

Assessment and Validation of the Scale of Professional Readiness of Future Teachers for the Use of Neural Network Technologies in the Educational Process

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Abstract—The rapid integration of neural network technologies into education has increased the need to assess future teachers' professional readiness for the pedagogically appropriate, ethically responsible, and methodologically effective use of artificial intelligence tools in teaching practice. However, there remains a lack of validated instruments specifically designed to measure this form of professional readiness in teacher education. The aim of this study was to develop and validate a scale for assessing the professional readiness of future teachers to use neural network technologies in the educational process. The study involved 150 students enrolled in teaching programs at L.N. Gumilyov Eurasian National University. The developed instrument included 36 items organized into three theoretically derived content domains: cognitive, operational, and reflexive-motivational readiness. In the present study, the scale was validated as an overall measure of professional readiness using the Rasch model, while the internal multidimensional structure requires further verification through Exploratory Factor Analysis (EFA) or Confirmatory Factor Analysis (CFA) in future research. Data was analyzed using the Rasch measurement model to evaluate one-dimensionality, category functioning, item fit statistics, reliability and separation indices, Wright map targeting, and Differential Item Functioning (DIF). The results demonstrated acceptable psychometric properties of the scale. The main measured dimension explained 48.7% of the total variance, while all response categories functioned in an ordered manner. Most items showed acceptable Infit and Outfit statistics, with only two items demonstrating borderline fit values. Reliability indices were high for both items (0.95) and respondents (0.91), indicating stable measurement performance. DIF (Differential Item Functioning) analysis revealed no substantial gender bias across items. The findings suggest that the proposed scale is a reliable and valid instrument for assessing future teachers' professional readiness to use neural network technologies in educational settings. The scale can be applied in teacher education research, curriculum evaluation, and the development of AI (Artificial Intelligence)-related pedagogical competencies in higher education.

Keywords—neural network technologies, artificial intelligence in education, professional readiness, future teachers, teacher education, digital pedagogy, Rasch model, psychometric validation, AI competence, educational technology assessment

I. INTRODUCTION

In the context of the rapid digital transformation of education, the problem of training future teachers to use modern intellectual technologies in their professional

activities is becoming particularly relevant. One of the most notable trends in the development of the digital educational environment in recent years has been the introduction of neural network technologies, which open wide opportunities for personalizing learning, automating routine pedagogical tasks, analyzing educational data, developing educational materials, and improving the effectiveness of interaction between teachers and students [1].

The modern educational process is increasingly focused not only on the acquisition of subject knowledge [2], but also on the formation of future specialists' ability to effectively use digital and intellectual tools in professional practice. In this regard, the use of neural network technologies in teaching ceases to be an additional competence and becomes an important component of the professional readiness of a future teacher. The use of generative models, intelligent learning support systems, automated feedback tools and analytical tools based on artificial intelligence requires students not only to be technically aware, but also to take a pedagogically sound, ethically responsible and methodically competent approach.

Despite the high potential of neural network technologies in education, the level of readiness of future teachers for their meaningful and productive use remains insufficiently studied. In practice, students of pedagogical fields often demonstrate fragmentary ideas about the possibilities and limitations of neural network tools, have difficulty choosing adequate scenarios for their use in the educational process, and are not always able to critically evaluate the results generated by such systems [3]. In addition, insufficient digital pedagogical competencies, lack of sustained motivation to use innovative technologies, and poor methodological training may reduce the effectiveness of implementing neural network solutions in educational practice.

The professional readiness of future teachers to use neural network technologies is a multidimensional construct that includes cognitive, operational, and reflexive-motivational components [4]. It manifests itself in a positive attitude towards the use of digital innovations, an understanding of the pedagogical potential of neural network tools, the ability to integrate them into the learning process in accordance with didactic goals, as well as in a willingness to critically reflect on the results of their own activities and comply with ethical standards for the use of artificial intelligence in education [5].

At the same time, the development of this area requires

reliable and valid diagnostic tools to assess the degree of professional readiness of future teachers to use neural network technologies. Without a scientifically based scale, it becomes difficult both to conduct empirical research and to monitor the effectiveness of educational programs aimed at developing relevant competencies [6]. That is why the development and validation of a scale capable of adequately measuring key aspects of the professional readiness of students of pedagogical specialties to use neural network technologies in the educational process is of particular importance [7].

The present study is aimed at assessing and validating the scale of professional readiness of future teachers for the use of neural network technologies in the educational process. The proposed tool is aimed at identifying the level of formation of attitudes, knowledge, practical skills and reflexive readiness necessary for the effective integration of neural network solutions into teaching activities. The study pays special attention to checking the psychometric characteristics of the scale, its internal consistency, structural validity and suitability for use in higher pedagogical education.

In accordance with the purpose of the study, the following research questions were formulated:

RQ1: Does the developed scale have sufficient psychometric characteristics to measure the professional readiness of future teachers to use neural network technologies in the educational process?

RQ2: Does the scale demonstrate the correct functioning of the response format and assessment categories used?

RQ3: Do all points on the scale correspond to statistically acceptable indicators of consistency and measurement quality?

RQ4: Are the reliability and separability indicators of the scale at the respondent and point levels sufficient for its practical application?

RQ5: Does the scale ensure an adequate ratio between the level of readiness respondents and the difficulty/severity of individual statements?

RQ6: Does the scale maintain measurement invariance across gender groups of respondents?

