs significantly from assessing subject knowledge and skills. Assessment of subject preparation comprises the studied material's verbal (oral or written) reproduction; evaluation of competence requires demonstrating the performance of a professional function - solving a corresponding professional task and creating some engineering "product" by the student. The authors have developed a technology for evaluating the level of a technical university graduate's competence based on the understanding that competence is the highest degree of mastery of professional activity.

A Russian scientist, Maslak (2021), compares three methods for evaluating competence development: within the framework of classical test theory, based on indices, and within the framework of the theory of measuring latent variables. Classical test theory (CTT) is the most frequently used method for evaluating the level of competence development. The author discussed the advantages and disadvantages of CTT. The level of competence development is determined by the number of points scored or the proportion of correct answers in CTT. The accessibility, clarity, and interpretation of the grades obtained are the unconditional advantages of CTT. The index method is similar to the classical testing theory but is more complicated. This method proposes that the grades of academic performance are "weighed" depending on the complexity of the tasks. The integral grade is determined by summing up these weighted grades. Consequently, the integral grade is a weighted average.

Based on the facts presented in the Introduction and the conclusions of the Literature Review, we formulate the purpose of our study and its questions.

The purpose of our study is to develop test tasks for assessing the professional competencies of bachelor's degree graduates at the stage of formation at the university.

The main question of the study: what competency model can be used to develop tasks? There are also additional questions: what types of tasks should be used to assess competencies; what indicators are important in proving the quality of the developed tasks, i.e. how to show the suitability of tasks for use in assessing competencies?

### **Methodology**

The R&D design, as described by Gall et al. (2003) in their book, used in our study. A ten-step design was included in the book's first edition in 1983. Notably, this approach mainly used in technical sciences in post-Soviet countries. Examples of this design could not found in educational research or academic publications. The R&D design was adapted for our case by specifying that the following five main steps should implemented: 1) conduct research, 2) develop a prototype, 3) small-scale experiment to improve the prototype into a model, 4) large-scale experiment to improve the model into a final product, 5) dissemination through publication. Below, we describe the content of each of the five steps and the tools and methods used. The final product is test assignments for assessing the professional competencies of bachelor's degree graduates.

**Conducting research.** In the first step, we studied the state of affairs in evaluating the readiness of bachelor's degree graduates to perform work functions of various professions in the IT industry. Meanwhile, a critical topic was defining the competency model based on which the assessment is conducted. To perform this, we reviewed international documents in the IT industry, encompassing substantiated approaches and descriptions of the competency structure. Approaches to assessing competencies in Kazakhstani and Russian universities were studied. In Kazakhstani universities, competency assessment was conducted using different forms during the final certification. Similarly, in Russian universities, the final certification was executed. Exams such as the Federal Internet Exam for Bachelor's Degree (FIEB) and the Federal Internet Exam in the Sphere of Professional Education (FEPE) existed. Our previous work presents the analysis results of the tools used to assess competencies. The types of most frequently used tasks to assess competencies and the methods for their development are also described (Abdiyev et al., 2024). One should notice that, in Russia, an Independent Assessment of Professional Qualifications is independently conducted for universities. Abdiyev et al. (2024) also report a brief description of this assessment and the types of tasks employed.

**Development of a prototype – a preliminary version of the tasks.** This stage involved reviewing and approving the test structure. The preliminary structure indicated each task's place in the test version and its type. Moreover, it demonstrated the task's maximum score for the correct answer. The research group members developed this structure. We relied on the structures already used in the FIEB, FEPE, and the Independent Assessment of Professional Qualifications.

Teachers with experience in this field and trained in seminars specially conducted by the research group members were invited to develop the tasks. The first training seminar was held on May 16, 2023, titled - "Analyzing the content of the PS to establish a link with the content of the EP and determine the measurability of the requirements for the knowledge, skills, and abilities of IT specialists." The second was on January 11, 2024, entitled "Forms of tasks for assessing the knowledge, skills and professional skills required to perform work functions," within the general topic's framework "Assessment of educational achievements of students as a type of professional activity of a university teacher." Four teachers were invited to develop the tasks.

Additionally, general issues of measuring competencies and possible types of tasks for evaluating competencies were discussed with employers at the Expert session "Problems of measuring professional competencies of IT specialists" (2023).

The seminars encompassed methods for developing tasks and addressed the proposed types of tasks and the test structure. A survey was also conducted on the state of affairs in evaluating competencies, the methods and tasks used, and their utilization. Abdiyev et al. (2024) report the results of this work.

**Small-scale experiment to improve the prototype into a model.** After developing the tasks for testing, 20 tasks were chosen to evaluate students according to the requirements of the "Database Administration" software system, and one version was compiled. Specially invited experts reviewed this version. The objective of the small-scale experiment is to determine the compliance of the developed tasks with the specific requirements for knowledge, skills, and abilities for the labor functions of the software system in the preliminary testing. To this end, the task developers preliminarily prepared a table demonstrating the task and the content it evaluates. The experts were asked to evaluate whether the correspondence of the tasks and the requirements for knowledge, skills, and abilities defined in the software system were accurately reflected. The specified answer options included the following: fully, partially, partially, or does not comply. Full compliance was the leading indicator of the tasks' content validity.

Next, we modified the task texts and other data to ensure complete and accurate compliance with the knowledge and skill level requirements PS specifies. We also described the requirements for

each labor function that job seekers must master. Therefore, this work compared the task texts and the PS requirements.

