A Multi-criteria-Based Expert Modeling for Assessing the Textbook Quality

Zhanat Nurbekova, Talgat Sembayev*, Dauren Dossymbek, Kanagat Baigusheva, Sayat Omarov, and Yeldos Nurlanov

***Abstract*—This research considers the application of a multi-criteria approach to assess the quality of textbook content. The issues of determining evaluation criteria and organizing the work of experts are brought to the fore, as these factors directly affect the objectivity and efficiency of the evaluation process. The definition of criteria consisted of reviewing common mistakes and comments on the quality of textbooks, forming a preliminary and final list of criteria. The organization of the work of the experts consisted in the development of a platform with the introduction of a multi-criteria approach. As a result, 39 criteria were formulated and proposed, grouped into 10 main sections such as "Structure and organization", "Content", "Didactic aspects", "Methodological aspects", "Language level", "Psychological and psycholinguistic aspects", "Cultural and Value Aspects", "ICT Integration", "Differentiation Aspects", and "Layout and Design". The work of experts in the developed expert system is described, which helps in making a decision. The implementation of the multi-criteria approach in this expert system is the main contribution of the research work, which helps to improve the process of evaluating textbooks. The paper presents the results of the survey among 44 experts that helped to identify the most significant criteria which affect the evaluation a textbook. The paper presents the results of the survey among 44 experts that helped to identify the most significant criteria which affect the evaluation a textbook. Moreover, the base of allowed errors was formulated for the following types: for illustrations, QR codes, for texts, for the language of presentation, technical errors, content errors, errors for multimedia objects.**

***Index Terms*—Assessment, descriptors, multicriteria assessment, textbook**

I. Introduction

The digital transformation of education makes an invaluable contribution to the learning process, making it more efficient and as accessible as possible for students. The development of educational platforms, mobile learning and integration with advanced digital technologies are proof of this. Yet one thing remains unchanged—the use of textbooks in teaching. The textbook is the main compass orienting the teacher and the student in the assimilation of new knowledge [1]. Moreover, textbooks reflect socio-cultural values, political ideologies that are distinct from the dissemination of knowledge. Indeed, at the level of UNESCO, the development and revision of textbooks and curricula was recognized as a high priority [2, 3]. In June 2018, the First International Summit was held in London, where 14 countries came to the conclusion that the neglect of textbooks is a gross mistake in public policy and international comparisons reveal important principles of quality [4]. As you know, the advantages of quality textbooks are enough. They help standardize learning, provide structure according to the curriculum, can educate both students and teachers, and define the main trajectory. Among the shortcomings of low-quality textbooks are deviations from the direction of study, inconsistency with the needs of students, distortion of content, etc. [5]. It is important to emphasize that in the study, textbooks mean a set of educational publications, which include educational and methodological complexes, methodological guides for performing practical and laboratory work, electronic textbooks that accompany digital content, etc.

The review of textbooks is a necessary condition for any effective educational process, which is characterized by the achievement of the general goals set by the education system, as well as the goals and objectives outlined by a well-organized curriculum.

The need for quality textbooks is increasing every day, and new methods of evaluating their quality are emerging. Different countries have different textbook approval systems, but in general they can be divided into four main models: liberal or laissez-faire, centralized, accreditation model and professional assessment model [6]. Whereas in the US, the textbook board focuses on textbook content and style, organization of learning activities, assessment strategy, and assessment materials, in the Philippines, the National Book Development Board (NBDB) has a policy of evaluating books based on curriculum coverage competencies, accuracy of content, relevance to society and culture, and correctness of the language used [7]. Many developing countries strategically focused on quality education are developing their own criteria for evaluating educational materials. Pasaribu in his article gives a variety of criteria for evaluating the quality of textbooks, in which he highlights: compliance with the curriculum, integration with teaching methods, the function of helping the teacher and the student, the attractiveness of the illustrations used, stimulating creativity, consolidating the values of adults and children [1].