II. LITERATURE REVIEW

A. Assessment of the Professional Readiness of Future Teachers to Use Neural Network Technologies

In modern pedagogical science, it is increasingly recognized that students' professional readiness to use innovative technologies can be reliably assessed using specially designed questionnaires and scales. At the same time, the creation of such measuring tools requires strict consideration of the context of professional activity, the specifics of educational tasks and the specifics of those competencies that are supposed to be diagnosed. This is especially important in the context of the active introduction of neural network technologies into the educational process, when both the content of pedagogical activity and the requirements for the digital competence of a future teacher are changing.

In recent years, researchers have increasingly turned to the problem of educating teachers to use artificial intelligence,

digital platforms, intelligent learning systems, and generative models [8]. However, despite the growing interest in this issue, most of the existing research focuses either on general aspects of digital literacy or on individual technological skills, without fully covering the integrated professional readiness of future teachers to use neural network technologies in the educational process [9]. Meanwhile, such readiness is a multicomponent education that includes motivation to use innovations, knowledge about the possibilities and limitations of neural network tools, practical skills in their pedagogically appropriate use, as well as the ability to reflect and ethically assess the consequences of their use [10].

An analysis of scientific publications shows that existing approaches to assessing teachers' digital and professional readiness are most often based on multidimensional models that identify cognitive, operational, motivational, and personality-reflective components [11]. Such models allow us to consider readiness not as a sum of disparate skills, but as an integrated system reflecting the ability of a future specialist to act effectively in a technologically saturated educational environment [12]. At the same time, there remains a significant research gap associated with the lack of validated tools specifically designed to diagnose the readiness of future teachers to use neural network technologies [13].

In this regard, the development and validation of a specialized scale is of particular importance. Such a tool should not only capture the general level of digital awareness of students but also assess their confidence in the use of neural network technologies, understanding of pedagogical scenarios of their application, the ability to critically interpret the results of intelligent systems and willingness to comply with ethical standards when working with AI tools in education. Therefore, assessing the professional readiness of future teachers to use neural network technologies requires the creation of a scientifically based scale with proven psychometric characteristics suitable for use in research and educational practice [14].

B. Cognitive, Operational, Motivational, and Reflexive Components of Professional Readiness

One of the key bases for constructing a scale of professional readiness of future teachers for the use of neural network technologies is the idea of its multicomponent structure. In scientific literature, professional readiness for innovative pedagogical activity is usually considered as a unity of several interrelated components, each of which reflects a certain aspect of a person's readiness for effective professional action [15].

The cognitive component is associated with the future teachers having a system of knowledge about neural network technologies [16], the principles of their functioning, the possibilities and limitations of their use in teaching. This component assumes an understanding of what tasks can be solved using neural network tools, in which pedagogical situations their use is appropriate, as well as what risks are associated with the uncritical use of such technologies in educational practice. Without sufficient theoretical training, the use of neural network solutions can become superficial or formal [17].

The operational component reflects the ability of students

to practically apply neural network technologies to solve professional problems. We are talking about choosing appropriate tools, designing tasks using AI, creating educational materials, analyzing educational data, organizing feedback and adapting the learning content to the capabilities of intelligent systems. It is this component that shows how much a future teacher can move from knowledge of technology to its actual methodically justified use in the educational process [18].

The motivational component characterizes students' attitude to the use of neural network technologies, the degree of their interest in mastering new digital tools, awareness of their importance for the future profession and internal readiness for innovative teaching activities. The presence of positive motivation is of particular importance, since it largely determines the desire of future teachers to master new technologies, overcome the difficulties of digital adaptation and incorporate innovative solutions into their own professional practice.

The reflexive component is related to the ability of future teachers to critically evaluate the results of using neural network technologies, analyze their own experience of using them, identify limitations and risks, and consider the ethical, methodological and social consequences of introducing AI into the educational environment. This component is particularly important because the use of neural network technologies in education requires not only technical training, but also pedagogical responsibility related to issues of reliability, authorship, academic integrity, confidentiality of data and the preservation of the subject role of the teacher.

Based on this, the professional readiness of future teachers to use neural network technologies should be considered as an integrated system in which knowledge, practical skills, motivation and reflection are in constant interaction [19]. The identification of these components creates a theoretical basis for the development of the scale structure and subsequent verification of its validity.

The proposed framework is an original integrative model developed for the present study based on the synthesis of research on professional readiness, digital competence, AI literacy, and technology integration in teacher education. The cognitive, operational, and reflexive-motivational domains were derived from recurring constructs identified in previous studies and adapted specifically to the context of neural network technologies in education.

C. The Relationship between Technological Competence, Pedagogical Expediency and Reflexive Assessment in Digital Education

Modern research in the field of digital pedagogy shows that the successful implementation of neural network technologies in the educational process depends not only on the level of technical awareness of the future teacher, but also on how he is able to correlate technological capabilities with learning objectives, age characteristics of students, the content of the subject and the principles of pedagogical ethics [20]. In this sense, willingness to use neural network technologies acts as an integrative characteristic formed at the intersection of technological competence, methodological training and professional reflection.

One of the significant problems is that many students

perceive neural network technologies primarily as a convenient technical tool, not always realizing the need for a pedagogically sound approach to their use. This perception can lead to the clichéd use of AI services, a decrease in independence in professional thinking, and an underestimation of the risks associated with the unreliability of generated content or incorrect interpretation of results. As a result, the formation of readiness for the use of neural network technologies requires not only the development of the tools themselves, but also the development of the ability to make pedagogically informed decisions in a digital environment.