**A large-scale experiment to improve the model into a final product.** This stage involved the main testing, comprised of presenting tasks to students for completion. As our research suggested, 123 tasks were developed to evaluate knowledge, skills, and abilities based on the requirements of two PSs - "Database Administration" and "Software Development." Of these, 20 tasks were selected to evaluate students according to the "Database Administration" PS requirements, and one version of the survey was compiled. The open Online Test Pad system, [www.https://onlinetestpad.com](http://www.https://onlinetestpad.com), was selected for assessment.

While experimenting, we estimated the required number of participants (sample size) to surpass 100 people. We obtained this number using the empirical rule: "The number of participants should be 5-10 times greater than the number of tasks." Crocer & Algina (2010) report that this rule is the most frequently used when determining the sample size for testing when the number of tasks is 20. Therefore, the survey link was sent to more than 170 students. When the number of responses reached 134, we stopped the survey. Thus, 134 students of the EP CE&S participated in the experiment. The completion time was not specified; the approximate time to answer all 20 questions ranged from 45 to 60 minutes. No special measures were taken to limit the survey time. After completing the survey and generating the results in tables, we saved and processed the data in Excel. The Iteman program, <https://assess.com/iteman/>, was also used to determine some test characteristics. The research group members had the licensed version of the program and a trial version with limited capabilities.

The results were psychometrically analyzed using CTT methods. We mainly aimed to determine whether the assignments were suitable for evaluating professional competencies.

Next, we carried out optimization, i.e., we worked on tasks with low scores. Optimization comprised their revision or text correction. When revision was needed, the task was excluded from the database, and another task of the same type was included instead. In case of correction, the corrected task was resaved in the database.

**Dissemination through publication.** To disseminate the results, we have developed a Training and Methodological Complex. The complex should include examples of tasks developed to assess the professional competencies of graduates, a description of the competency model used, the results of testing the tasks, instructions for teachers, and a description of the open information systems used. Publishing a training and methodological complex is the most convenient form of

work for disseminating and implementing the results of scientific research in the university's educational process.

### **Findings**

**Conducting research.** The following points were determined based on the research results and literature review:

- The level of graduates' professional competencies based on the Professional Standards requirements is not evaluated in universities in Kazakhstan. Instead, in universities, the Professional Standards are formally used only as a guide for determining the areas of the IT industry's knowledge.
- Universities in Kazakhstan issue diplomas without specifying the qualifications of graduates despite the approval of the Law on Professional Qualifications. Thus, independent confirmation of qualifications is not conducted upon entering the labor market.
- In Russia, external examinations evaluate bachelor's degree graduates, and they are based on educational standards of specialties. In Kazakhstan, these standards do not exist, and no types of external assessment are present. In Russia, an Independent Assessment of Qualifications is based on professional standards requirements, with participation in the assessment being voluntary.- In Kazakhstan, a competency model based on the PS requirements is not employed.
- A need exists to develop an internal competency assessment system enabling graduates to evaluate their level before entering the labor market.
- International IT industry documents describe a competency model as a foundation for defining a new model based on the PS requirements.
- Types of tasks for assessing competencies can be determined using the principle of prevalence, the property of manufacturability, and analogy with the types used in other assessments conducted in Russia and Kazakhstan.

Note that when formulating conclusions, we additionally relied on the results of our previous works (Abdiyev et al., 2024). We aimed to fully describe the results of all our studies in recent years. Our overall goal includes developing and implementing an internal system for voluntary assessment of the educational program graduates' level of professional competencies in the ICT field.

In this paper, the profession described in the PS "Database Administration" is used in the most complete form. This document has 25 standards; the second version was approved in 2022. One can refer to the Register of Approved Professional Standards (2022). It is the most frequently mentioned standard in Kazakhstan's universities' educational programs. We have already reported

that many universities only formally demonstrate the PS. When familiarizing themselves with the EP content, one cannot find confirmation of the facts of the formulation of learning outcomes using descriptions of any profession's labor functions in the IT industry. No cases of formulating the definition of professional competencies exist that use the PS's requirements. In our study, we holistically describe approaches and accurately use the descriptions of professions described in the PS.

**Development of a prototype – a preliminary version of the tasks.** In our study, by using an analogy with the international standards of CC2020 and CS2023, we adopted the following formula for determining competencies:

Competence = [Knowledge + (Skills and Abilities)] in the context of the LF PS, where the context of the LF PS denotes the performance of PS's specific labor functions. Connecting with this formula, we consider competencies in the context of specific actions concerning the IT industry's profession. Therefore, the first task that the developers of assessment systems should solve is to determine the areas of knowledge, skills, and abilities required to perform the TF of the selected profession. Personal competencies should be included in the competencies formula. However, we did not include them due to all PS's immeasurable and overly general formulations. Our future research can address clarifying such formulations and using proper replacements.

The first issue we considered is associated with the redundancy in the number of LFs recommended for mastering by applicants without work experience. In the PS "Database Administration" for the IQF's 5th level profession, seven LFs are recommended for mastering. We proposed to exclude two LFs while training level five specialists, namely LF6 – Ensuring Uninterrupted Operation of the Database Management System (DBMS) and LF7 – Managing DB Development. We justified our decision because LF6's tasks are ensured by the tasks described in LF2 – Ensuring DB Functioning, LF3 – Monitoring and Managing DB Backup, and LF4 – Ensuring DB Information Security. Regarding LF7, we considered that managing DB development could not be assigned to specialists without work experience. The experts approved our decision. Consequently, we considered the PS "Database Administration" with five LFs instead of seven. Moreover, the description of knowledge, skills, and abilities requirements was more conveniently presented, as the Appendix illustrates. The number of knowledge, skills, and abilities included in the description of LF1-LF5 was not reduced. For example, LF1 specifies six areas of knowledge and five skills and abilities, whereas LF2 specifies six areas of knowledge, ten skills and abilities. To master the profession, one must master five LFs (in the original PS - seven

LFs), 26 areas of knowledge, and 28 skills and abilities (in the original PS - 31 areas of knowledge and 35 skills and abilities). These numbers are overwhelming for a bachelor's degree graduate, and our next task involves justifying the reduction and enlargement of the areas of knowledge, skills, and abilities formulated in the PS. All our proposals will be sent to the PS developers.