The international literature and practice of various educational systems emphasizes the diversity of approaches

Manuscript received February 27, 2023; revised April 17, 2023; accepted June 13, 2023.

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doi: 10.18178/ijiet.2023.13.9.1944

to the examination of textbooks. Despite the great variety of types of verbal examination in the form of reports, the most common form of examination is the "structured examination" of the most important characteristics of the textbook [8]. They are defined at the very beginning and combine the main and most valuable features of an effective textbook. It should be mentioned that this approach may vary, as its structure depends on the concept of examination underlying it. Undoubtedly, the criteria for evaluating textbooks should simultaneously cover the maximum number of development aspects and a more specific formulation of the requirement. This prompted the use of a multi-criteria approach to assess the quality of textbooks in our research.

The next necessity in achieving a quality textbook is the effective organization of the work of the experts who evaluate it. After all, all the processes accompanying the evaluation of the textbook can affect the speed and objectivity of the decisions made. Optimization of this process is impossible without the use of digital technology. There is a problem of workload of experts, which negatively affects the quality of assessment. In addition, often repeated mistakes of the authors complicate the work and slow down the productivity of experts. The fragmentation and heterogeneity of the information processed in the process of reviewing the content of textbooks, the lack of knowledge management tools and a scientifically based quality assessment system shows the unresolved problem of providing experts with digital intellectual services for conducting an examination and making objective decisions, as well as monitoring the examination process.

In connection with the above problems, complex research tasks were set:

- firstly, to develop a science-based system for assessing the quality of textbooks based on multi-criteria assessment
- secondly, to develop a platform for the effective organization of the work of experts

The purpose of this study is to determine the impact of multi-criteria assessment through a system for experts on improving the quality of textbooks.

The study touches upon the issues of the specifics of the implementation of multi-criteria assessment of the quality of textbooks in an expert system and the optimization of the work of experts.

II. Literature Review

Multi-criteria evaluation is an approach to decision evaluation that takes into account several criteria instead of one. In this approach, solutions are evaluated on the basis of several attributes and the solution is considered the best if it has the best performance in all criteria. For example, when assessing the quality of an English textbook for an Indonesian high school, this method has shown its applicability [9]. As part of the American Project 2061, which aims to improve science education, the following criteria are used to assess the learning effectiveness of each textbook: providing a sense of purpose, taking account of student ideas, engaging students with relevant phenomena, developing and using scientific ideas, promoting students 'thinking about phenomena, experiences, and knowledge, assessing progress, enhancing the science learning environment [10, 11].

The results of a study on the application of the Multi-Criteria Decision Making Method (MCDM) over the past decade are conceptually presented in the work of Taherdoost H. and Madanchian M. Examples of the main elements of the MCDM concept are given, such as alternatives, aggregation, criteria, preferences, decisions, etc. The main categories and various classifications of MCDM are described. According to the ScienceDirect database, from 2012 to 2022. 10116 articles used the keywords "multi-criteria decision making" and 7619 articles "MCDM", respectively. Moreover, the increase in published scientific articles in recent years on the use of MCDM shows that it has become more popular [12].

The multi-criteria assessment method has proven its effectiveness and is widely used in many areas. It helps in making complex decisions with a collaborative approach [13–15], justifying and weighing each element of influence on the final conclusion.

In the studies of Biswas and Pamucar multi-criteria analysis was successfully used to decide on the most suitable location for B-schools (Business schools). They identified the factors influencing the decision when choosing an educational institution and identified the main criteria such as location awareness, convenience in traveling, commutation time, connectivity with market, connectivity with the recruiters/industrial zones, availability of the amusement facilities, availability of medical facilities, internet accessibility, environment friendliness, safety, cost of commutation/living, familiarity with the local language [16]. In addition, various MCDM methods such as Evaluation based on Distance from Average Solution (EDAS), Additive Ratio Assessment (ARAS), Multi-Attributive Border Approximation Area Comparison (MABAC), Measurement of Alternatives and Ranking according to compromise Solution (MARCOS) and Complex Proportional Assessment (COPRAS) have been successfully used in selecting the most suitable SMD (smart mobile devices) resource for MCC (mobile crowd computing) [17].