In addition, research shows that lack of confidence in one's own digital capabilities, poor methodological training, and lack of a systematic understanding of the role of AI in education can make it difficult to integrate innovative technologies into teaching practice. The low level of readiness is manifested in difficulties in choosing relevant neural network tools, in the inability to adapt them to specific pedagogical tasks, as well as in the limited ability to assess the quality and relevance of the results obtained using such systems. This is especially important for future teachers, since their professional activity involves not just the use of technology, but its inclusion in the educational process, considering the goals of student development.

In contrast to the formal technological approach, modern pedagogical science emphasizes the need for a comprehensive understanding of the digital transformation of education [21]. Neural network technologies should be considered not as an end in themselves, but as a means of improving the quality of learning, developing critical thinking, personalizing educational trajectories and expanding the professional tools of the teacher. Therefore, effective training of future teachers requires the formation of a professional readiness that combines knowledge of technology, practical mastery of it, sustained motivation for innovation and the ability for critical pedagogical reflection.

That is why the development of a scale of professional readiness of future teachers for the use of neural network technologies in the educational process is an important scientific and practical task. Such a scale will allow not only to diagnose the level of formation of appropriate readiness, but also to identify problem areas in the preparation of students, substantiate the directions for improving educational programs and evaluate the effectiveness of pedagogical interventions aimed at developing the AI competence of future specialists.

III. MATERIALS AND METHODS

A. Study Participants

The study involved 150 students from the pedagogical fields of the L.N. Gumilyov Eurasian National University. The target sample included students who were studying educational programs related to future professional activities in the field of education and pedagogy. To minimize possible bias, participation in the study was organized on a voluntary and anonymous basis. The questionnaire included only the main socio-demographic characteristics of the respondents, in particular gender and course of study.

Prior to the start of statistical processing, a preliminary

check and cleaning of the data was carried out to exclude questionnaires filled out formally, incompletely or with logical contradictions. As a result, all 150 questionnaires were considered suitable for further analysis, as the respondents' responses demonstrated sufficient completeness and consistency.

From the point of view of psychometric assessment and primary validation of the measuring instrument, this sample is acceptable for testing the scale and analyzing its main indicators. Although larger samples provide more stable estimates of the parameters, the volume of 150 participants allows for an initial check of the scale structure, internal consistency of points, as well as assessing the overall quality of the instrument's functioning in the context of pedagogical research.

The final sample included 58 boys (38.7%) and 92 girls (61.3%). According to the courses of study, the participants were distributed as follows: 52 first-year students (34.7%), 46 second-year students (30.7%), 30 third-year students (20.0%) and 22 fourth-year students (14.6%) (Table 1).

Table 1. Demographic characteristics of the study participants

Variable	Level	Frequency	Percent
Gender	Male	58	38.7%
	Female	92	61.3%
Course of study	1st year	52	34.7%
	2nd year	46	30.7%
	3rd year	30	20.0%
	4th year	22	14.6%

Ethical approval for this study was granted by the Institutional Ethics Committee of L.N. Gumilyov Eurasian National University (Protocol No. 11, dated December 5, 2025). All participants provided informed consent prior to participation. Participation was voluntary and anonymous, and all collected data were treated confidentially and analyzed in aggregated form only.

B. A Research Tool

In this study, the developed scale of professional readiness of future teachers for the use of neural network technologies in the educational process was used. This tool was designed to assess the level of formation of key components of professional readiness related to the meaningful, methodically sound and ethically responsible use of neural network technologies in future teaching activities.

The final version of the scale included 36 statements combined into three meaningful blocks: a cognitive component, an operational component, and a reflexive-motivational component. This structure made it possible to cover the main aspects of the professional readiness of future teachers to work with neural network technologies in an educational environment.

To ensure the meaningful validity of the tool, the statements were subjected to expert evaluation. Five experts in the field of pedagogy, digital education and artificial intelligence in education took part in the examination. The experts confirmed that the content of the scale corresponds to the objectives of the study and reflects the essential characteristics of the professional readiness of future teachers to use neural network technologies. According to their recommendations, minor editorial clarifications were made

to certain formulations aimed at increasing the clarity, accuracy and application of the statements. Additionally, a pilot discussion of the instrument was conducted with a small group of students, which confirmed the clarity and accessibility of all points on the scale.

The final version of the scale included 36 statements concerning three aspects of professional readiness: cognitive (paragraphs 1–12), operational (paragraphs 13–24) and reflexive-motivational (paragraphs 25–36). The responses were recorded on a 7-point Likert scale, ranging from “totally disagree” to “totally agree.”

To increase transparency and allow independent evaluation of content validity, sample items from each component of the scale are presented below. The cognitive component included items such as: “I understand the basic principles of how neural network technologies function in educational contexts”. The operational component included items such as Q4: “I can independently design learning tasks using neural network technologies in accordance with pedagogical objectives”. The reflexive-motivational component included items such as Q11: “I can critically assess the ethical risks associated with the use of artificial intelligence and neural network tools in education”. These examples demonstrate that the scale was designed not only to assess technical familiarity with AI tools but also pedagogical applicability, ethical awareness, and reflective readiness.

1) The cognitive component

The cognitive component of the scale was aimed at assessing the level of knowledge of future teachers about the essence of neural network technologies, the principles of their functioning, the possibilities of application in the educational process, as well as potential limitations and risks. The statements in this block reflected an understanding of the role of neural network tools in personalizing learning, automating task verification, creating educational materials, analyzing educational data, and supporting educational communication.