A test structure was first designed to develop the tasks, specifying the types of tasks, their number, and points for correct answers to each task. Table 1 depicts the approved test structure.

For testing, we prepared a version with 20 tasks; 15 tasks were evaluated with a maximum score of 1, 5 tasks with 2 points for an answer without errors, 1 point with one error, and zero points with two errors. The type of the first five tasks involved choosing one correct answer from the five choices. Tasks 6-8 - choosing three correct answers from seven, tasks 9-10 - establishing a match, and task 11 - to establish the correct sequence. The following four tasks have the open type, requiring entering an answer in one word. Questions 16-20 relate to one situation described before task 16; the type of these questions involves choosing one correct answer from five choices. A pseudo-real situation is defined as a situation that can occur in practice. Tasks 16-20 evaluate skills and abilities in different LFs, and all other tasks assess the necessary knowledge to perform the functions of a specialist.

**Table 1**

*The Structure of the Test Prepared for Assessing Competencies*

Task number and location	Task Type	Number of tasks	Maximum possible points (point for correct answer to one task)
1 - 5	Closed-form with one correct answer	5	5 (1)
6 - 8	Closed-form with three correct answers	3	6 (2)
9 - 10	Establishing a correspondence	2	4 (2)
11	Establishing the correct sequence	1	1 (1)
12 - 15	Open the form by entering a short answer (one word or one number)	4	4 (1)
16 - 20	Situational task (one situation with five closed-form questions with choosing one correct answer)	5	5 (1)
	Total	20	25

While determining the types of tasks and points for correct answers, we relied on our experience and the principle of task prevalence. All types of tasks are commonly found in universities in Kazakhstan and the CIS countries, so students and teachers are familiar with them. Additionally, we proceeded based on the fact that they should be suitable for mass use, i.e., convenient for implementation online via the Internet; in other words, they should be technological.

**Small scale testing.** At this stage, we selected experts to evaluate the developed tasks' compliance with the assessment objectives, i.e., how they correspond to the specific requirements described in the PS.

Table 2 depicts information about the experts. We selected experts from among teachers of IT disciplines with experience in teaching disciplines concerning the PS content. A desirable condition for the invitation posed that the expert should work as an IT specialist in a company operating in the local labor market. No specially developed set of requirements existed for selecting experts; they were invited based on the principle of accessibility for research group members.

**Table 2**

*Information about the experts who assessed the compliance of the tasks with the requirements of the PS*

Experts	Taught subjects	Work experience, years	Experience in the IT industry
Expert 1	Databases, IS design	10-20	yes
Expert 2	Cloud technologies, Operating systems	5-10	no
Expert 3	System programming, Databases	5-10	no
Expert 4	Software engineering, Information systems	10-20	yes
Expert 5	Databases, Information security	more than 20	yes

The experts evaluated the pre-prepared table of assignments' compliance with the specific requirements of the TF described in the "Database Administration" PS. The Appendix presents the content of the PS requirements as a fragment. The "Database Administration" PS was selected for a separate analysis because it is frequently used in the universities' EPs. In the PS's content, we were interested in the wording of the requirements for the professions of the 5th level of the Industrial Qualification Framework (IQF) because bachelor's degree graduates must meet this level's requirements.

Thanks to the experts' work, a final version of the table was obtained, demonstrating the compliance of each task with the requirements for knowledge (abbreviated designation - Kn) and skills and abilities (SA) specified in the PS. This version differs from the preliminary version because the four tasks' LF numbers and knowledge areas were modified. Table 3 lists the numbers next to the abbreviated designations corresponding to the number of knowledge, skills, and abilities specified in the PS.

**Table 3***Compliance of tasks with the requirements of the PS "Database Administration"*

Tasks #	LF	Assessed knowledge (Kn), skills and abilities (SA)	
Task 1	LF 2		Kn 6
Task 2	LF 1		Kn 2
Task 3	LF 1		Kn 1
Task 4	LF 4		Kn 3
Task 5	LF 3		Kn 3
Task 6	LF 2		Kn 4
Task 7	LF 3		Kn 4
Task 8	LF 5		Kn 4
Task 9	LF 3	Kn1, Kn2, Kn5	
Task 10	LF 4	Kn 1, Kn 4	
Task 11	LF 3		Kn 2
Task 12	LF 1		Kn 4
Task 13	LF 3		Kn 4
Task 14	LF 4		Kn 5
Task 15	LF 5	Kn 1, Kn 2	
Task 16	LF 2		SA 10
Task 17	LF 5		SA 2
Task 18	LF 5		SA 1
Task 19	LF 4		SA 4
Task 20	LF 2		SA 10

**Large-scale testing.** After this preliminary work, testing was conducted using the tasks described above. Table 4 depicts the descriptive statistics of the results.

**Table 4***Descriptive statistics*

Mean	12.88
Standard Deviation	6.25

Table 5 shows the results of the frequency distribution of the scores. It can be noted that the frequencies shift to the right, which means a relatively larger number of high results. This may correspond to the difficulty level of the entire test being below the average level.

**Table 5***Frequency distribution*

Points for answers	1	2	3	4	5	6	7	8	9	10	11	12	
Frequencies	1	3	5	5	6	5	4	7	6	8	6	9	
	13	14	15	16	17	18	19	20	21	22	23	24	25
	11	7	7	5	5	6	5	3	4	4	5	4	3

Table 6 depicts the leading indicators reflecting the quality of the tasks. Cronbach's alpha for the entire test is 0.805, illustrating good internal consistency in the tasks. The correlation coefficient for each task was calculated with the total score for all participants. The results reveal that the lowest correlation coefficients were observed for 1, 2, 13, and 19. The difficulty level  $p$  illustrates the proportion of participants correctly answering a question. In tasks with non-dichotomous answer options (tasks 6-10), we first divided the sum of points received by all participants by the number of participants to calculate the difficulty level of the tasks. Afterward, we divided the resulting indicator by the maximum possible number of points for the answer, i.e., by 2. The  $p$  indicator can range from 0 to 1, with values close to 1 indicating a very easy task, while values close to 0 imply a very difficult task.

We divided all participants into two equal parts to calculate the discriminative index  $D$ . The first half represents the best 50% of participants by the points received. Conversely, the second half depicts the worst 50% of participants by the points received. Then, two intermediate values were calculated:

$$p_u = (\text{sum of points of the best 50\%}) / \text{number of best 50\%},$$

$$p_l = (\text{sum of scores of worst 50\%}) / \text{number of worst 50\%}.$$

The  $D$  index is calculated as the difference between two values:

$$D = p_u - p_l$$

In tasks with non-dichotomous choice, we divided the obtained values by 2. Here, we wish to note the principle of “dividing by 2,” or more precisely, by “the difference between the highest and lowest score for the task” we encountered in the article (Abbakumov, 2023). This approach is logically correct, considering the weight of tasks with polytomous choice.

**Table 6**  
*Leading indicators of task quality*

Task	Correlation with the total score	Difficulty level, $p$	Discrimination index, $D$
Task 1	0.358	0.80	0.25
Task 2	0.370	0.71	0.28
Task 3	0.428	0.72	0.25
Task 4	0.458	0.76	0.30
Task 5	0.524	0.45	0.48
Task 6	0.534	0.32	0.40
Task 7	0.663	0.40	0.54
Task 8	0.651	0.57	0.49
Task 9	0.608	0.39	0.49
Task 10	0.555	0.57	0.32
Task 11	0.436	0.27	0.30
Task 12	0.604	0.49	0.55
Task 13	0.307	0.40	0.22

Task 14	0.532	0.42	0.48
Task 15	0.670	0.43	0.60
Task 16	0.470	0.68	0.34
Task 17	0.582	0.43	0.52
Task 18	0.434	0.60	0.39
Task 19	0.320	0.69	0.22
Task 20	0.630	0.53	0.58
Cronbach's Alpha 0.805			

We interpret the obtained discriminative indices using the guidelines reported in Croker and Algina (2010). The authors claim that Ebel first formulated them in 1965. Table 7 presents the interpretation results.

We conducted a distractor analysis to finalize the quality of the tasks. We calculated the percentage of respondents choosing each available answer to achieve this. The analysis was conducted in Excel (calculating the percentage of choices) and Iteman (graphical representation of distractor behavior). Consequently, cases of choosing distractors were determined to be less than 5% of participants in tasks 1 (three distractors), 3 (three distractors), and 4 (one distractor). The 5% threshold is frequently used when using CTT methods to analyze tasks.

**Table 7**

*Interpretation of the obtained values of the tasks' discriminative indices*

Meaning of D	Interpretation	Task Numbers from Table 6
$D \geq 0,40$	The task functions quite satisfactorily	5, 6, 7, 8, 9, 12, 14, 15, 17, 20
$0,30 \leq D \leq 0,39$	The task requires little or no correction	4, 10, 11, 16, 18
$0,20 \leq D \leq 0,29$	The task is marginal and needs revision	1, 2, 3, 13, 19
$D \leq 0,19$	The task should be excluded from the test or completely redone	no

After determining all the leading indicators of task quality, we can conclude their possible use. Meanwhile, our assessment system does not intend to select participants based on any criteria. It is offered to students as a system for voluntary assessment of their readiness level to perform the work functions described in the PS. We did not establish the ratio of easy, medium, and complex tasks in the version prepared for testing the tasks. Based on the experiment results, preparing recommendations on the ratio of tasks by difficulty level may be possible. For example, Table 5 depicts that one of the possible distribution options may involve the following: easy,  $p > 0.7$  - four tasks; average,  $0.4 \leq p \leq 0.7$  - 13 tasks; difficult,  $p < 0.4$  - three tasks. However, the easy category includes tasks with questionable qualities (1-4), making a recommendation challenging to approve. The tables with task quality indicators depict that task 1 has a low level in three indicators (correlation, D, and distractors). We gather that this task should be revised. Three tasks have low indicators in two criteria - task 2 (correlation, D), task 3 (D, distractors), and task 19 (correlation,

D) and are subject to correction. All the listed tasks have a type that requires choosing the correct answer from a set of proposed ones. Therefore, considering the wording of the tasks' text is worthwhile. In task 4, replacing one "non-working" distractor is necessary. Task 13 is open-ended, thus, after reviewing the text of the question, we decided to adjust it. Altogether, comments in one form or another impacted six tasks due to testing, and all will be eliminated in our future work.