Unlike the general scales of digital competence, this component was focused specifically on the pedagogical context, which made it possible to assess not just awareness of technology, but a professionally significant understanding of its educational potential.

2) Operational component

The operational component was related to the assessment of the practical readiness of future teachers to use neural network technologies in real educational situations. It included statements revealing respondents' ability to choose appropriate digital tools, apply them to prepare learning materials, provide feedback, design assignments, and support individualized learning.

This block was aimed at identifying to what extent students are ready to move from theoretical knowledge about neural network technologies to their meaningful and pedagogically appropriate use in educational practice.

3) Reflexive and motivational component

The reflexive-motivational component reflected the attitude of future teachers to the use of neural network technologies, the degree of their interest in mastering innovative digital tools, awareness of their importance for

professional activity, as well as their willingness to critically evaluate the results of their use. This block included statements related to pedagogical responsibility, compliance with ethical standards, critical analysis of the reliability generated content and understanding the role of teachers in the context of digitalization of education.

In this study, reflexive and motivational aspects were considered as a combined component because readiness to use neural network technologies requires not only interest and positive intention but also the ability to critically evaluate the consequences of their use. Motivation determines the willingness of future teachers to master and apply AI-based tools, while reflection ensures that this application remains pedagogically meaningful, ethically responsible, and critically controlled. Therefore, the reflexive-motivational component reflects the internal professional position of future teachers toward the use of neural network technologies in education.

The inclusion of this component made it possible to show that professional readiness for the use of neural network technologies is not limited to knowledge and skills but also includes a motivational orientation and a developed reflexive position.

The expert panel consisted of five specialists with academic and practical experience in teacher education, digital pedagogy, educational measurement, and artificial intelligence in education. The experts evaluated each item in terms of relevance, clarity, and representativeness using a four-point rating scale. Item-level content validity indices (I-CVI) ranged from 0.80 to 1.00, while the scale-level content validity index based on average agreement (S-CVI/Ave) was 0.93. These results indicate an acceptable level of content validity. Items with minor wording concerns were revised according to the experts' recommendations before the main data collection.

C. Data Collection

The data was collected in an online format using a digital survey platform. A convenient selection method based on the availability of participants was used to form the sample. Before completing the questionnaire, all respondents were provided with information about the objectives of the study, the voluntary nature of participation, the confidentiality of the data obtained, and the possibility to opt out at any stage.

It was explained to the students that the results would be used exclusively for scientific purposes, and the answers themselves would be analyzed in a generalized form without identification. This approach has helped to increase the reliability of data and create conditions for a more sincere expression of students' attitudes towards the use of neural network technologies in the educational process.

D. Data Analysis Procedure

To assess and validate the scale of professional readiness of future teachers for the use of neural network technologies in the educational process, an analysis based on the Rasch model was used. The application of this approach made it possible to verify the psychometric quality of the developed instrument and evaluate its suitability for the diagnosis of the studied construct.

The analysis was aimed at verifying six key characteristics of the scale: one-dimensionality, the correct functioning of

response categories, the correspondence of points to the model, reliability and separation indices, consistency in the distribution of points and respondents, as well as measurement invariance between different groups of participants.

At the first stage, the one-dimensionality of the scale was checked as one of the basic conditions for the application of the Rasch model. One-dimensionality refers to the presence of a dominant latent feature that explains most of the variability in respondents' responses. An analysis of the main components of the residues was used to evaluate this property. When interpreting the results, the indicators of the proportion of the explained variance and the magnitude of the first contrast were considered, which made it possible to determine how much the scale reflects a single measured construct.

At the second stage, the functioning of the categories of the 7-point Likert scale was evaluated. The analysis was aimed at determining how consistently and logically respondents use the proposed response categories. Attention was paid to the monotony of average measurements and the ordering of thresholds between neighboring categories. This allowed us to check whether the selected response format is adequate for the diagnosis of professional readiness.

Then the statistics of the correspondence of the points of the Rasch model were analyzed. To do this, the Infit and Outfit Mean Square indicators were calculated, which allow us to identify statements that do not agree with the general measurement construct. Additionally, the correlation coefficients of the points with the general scale were evaluated, which made it possible to determine the degree of their contribution to measuring the professional readiness of future teachers to use neural network technologies.

Rasch analysis was conducted using Winsteps software. The analysis included item and person reliability, separation indices, item fit statistics, rating scale functioning, Wright map interpretation, principal component analysis of residuals, and differential item functioning analysis.

At the next stage, reliability and separation indicators were determined for both the respondents and the points on the scale. Reliability by respondents showed the stability of the distribution of students in terms of the severity of the trait under study, and point-by-point reliability characterized the consistency and hierarchy of the statements themselves. The separation indexes allowed us to establish how well the scale is able to distinguish groups of respondents with different levels of professional readiness and how clearly the points are ordered according to the degree of difficulty of agreeing with them.

Next, a visual analysis of the Wright map was performed, which made it possible to compare the distribution of participants by readiness level with the parameters of the scale points. This stage was important for assessing the targeting of the tool, that is, the degree to which statements correspond to the range of severity of the trait studied among respondents.

At the final stage, the differential functioning of the points was analyzed to identify possible bias of individual statements in relation to different subgroups of participants. In this study, the analysis was carried out by gender, which allowed us to determine whether the scale functions equally

for boys and girls. The absence of significant differences in the work of the points between the subgroups was considered as evidence of the fairness and stability of the instrument.