**Distribution through publication.** To implement the results of our work in the university's educational process, we have developed the educational and methodological complex "System of assessment of professional competencies based on the requirements of professional standards of the IT industry". In the educational and methodological complex, we included examples of tasks designed to assess knowledge, skills, and abilities according to the requirements of professional standards. In addition, a description of the new competency model, methods for developing tasks, and general problems of measuring professional competencies are included. The problems of using the content of the PS in university programs are described in detail. The decision to publish the educational and methodological complex was approved by the Academic Council of the Turan University, its version will be posted in the electronic library. At the request of interested organizations and/or specialists, the educational and methodological complex will be distributed free of charge.

### **Discussion, Conclusion, and Implications**

The aim of our study was to develop and implement test tasks for assessing the professional competencies of graduates of the bachelor's degree program in the field of training at universities "Information and Communication Technologies". In doing so, we asked ourselves the following questions: how to define a competency model so that, based on it, it would be possible to develop test tasks for assessment; what types of tasks should be included in the test structure; how to justify the quality of the developed tasks?

As a result of our research and testing of the developed tasks, we determined that a new competency model can be formulated based on the Computing Curricula 2020 model. We proposed using a new formula to determine competencies using "knowledge, skills and abilities in the context of work functions" described in the PS. We also use the concept of "performance of work functions" of a specific IT profession. This means that the concept of "having professional competencies in a profession" for a graduate of a bachelor's degree program is equivalent to the concept of "being ready to perform all work functions" described in the relevant standard.

When determining the types of tasks and points for correct answers, we relied on our experience and principles of prevalence, technological effectiveness of tasks. All types of tasks should be known and familiar to both students and teachers. They should be suitable for mass application, be convenient for implementation online. Thus, we included the following types of tasks in the test structure: choosing one correct answer out of five proposed, choosing three correct answers out of seven proposed, establishing a match, establishing the correct sequence, an open type with entering an answer in the form of one word, a situational task. Five tasks assess skills and abilities in different LFs, all other tasks assess knowledge that is necessary to perform functions in the profession.

To prove the quality of the developed tasks, we calculated the correlation of each task with the total score, the difficulty level and the discriminativity indicator of each task. We also calculated Cronbach's alpha, which is an indicator of the reliability of the test. The obtained values of quality indicators allow us to state that the tasks can be used for assessment, with the exception of some tasks that require content correction and distractor revision.

We proposed a new competency model expressed using the following formula: Competency = [Knowledge + (Skills and Abilities)] in the context of the LF PS, where the context of the LF PS means the performance of specific work functions of the PS. This formula differs from the formula given in the CC2020 Task Force (2020) in that the concept of "task" is specified by indicating the work functions of the IT profession described in the PS. Such specification allows us to develop tasks to assess the knowledge, skills, and abilities required for the profession.

Kazakh authors Kassymbekova et al. (2021) also proposed their competency model. However, their model is not focused on the requirements of industry PS, their practical experience is related to teaching students foreign languages. In our model, a reference to the PS of the IT industry is clearly indicated.

Naseikina & Tagirov (2015) developed a structural and functional model for the formation of professional competence of future IT specialists. They take into account the requirements of IT employers reflected in the PS existing in Russia. These requirements are taken into account when developing the target block of the model. At the same time, it should be noted that the model is not focused on the content of international documents. The model formula we proposed is based on the competency model of the Computing Curricula document.

The work of the Russian author Yeltunova (2015) describes the competency model of a college graduate majoring in "Programming in Computer Systems". The model is defined as a set of professional competencies approved in the educational standard; technological maps have also

been developed. It should be noted that in Russia there are approved standards for specialties that describe the competencies required for graduates to master.

When determining the types of tasks for assessing competencies, we proceeded from the principle of their prevalence and technological properties, as well as by analogy with the types used in other assessments conducted in Russia and Kazakhstan. In the work of Abdiyev et al. (2024), we provided an overview of different types of external and internal assessment in higher education. The types of tasks we selected do not differ from the most common types given in the review. The main feature of the tasks is their purpose, i.e. what requirements they are aimed at assessing. In our case, they are aimed at assessing two requirements of professional standards: 1) knowledge, 2) skills and abilities. Moreover, these requirements are described for specific professions in the IT industry.

The difference in the results of Russian scientists is that there are approved standards of specialties, one of the requirements of which is the mandatory development of Assessment Tools Funds. In the dissertation work of Baikina (2022), one of the examples of such a fund is described. In the work of Zakharova (2018), a description of the fund for one specific specialty is also given. Oral and written surveys, written problem solving, and checking of laboratory work were used as forms of control during the assessment. At the preliminary stage, the author compared the requirements of the PS and educational standards of higher education.

To justify the quality of the developed tasks, we used the methods of classical test theory. Scientists from different countries often use these methods. For example, in the work of Dalim et al. (2023), an experiment was described to determine the internal reliability of the test using Cronbach's alpha. Chilean scientists in the work of Urrea et al. (2022) also used these methods in the analysis of the psychometric qualities of the information competence assessment tool. The difference in our work lies only in the difference in the set of calculated coefficients. This difference depends only on the content and purpose of the assessment tools. The work of Kazakhstani authors Koshmaganbetova et al. (2020) presents the results of assessing the quality of multiple-choice test items used in the educational process of a medical university. In this case, the methods of classical test theory are also used.

Thus, in our work, we proposed using a new competency model to develop tasks for assessing the competencies of graduates of the educational program in the ICT field. To justify the suitability of the tasks for assessment, we used statistical data from the testing of the tasks.

The overall goal of our research group is to create an internal system for assessing the level of professional competencies of bachelor's degree graduates at the stage of study at the university. In

our opinion, such an internal assessment system will allow each student to assess their level of training before entering the labor market. The system, if successfully implemented, will become one of the opportunities to improve the quality of higher education.

Our experience has shown that additional preliminary work with the approved PS is needed, since in some cases, clarifications are required in the wording of the requirements for knowledge and skills in order to bring them to a level sufficient for developing tasks. We have shown how preliminary work can be carried out with the text of one PS; perhaps the same approach can be used when working with other PSs in the IT industry.

The descriptions of personal competencies given in the PS are too generalized and do not have the property of measurability. Therefore, in our competency model, we did not include personal competencies in the formula. This may lead to the fact that when implementing the assessment system, it may be necessary to supplement it with requirements for personal indicators. For example, reviewing a portfolio, conducting an additional interview may be necessary activities. Such an addition is a limitation for the application of our method for assessing professional competencies. Because the forms of the activities we named may be subjective compared to direct measurement methods.

To solve the methodological problems associated with the definition of the concept of "professional competencies" in the context of the requirements of the PS, joint work of representatives of the IT community and teachers of IT disciplines is required. This need arises due to the lack of a scientifically based Concept of a Competency-Based Approach in Higher Education in Kazakhstan. This hinders the development of systems for assessing the professional competencies of future IT specialists. Because, to develop assessment systems, first of all, precise formulations with measurable components are needed. The model we propose may become the first issue for discussion with the IT community.

The competency model we propose and the tasks developed for assessing the competencies can be used when considering the profession described in the "Database Administration" PS. Using the approach we propose, it is possible to develop tasks for assessing competencies for professions described in other PSs in the IT industry.

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## References

- Abbakumov D.F. (2023) Difficulty of a test task. Article in the Great Russian Encyclopedia. Date of publication: 12/8/2023. URL: <https://bigenc.ru/c/trudnost-testovogo-zadaniia-da0711> (In Russ.)
- Abdiyev, K., Zhassandykyzy, M. & Primbetova, G. (2023). The alignment of university educational programs with the professional standards of the IT industry. *Journal of Social Studies Education Research*, 2023, 14(4), 299-327. URL: <https://jsser.org/index.php/jsser/issue/view/45/showToc>
- Abdiyev, K., Zhassandykyzy, M., Maintcer, D., Naumenko, V. & Primbetova, G. (2024). Analysis of tools for measuring professional competencies of graduates in the direction of ICT training. *Bulletin of Abai KazNPU. Series of Physical and Mathematical Sciences*, 87(3), 190-206. <https://doi.org/10.51889/2959-5894.2024.87.3.017> (In Russ.)
- Aimukhambet, Z., Aituganova, S., Alimbayev, A., Sagynadin, G., & Seiputanova, A. (2023). The Effects of Computer Aided Education in the Education of Folk Cultural Products. *Journal of Curriculum Studies Research*, 5(2), 167-185. <https://doi.org/10.46303/jcsr.2023.25>
- Baikina, E.A. (2022). Design of a competence-oriented system of assessment tools in the leading professional educational programs of the university. *Abstract of the dissertation for the degree of candidate of pedagogical sciences in the specialty 5.8.7 - Methodology and technology of professional education*. Volgograd, Volgograd State Social and Pedagogical University. (In Russ.)
- Bowers, D., Sabin, M. (2022). Using a Professional Skills Framework to Support the Assessment of Dispositions in IT Education. SIGITE 2022 - Proceedings of the 23rd Annual Conference on Information Technology Education, 103-109. <https://doi.org/10.1145/3537674.3554747>
- Bowers, D.S., Sabin, M., Raj, R.K. & Impagliazzo, J. (2022). Advancing Computing Education: Assessing CC2020 Dispositions. In: 2022 IEEE Frontiers in Education Conference (FIE), IEEE. DOI: <https://doi.org/10.1109/fie56618.2022.9962670>
- Bowers, D. & Sabin, M. (2023). Demonstrating the use of a professional skills framework to support the assessment of dispositions in IT education. *Education and Information Technologies* (2023). <https://doi.org/10.1007/s10639-023-11933-z>
- Cahyaningrum, B. N., Untoro, W., Setiawan, A. K. & Wahyudi L. (2024). Increasing Student Competence by Implementing Strategic Management in Indonesian Private University, *Journal of Social Studies Education Research*, 15(3), 173--212. <https://jsser.org/index.php/jsser/article/view/5873/684>
- CC2020 Task Force (2020). *Computing Curricula 2020: Paradigms for Global Computing Education*. Association for Computing Machinery, <https://doi.org/10.1145/3467967>
- Crocer, L. & Algina, J. (2010). *Introduction to classical and modern test theory*. Moscow, Logos Publishing House. 668 p. (In Russ.)