It can be concluded that the chosen methodological procedure provided a comprehensive quality check of the developed scale and made it possible to assess its suitability for further use in research on the professional readiness of future teachers to use neural network technologies in the educational process.

IV. RESEARCH RESULTS

A. The Results of the Study

1) One-dimensionality of the scale

To verify the one-dimensionality of the scale of professional readiness of future teachers for the use of neural network technologies in the educational process, an analysis of the main components of the residuals was carried out. The results showed that the main measured dimension explains 48.7% of the total variance, which exceeds the minimum allowable threshold of 40% and indicates acceptable compliance of the scale with the requirements of the Rasch model. The unexplained variance in the first contrast was 2.7 units of eigenvalue, or 6.1%, which also indicates the absence of a pronounced secondary dimension (Table 2). Taken together, these indicators allow us to conclude that the scale as a whole reflects a single integral construct of future teachers' professional readiness for the use of neural network technologies.

Logits are measurement units used in Rasch analysis to place both respondents and items on the same latent scale.

Higher positive logit values indicate higher respondent readiness or greater item difficulty, whereas negative values indicate lower readiness or easier agreement with the item. Outfit MNSQ reflects unexpected responses to items that are far from a respondent's ability level, while Infit MNSQ is more sensitive to responses near the respondent's estimated level. The separation index shows how well the scale distinguishes different levels of respondent readiness or item difficulty.

Table 2. Standardized residual variance (in eigenvalue units)

Indicator	Empirical significance	Percent
Total initial variance of observations	64.0	100.0%
Variance explained by the measured variable	31.2	48.7%
The variance explained by the respondents	17.5	27.3%
The variance explained by the points	13.7	21.4%
Unexplained residual variance	32.8	51.3%
Unexplained variance in 1st contrast	2.7	6.1%
Unexplained variance in the 2nd contrast	2.3	4.9%
Unexplained variance in the 3rd contrast	2.0	4.1%
Unexplained variance in the 4th contrast	1.8	3.6%
Unexplained variance in the 5th contrast	1.5	3.1%

2) Functioning of the rating scale

An analysis of the 7-point Likert scale showed that the response categories functioned in an orderly manner. The average values of the categories increased sequentially from -1.12 to 2.84 logits, which confirms the monotony of the scale (Table 3). The structural calibrations were also arranged in a logical sequence, without disturbing the order of the categories. This may suggest that respondents used the response categories in a statistically consistent and ordered manner (Fig. 1).

Table 3. Rating scale calibration analysis

Category	Frequency	Percent	Average observed value	Infit MNSQ	Outfit MNSQ	Structural calibration
1	12	2.8%	-1.12	1.41	1.55	-3.18
2	26	6.1%	-0.64	1.22	1.31	-1.94
3	49	11.4%	-0.08	1.09	1.14	-0.98
4	101	23.6%	0.57	0.97	1.01	-0.12
5	118	27.5%	1.14	0.93	0.95	0.84
6	94	21.9%	1.93	1.02	1.07	1.76
7	29	6.7%	2.84	1.18	1.24	3.05

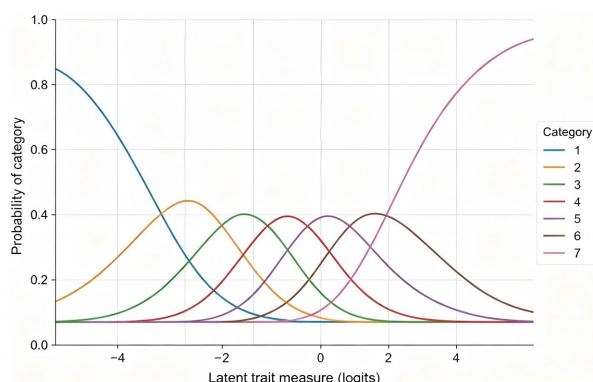


Fig. 1. The probabilities of response categories on a 7-point scale.

The correspondence of the points of the model and the polarity of the points.

Verification of compliance statistics showed that 34 of the 36 points on the scale meet the requirements of the Rasch model and demonstrate acceptable values of Infit and Outfit MNSQ. The values of Infit MNSQ ranged from 0.76–1.32, and Outfit MNSQ ranged from 0.74–1.39. The PTMEA

CORR coefficients ranged from 0.34–0.79, which indicates a positive relationship between most statements and the general construct (Table 4).

Table 4. Item compliance statistics

Point	Measure	Infit MNSQ	Outfit MNSQ	PTMEA CORR
Q1	0.48	1.18	1.24	0.61
Q2	0.72	1.26	1.31	0.58
Q3	0.35	1.14	1.19	0.64
Q4	0.81	1.32	1.54	0.49
Q5	-0.26	1.07	1.12	0.66
Q6	0.12	1.03	1.05	0.69
Q7	-0.14	0.94	0.96	0.72
Q8	-0.31	0.91	0.88	0.74
Q9	0.09	0.89	0.87	0.76
Q10	-0.18	0.84	0.81	0.77
Q11	0.66	1.29	1.39	0.34
Q12	-0.39	1.01	1.00	0.71
Q13	-0.07	0.93	0.92	0.73
Q14	0.21	1.02	1.01	0.70
Q15	-0.22	0.86	0.84	0.75
Q16	-0.11	0.82	0.80	0.76
Q17	-0.44	0.88	0.85	0.74
Q18	0.04	0.79	0.78	0.78
Q19	-0.15	0.95	0.94	0.71
Q20	0.27	1.16	1.18	0.63