- Dalim, S. F., Aris, S. R. S., Hoon, T. S., Nadzri, F. A., Deni, S. M., Yahya, N., & Si, E. M. (2023). Framework for numeracy and digital skills attributes in higher education. *Research in Social Sciences and Technology*, 8(3), 16-35. <https://doi.org/10.46303/ressat.2023.18>
- Expert Session “Problems of measuring professional competencies of IT specialists” (2023). URL: <https://turan.edu.kz/ru/nauka-i-innovaczii/research-institute-of-informatization-of-education> (In Russ.)
- Frezza, S., Daniels, M., Pears, A., Cajander, A., Kann, V., Kapoor, A., McDermott, R., Peters, A-K., Sabin, M. & Wallace, C. (2018). Modelling competencies for computing education beyond 2020: A research based approach to defining competencies in the computing disciplines. In *Proceedings Companion of the 23rd Annual ACM Conference on Innovation and Technology in Computer Science Education (ITiCSE '18 Companion)*, July 2–4, 2018, Larnaca, Cyprus. ACM, New York, NY, USA, 27 pages. <https://doi.org/10.1145/3293881.3295782>
- Gall, M.D., Gall, J.P. & Borg, W.R. (2003). *Educational Research: An Introduction*, Seventh Edition. Boston: Allyn and Bacon. 683 pages.
- Guidelines for developing of educational programs for higher and postgraduate education (2023). *Ministry of Science and Higher Education, National Center for the Development of Higher Education*. URL: [https://enic-kazakhstan.edu.kz/uploads/additional\\_files\\_items/100/file/rukovodstvo-po-razrabotke-obrazovatelnyh-programm-vysshego-i-poslevuzovskog.pdf?cache=1683267750](https://enic-kazakhstan.edu.kz/uploads/additional_files_items/100/file/rukovodstvo-po-razrabotke-obrazovatelnyh-programm-vysshego-i-poslevuzovskog.pdf?cache=1683267750) (In Russian)
- Kassymbekova M.A., Sadykova A.K., Akhmetova M.K. & Zhylytyrova Zh.T. (2023). Problem of measuring and evaluating competencies in higher professional education. *Bulletin of Kazakh Ablai Khan University of International Relations and World Languages. Series “Pedagogical Sciences”*, 2 (69), 28-42. <https://doi.org/10.48371/PEDS.2023.69.2.002>
- Koshmaganbetova, G.K., Zhamalieva, L.M., Kashkinbaeva, A.R. & Dil'magambetova, G.S. (2020) Assessment of the quality of MCQ test items by complexity and discriminability indicators: a cross-sectional study. *West Kazakhstan Medical Journal*, 3(62), 146-151. <https://zkmj.edu.kz/wp-content/uploads/2024/06/WKMJournal-3.62.pdf> (In Russian)
- Kumar, A.N., Raj, R.K., Aly, S.G., Anderson M.D., Becker, B.A., Blumenthal, R.L., Eaton, E., Epstein, S.L., Goldweber, M., Jalote, P., Lea, D., Oudshoorn, M., Pias, M., Reiser, S., Servin, C., Simha, R., Winters, T. & Qiao, X. (2023). *Computer Science Curricula 2023*. ACM Press, IEEE Computer Society Press, and AAAI Press. <https://doi.org/10.1145/3664191>
- Marais, E. (2023). The Development of Digital Competencies in Pre-Service Teachers. *Research in Social Sciences and Technology*, 8(3), 134-154. <https://doi.org/10.46303/ressat.2023.28>
- Maslak, A.A. (2021). Comparative analysis of methods for measuring competencies. Collection of materials from the XVI Forum of the Guild of Experts in the Field of Professional Education within the framework of online conferences, Moscow, December 15, 2020. - Moscow: Association "Guild of Experts in the Field of Professional Education", 2021. - P. 115–121. - EDN QYBHXK. URL: <https://elibrary.ru/item.asp?id=45749456> (In Russ.)

- Mukashova, A., Mukanova, A., Ospanova, T., Bakiyeva, A. & Makhatova, V. (2023). Important aspects of developing educational programs based on the competency-based approach. *News of the National Academy of Sciences of the Republic of Kazakhstan. Series: Physics and Mathematics*, 3, 99–111. <https://doi.org/10.32014/2023.2518-1726.207>
- Naseikina, L.F. & Tagirov, V. K. (2015). Structural and functional model of formation of professional competence of future IT specialists. *Bulletin of Orenburg State University*, 2(177), 118-123. URL: <https://cyberleninka.ru/article/n/strukturno-funktsionalnaya-model-formirovaniya-professionalnoy-kompetentnosti-buduschih-it-spetsialistov> (In Russ.)
- Orakova, A., Nametkulova, F., Issayeva, G., Mukhambetzhanova, S., Galimzhanova, M., & Rezuanova, G. (2024). The Relationships between Pedagogical and Technological Competence and Digital Literacy Level of Teachers. *Journal of Curriculum Studies Research*, 6(1), 1-21. <https://doi.org/10.46303/jcsr.2024.2>
- Raj, R. K., Sabin, M., Impagliazzo, J., Bowers, D., Daniels, M., Hermans, F., Kiesler, N., Kumar, A. N., MacKellar, B., McCauley, R., Nabi, S.W. & Oudshoorn, M. (2021). Professional competencies in computing education: Pedagogies and assessment. In 2021 ITiCSE Working Group Reports (ITiCSEWGR '21), June 26-July 1, 2021, Virtual Event, Germany. ACM, New York, NY, USA, 29 pages. <https://doi.org/10.1145/3502870.3506570>
- Register of Approved Professional Standards (2022). URL: <https://atameken.kz/ru/services/16>. (In Russ.)
- Sabin, M., Alrumaih, H. & Impagliazzo, J. (2018). “A Competency-Based Approach toward Curricular Guidelines for Information Technology Education.” In 2018 IEEE Global Engineering Education Conference. Santa Cruz de Tenerife, Spain: IEEE Xplore.
- State Compulsory Standard of Higher Education (2022). *On approval of state compulsory standards of higher and postgraduate education. Order of the Minister of Science and Higher Education of the Republic of Kazakhstan dated July 20, 2022, No.2*. URL: <https://adilet.zan.kz/rus/docs/V2200028916> (In Russ.)
- Urta, C.V., Egozcue, B.V., Castro, S.O., Alvarado, M. (2022). Adaptation of the information competency assessment instrument and its application to undergraduate students of the universities of Magallanes and Playa Ancha. *Journal of Higher Education Theory and Practice*, 22 (10), 61-80. <https://doi.org/10.33423/jhetp.v22i10.5426>
- Vasilieva, N.O. (2017). Evaluation of students' educational outcomes based on a competency model. *Modern problems of science and education*. 6. URL: <https://science-education.ru/ru/article/view?id=27188> (In Russ.)
- Yeltunova, I.B. (2015). Model of the professional competencies assessment system. *Modern problems of science and education*. 1–1. URL: <https://science-education.ru/ru/article/view?id=17261> (In Russ.)
- Yelubay Y., Dzhussubaliyeva D., Moldagali B., Suleimenova A., Akimbekova S. (2022). Developing future teachers' digital competence via massive open online courses (MOOCs). *Journal of Social Studies Education Research*, 13 (2), pp. 170 – 195.

- Zakharova, I.V. (2018). On the development of funds for assessment tools in the ICT field, considering professional standards. *Educational Technologies and Society*, 21 (1), 322-335. URL: <https://cyberleninka.ru/article/n/o-razrabotke-fondov-otsenochnyh-sredstv-v-oblasti-ikt-s-uchetom-professionalnyh-standartov> (In Russ.)
- Zakieva, R., Leontiev, A., Serikov, V. (2023). Technology for assessing the level of competence formation of a graduate of technical university. *Education and Self Development*. 18(1), 121–134. <https://doi.org/10.26907/esd.18.1.09> (In Russ.)

### Appendix

#### Requirements for knowledge, skills and abilities in the profession "Specialist in database administration", 5th level of the IQF. *Fragment of the PS "Database Administration"*

Knowledge	Skills and Abilities
LF 1 - Installing and configuring software	
<ol style="list-style-type: none"> <li>1. Composition of the hardware and software system in use, with the characteristics of its components.</li> <li>2. Functional capabilities of the installed software, including the OS.</li> <li>3. Requirements for the installed software.</li> <li>4. Mechanisms for managing the resources of the hardware and software system.</li> <li>5. Methods for setting up and configuring system and application software.</li> <li>6. Principles of security.</li> </ol>	<ol style="list-style-type: none"> <li>1. Planning the installation of system software.</li> <li>2. Installing and managing the resources of the hardware and software system.</li> <li>3. Installing and configuring system and application software.</li> <li>4. Addressing errors that occur during installation and configuration of software.</li> <li>5. Utilizing technical documentation for installation and configuration of software.</li> </ol>
LF 2 - Ensuring the functioning of the database	
<ol style="list-style-type: none"> <li>1. Composition of the hardware and software complex and technical characteristics of its components.</li> <li>2. Composition and functionality of software used for database administration.</li> <li>3. Methods for monitoring database operation.</li> <li>4. Tools and methods utilized for managing database objects.</li> <li>5. Information analysis methods.</li> <li>6. Database query languages.</li> </ol>	<ol style="list-style-type: none"> <li>1. Monitoring software performance.</li> <li>2. Analyzing software performance issues.</li> <li>3. Monitoring database usage.</li> <li>4. Analyzing events that occur during database usage.</li> <li>5. Identifying and resolving faults during database operation.</li> <li>6. Maintaining and utilizing operational documentation for database management.</li> <li>7. Analyzing information obtained during database operation.</li> <li>8. Analysis of the need to upgrade the hardware and software complex based on the database operation results.</li> <li>9. Forecasting and assessing the risks of database failures.</li> <li>10. Creating and executing database queries.</li> </ol>
LF 3 – Monitoring and managing database backups	
<ol style="list-style-type: none"> <li>1. Composition of the hardware and software complex in use, along with technical characteristics of its components.</li> <li>2. System and application software used for performing database backup and recovery procedures.</li> <li>3. Methods for creating database backup procedures.</li> <li>4. Database backup and recovery regulations.</li> <li>5. Hardware and software complex for storing database backup copies.</li> </ol>	<ol style="list-style-type: none"> <li>1. Developing procedures for database backups.</li> <li>2. Performing recovery procedures to restore database operability after backups.</li> <li>3. Identifying and troubleshooting problems encountered during database backup or recovery.</li> <li>4. Monitoring the execution of database backup and recovery procedures.</li> <li>5. Verifying the integrity of database backup copies.</li> <li>6. Ensuring compliance with database backup and recovery regulations.</li> </ol>
LF 4 - Ensuring information security of the database	
<ol style="list-style-type: none"> <li>1. Database management system.</li> <li>2. Tools and methods for managing database user accounts.</li> </ol>	<ol style="list-style-type: none"> <li>1. Creating, modifying, and deleting database user accounts.</li> <li>2. Managing access levels for database user groups.</li> </ol>

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3. Methods for ensuring database security through software.
  4. Tools and methods for controlling database access.
  5. Information security principles.

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3. Utilizing tools and methods for database access control.
  4. Ensuring compliance with the organization's information security policy.

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LF 5 - Analysis and tuning of DBMS performance

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1. Tools and methods for monitoring, collecting, and analyzing statistical data on database operations.
2. Methods for evaluating database performance.
3. The composition of the hardware and software system in operation and the technical characteristics of its components.
4. Database query languages.

1. Analyzing and evaluating the performance of the database and server equipment using the collected statistical data.
  2. Identify the most resource-intensive queries that affect the DBMS performance for further optimization.
  3. Formation of reporting documentation on the state and functioning of the DBMS.
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