Q21	-0.37	1.21	1.27	0.59
Q22	-0.29	0.92	0.90	0.73
Q23	-0.71	1.09	1.11	0.67
Q24	-0.18	0.98	0.96	0.71
Q25	-0.24	1.00	1.02	0.70
Q26	-0.17	0.88	0.86	0.74
Q27	-0.09	0.81	0.79	0.77
Q28	0.11	0.83	0.82	0.76
Q29	-0.03	1.01	1.04	0.69
Q30	0.19	1.13	1.17	0.64
Q31	-0.28	0.85	0.84	0.75
Q32	0.08	0.84	0.83	0.77
Q33	0.14	0.76	0.74	0.79
Q34	0.53	0.94	0.95	0.73
Q35	0.31	0.86	0.87	0.75
Q36	0.17	0.89	0.88	0.74

However, two points showed borderline values. Item Q4, related to the self-design of tasks using neural network technologies, showed a slightly increased value of Outfit MNSQ (1.54), and item Q11, related to the assessment of ethical risks of using AI, demonstrated reduced discrimination. This may be due to the fact that these aspects are either more difficult for students to perceive, or require more precise formulation. In a subsequent version of the scale, these statements can be clarified.

3) Reliability and separation indexes

The scale has demonstrated good reliability indicators. The reliability of the points was 0.95, and the reliability of the respondents was 0.91. The division index of points was 4.58, and the division index of respondents was 3.19. These values suggest that the scale may distinguish different levels of professional readiness among respondents and provide a stable hierarchy of item difficulty (Table 5).

Table 5. Reliability and separation indexes

Indicator	Points	Respondents
Separation index	4.58	3.19
Reliability	0.95	0.91

4) The wright map

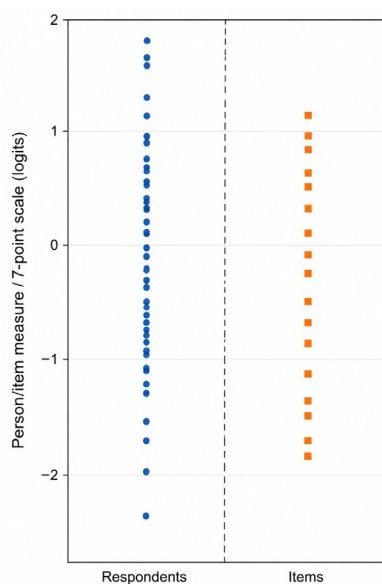


Fig. 2. Wright's map of the distribution of respondents and scale points.

An analysis of the Wright map showed that points Q4, Q11 and Q2 were the most difficult to agree on. These statements reflect more complex aspects of professional readiness

related to the design of pedagogical scenarios using neural network technologies, assessment of ethical risks and critical interpretation of the results of AI work. The least difficult point was Q23, which concerns the general recognition of the usefulness of neural network tools in the educational environment (Fig. 2).

The average level of readiness among the respondents was slightly higher than the average difficulty of the points. The difference between the average ability of respondents and the average difficulty of statements was 0.68 logits, which indicates a good targeting scale.

5) Differential Point Function (DIF)

A gender DIF analysis was performed to verify the invariance of the instrument. The results showed that the DIF contrast values for all points ranged from -0.34 to 0.19 logits, that is, they did not exceed the critical threshold of 0.50 logits (Table 6). This may indicate the absence of substantial gender-related item bias and supports the preliminary use of the scale across male and female respondents.

Table 6. DIF analysis by gender

Point	A measure for boys	A measure for girls	DIF contrast
Q1	0.52	0.44	0.08
Q2	0.79	0.63	0.16
Q3	0.38	0.31	0.07
Q4	0.89	0.71	0.18
Q5	-0.22	-0.30	0.08
Q6	0.15	0.10	0.05
Q7	-0.09	-0.17	0.08
Q8	-0.28	-0.34	0.06
Q9	0.04	0.13	-0.09
Q10	-0.15	-0.21	0.06
Q11	0.74	0.55	0.19
Q12	-0.35	-0.42	0.07
Q13	-0.03	-0.10	0.07
Q14	0.26	0.17	0.09
Q15	-0.18	-0.25	0.07
Q16	-0.07	-0.14	0.07
Q17	-0.39	-0.47	0.08
Q18	0.09	0.01	0.08
Q19	-0.11	-0.19	0.08
Q20	0.31	0.22	0.09
Q21	-0.29	-0.41	0.12
Q22	-0.22	-0.33	0.11
Q23	-0.65	-0.78	0.13
Q24	-0.12	-0.24	0.12
Q25	-0.18	-0.29	0.11
Q26	-0.11	-0.20	0.09
Q27	-0.04	-0.12	0.08
Q28	0.15	0.07	0.08
Q29	0.01	-0.06	0.07
Q30	0.22	0.14	0.08
Q31	-0.24	-0.31	0.07
Q32	0.12	0.05	0.07
Q33	0.18	0.10	0.08
Q34	0.58	0.46	0.12
Q35	0.34	0.25	0.09
Q36	0.20	0.16	0.04

V. DISCUSSION

The results obtained suggest that the scale of professional readiness of future teachers for the use of neural network technologies in the educational process has generally good psychometric characteristics. First, its structural integrity has been confirmed: the scale demonstrates acceptable one-dimensionality, which allows it to be used as an integral tool for assessing the overall readiness of future teachers to work with neural network technologies.

Although the instrument was conceptually organized into three content domains—cognitive, operational, and reflexive-motivational—the present Rasch analysis evaluated the scale as an overall measure of professional readiness. Therefore, the current findings support the use of the instrument as a unidimensional overall readiness measure. They do not confirm the existence of three separate empirical factors. Verification of the proposed internal structure requires additional factor-analytic procedures, such as EFA and CFA, and remains an important direction for future research.

The present findings are broadly consistent with previous studies examining AI literacy, digital competence, and technology readiness among pre-service teachers. Similar to the AI literacy framework proposed by Ng *et al.* [22], the current scale demonstrated that readiness extends beyond technical knowledge and includes ethical awareness and critical evaluation skills. Furthermore, the relatively higher difficulty of items related to instructional design and ethical decision-making supports observations by Kasneci *et al.* [23], who argued that future educators often demonstrate positive attitudes toward AI tools while lacking deeper pedagogical and critical competencies required for their responsible implementation. These results suggest that teacher education programs should place greater emphasis on applied AI pedagogy rather than focusing exclusively on technological familiarity.

The findings also support broader discussions on AI readiness in teacher education, which emphasize the integration of technological, pedagogical, and ethical competencies rather than isolated technical skills. The relatively higher difficulty of Q4 and Q11 suggests that future teachers require structured opportunities to practice AI-supported instructional design and ethical decision-making. Consequently, teacher education curricula may benefit from dedicated AI pedagogy modules, supervised practical activities, and reflective exercises involving neural network technologies.

Most of the points on the scale demonstrated good compliance with the model. At the same time, statements related not to a general positive attitude towards neural network technologies, but to their deep pedagogical and ethical understanding, turned out to be more difficult to agree on. This can be interpreted as a sign that students find it easier to accept the very fact of the usefulness of neural network tools than they are ready for their responsible, critical and methodically sound application in the real educational process.

High reliability and separation rates suggest that the scale may be suitable for both scientific research and practical diagnostic applications. The absence of a significant gender DIF also reinforces the argument for the fairness and sustainability of the developed tool.

However, some points, primarily Q4 and Q11, require additional work. In the future, it is advisable to clarify their formulations and re-test them on a wider sample. Additional factors verifying the scale using CFA or EFA on new data is also a promising direction.

VI. LIMITATIONS AND FUTURE RESEARCH

The study has several limitations. First, the sample

consisted of 150 students from one university, which is acceptable for preliminary Rasch validation but limits the generalizability of the findings. Second, the use of convenience sampling may have introduced sampling bias, as participants were selected based on availability rather than through random sampling. Third, the study relied on self-reported readiness, which may overestimate actual competence in using neural network technologies. Fourth, the validation was conducted in a single institutional and national context. Therefore, future studies should test the scale with larger and more diverse samples, include students from different universities and educational programs, and combine self-report data with performance-based tasks or observational measures.

VII. CONCLUSION

In this study, a scale of professional readiness of future teachers for the use of neural network technologies in the educational process was developed and validated, which made it possible to fill the existing gap between theoretical ideas about the digital transformation of education and practical tools for its assessment. The results obtained confirmed that the proposed tool has satisfactory psychometric characteristics and can be used to diagnose the level of formation of students' professional readiness to use neural network technologies in teaching activities.

The developed scale provides researchers and teachers with the opportunity to identify specific deficits in the training of future teachers, including insufficient knowledge of neural network technologies, limited practical skills in their application, as well as an insufficiently formed reflexive and ethical position regarding the use of artificial intelligence in education. This, in turn, creates the basis for the development of targeted educational interventions aimed at improving the quality of teacher training in the context of digitalization of education.

In addition, the use of this scale makes it possible to evaluate the effectiveness of the implementation of innovative pedagogical approaches, courses and educational programs focused on the development of AI competence, as well as to track the dynamics of the formation of professional readiness of students over time.

At the same time, the conducted research opens promising areas for further scientific research. It seems advisable to study the factors influencing the formation of future teachers' professional readiness for the use of neural network technologies, including the individual characteristics of students, the level of digital training, the features of the educational environment, as well as pedagogical conditions and teaching methods. Additional research may be aimed at testing the stability of the scale in various educational contexts, as well as at expanding its application in international comparative studies.

However, because the validation was conducted within a single institutional context, the findings should be interpreted as exploratory. Further validation with larger and more diverse samples is required before the scale can be recommended for broad national or international use.

Based on this, the proposed tool has promising potential as a preliminary validated instrument for use both in scientific research and in educational practice, contributing to a deeper

understanding of the processes of formation of professional readiness of future teachers to work in the context of the active introduction of neural network technologies into the educational environment.

APPENDIX

A. Full Scale Items

The grouping of items into content domains is conceptual and reflects the theoretical framework used during scale development. Item numbering was retained to preserve consistency with the Rasch analysis Table A1.

Scale of Professional Readiness of Future Teachers for the Use of Neural Network Technologies in the Educational Process

Response format: 1 = Strongly Disagree, 2 = Disagree, 3 = Partially Disagree, 4 = Neutral, 5 = Partially Agree, 6 = Agree, 7 = Strongly Agree. Although items are presented within conceptual content domains, item numbering follows the original sequence used during Rasch calibration. Consequently, some items discussed in the Results section (e.g., Q4 and Q11) are retained in their original numbering to ensure consistency between the psychometric analysis and the item list.

A. Cognitive Component

- Q1. I understand the basic principles of how neural network technologies function.
 Q2. I am familiar with the main types of neural network technologies used in education.
 Q3. I understand the pedagogical potential of neural network technologies in the educational process.
 Q4. I can independently design learning tasks using neural network technologies in accordance with pedagogical objectives.
 Q5. I am aware of the advantages of using neural network technologies in teaching and learning.
 Q6. I understand the limitations of neural network technologies in educational contexts.
 Q7. I am familiar with common applications of artificial intelligence in education.
 Q8. I understand how neural network technologies can assist in educational content creation.
 Q9. I understand how AI-based systems can support assessment and feedback processes.
 Q10. I am aware of ethical issues related to the use of neural network technologies in education.
 Q11. I can critically assess the ethical risks associated with the use of artificial intelligence and neural network tools in education.
 Q12. I understand the role of teachers when working with neural network technologies in modern educational environments.

B. Operational Component

- Q13. I can effectively use neural network tools to prepare educational materials.
 Q14. I can select appropriate neural network technologies according to learning objectives.
 Q15. I can integrate AI-based tools into lesson planning.
 Q16. I can use neural network technologies to support student learning activities.
 Q17. I can apply AI tools to create instructional resources.
 Q18. I can use neural network technologies to generate examples, exercises, and learning tasks.
 Q19. I can evaluate the quality of educational materials generated by AI systems.
 Q20. I can adapt AI-generated content to the needs of specific learners.
 Q21. I can use neural network technologies to provide feedback to students.
 Q22. I can employ AI tools to analyze educational information and learning outcomes.
 Q23. I can independently use neural network technologies during teaching practice.
 Q24. I can integrate neural network technologies into different stages of the teaching process.

C. Reflexive-Motivational Component

- Q25. I am interested in learning how to use neural network technologies in education.
 Q26. I am motivated to integrate AI-based tools into my future professional activities.
 Q27. I believe that neural network technologies can improve the quality of education.

- Q28. I am willing to continuously improve my AI-related competencies.
 Q29. I feel confident about using neural network technologies in my future teaching career.
 Q30. I am open to experimenting with innovative AI-based educational approaches.
 Q31. I critically evaluate the outputs generated by neural network technologies.
 Q32. I can identify potential inaccuracies in AI-generated educational content.
 Q33. I can critically assess the reliability of information produced by AI systems.
 Q34. I can reflect on the broader social consequences of AI use in education.
 Q35. I consider issues of academic integrity when using AI technologies.
 Q36. I am prepared to reflect on the educational consequences of using neural network technologies in teaching practice.

Table A1. Item parameter estimates

Item	Measure (logits)	Infit MNSQ	Outfit MNSQ	PTMEA CORR
Q1	0.48	1.18	1.24	0.61
Q2	0.72	1.26	1.31	0.58
Q3	0.35	1.14	1.19	0.64
Q4	0.81	1.32	1.54	0.49
Q5	-0.26	1.07	1.12	0.66
Q6	0.12	1.03	1.05	0.69
Q7	-0.14	0.94	0.96	0.72
Q8	-0.31	0.91	0.88	0.74
Q9	0.09	0.89	0.87	0.76
Q10	-0.18	0.84	0.81	0.77
Q11	0.66	1.29	1.39	0.34
Q12	-0.39	1.01	1.00	0.71
Q13	-0.07	0.93	0.92	0.73
Q14	0.21	1.02	1.01	0.70
Q15	-0.22	0.86	0.84	0.75
Q16	-0.11	0.82	0.80	0.76
Q17	-0.44	0.88	0.85	0.74
Q18	0.04	0.79	0.78	0.78
Q19	-0.15	0.95	0.94	0.71
Q20	0.27	1.16	1.18	0.63
Q21	-0.37	1.21	1.27	0.59
Q22	-0.29	0.92	0.90	0.73
Q23	-0.71	1.09	1.11	0.67
Q24	-0.18	0.98	0.96	0.71
Q25	-0.24	1.00	1.02	0.70
Q26	-0.17	0.88	0.86	0.74
Q27	-0.09	0.81	0.79	0.77
Q28	0.11	0.83	0.82	0.76
Q29	-0.03	1.01	1.04	0.69
Q30	0.19	1.13	1.17	0.64
Q31	-0.28	0.85	0.84	0.75
Q32	0.08	0.84	0.83	0.77
Q33	0.14	0.76	0.74	0.79
Q34	0.53	0.94	0.95	0.73
Q35	0.31	0.86	0.87	0.75
Q36	0.17	0.89	0.88	0.74

Note: Measure = item difficulty expressed in logits; Infit MNSQ = information-weighted fit statistic; Outfit MNSQ = outlier-sensitive fit statistic; PTMEA CORR = point-measure correlation coefficient. Acceptable item functioning is generally indicated by positive PTMEA CORR values and Infit/Outfit MNSQ values close to 1.00.

B. Item Parameter Estimates

To enhance transparency and facilitate independent evaluation of the Rasch calibration results, Appendix B presents the item-level parameter estimates obtained during the validation process. The table includes item difficulty measures (logits), Infit Mean Square statistics, Outfit Mean Square statistics, and Point-Measure Correlation coefficients (PTMEA CORR). These indicators provide additional information regarding item functioning, measurement consistency, and the contribution of individual items to the overall construct of professional readiness for the use of neural network technologies in education.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Berdimuratova Zhanar, Anara Karymsakova and Lili Nurliyana Abdullah conducted the literature search, analyzed the data and wrote the paper. Zhandos Zulpykhar and Meruert Serik visualized the data and reviewed the manuscript. All authors have accepted the final version of the manuscript.

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