The use of a multi-criteria approach to assess the quality of service and website selection problems has proven to be effective. A study covering the period from 2005 to 2016 showed that the most common individual approach to assessing the quality of service of a website and its choice is AHP (the analytic hierarchy process) and the main criterion for its performance is responsiveness [18]. Moreover, multi-criteria decision-making models help in evaluating environmental education programs [19], the effectiveness of e-learning (e-learning) [20], and even in evaluating acquired knowledge, abilities, and actitudes at the Energy Markets course [21].

Thus, the applicability of the multicriteria approach in different fields of science prompted us to use it to improve the quality of textbooks through the use of this model in an expert system.

III. Methods

The study began by identifying the need to improve the quality of textbooks. For this, 77 comments on the quality of

textbooks from various sources, such as news portals, newspapers, electronic media, social networks and letters to higher authorities, were reviewed and analyzed. According to the results of which 23 errors were confirmed. Moreover, many errors occurred several times: 4 misprint errors, 8 technical errors, 9 factual errors, 1 substantive error, 1 mistranslation (Fig. 1).

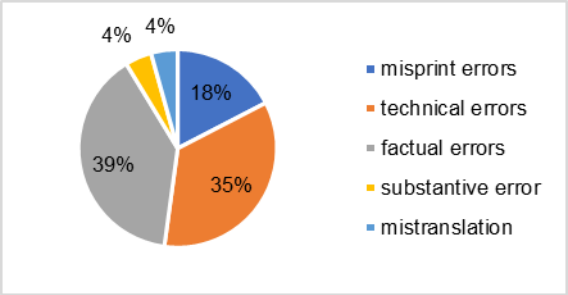

Fig. 1. Analysis of textbook content errors.

This fact also enhances the relevance in improving the quality of the content of textbooks. An objective assessment of the quality of the content of textbooks is also an urgent need in our realities.

Preliminary identification of errors in the content of textbooks helped determine the main criteria that will be used to develop detailed criteria.

The main stage of the study was the development of detailed criteria for evaluating the quality of textbooks. An analysis of existing criteria helped formulate 78 criteria, which are grouped into 10 main sections (Table I). They were then submitted to the experts for consideration.

TABLE I: CRITERIA PROPOSED FOR ASSESSING THE QUALITY OF TEXTBOOKS

№	Criteria
	Structure and organization of the textbook
1	Table of contents
2	Learning objectives described at the beginning of each chapter
3	Introduction to each chapter
4	Additional and explanatory texts
5	Applications
6	List of sources used
	Content
7	Implementation of the learning objectives specified in the curriculum (knowledge, skills and application)
8	Availability of basic knowledge (themes and subtopics provided for by the curriculum)
9	Logical sequence in the content of the textbook (logicality and interconnection of chapters, sections, paragraphs and topics)
10	Using the previous knowledge of students
11	Clarification of common misconceptions, erroneous versions
12	The presence of new (non-standard) situations / examples in the textbook
13	The degree of localization of the context (local history aspects)
14	Reliability of information. Correspondence of the presentation of the content to scientific and problematic approaches
15	Relevance of information
16	Using Appropriate Units and Metric Symbols
17	Specify the resources needed to complete the learning tasks
18	Adaptation of the content to the conditions of real life and activity
19	Balance between the volume and depth of the stated subject content
20	Compliance of the level of complexity of the content with the age characteristics and cognitive abilities of students
21	Intra-subject communication in the content of the textbook
22	Interdisciplinary integration of educational content
23	A variety of forms of presentation of educational content in the main, additional and explanatory texts
24	Correspondence of visual elements (graphics, pictures, maps, etc.) to the educational content
25	The presence of correct and understandable labels for visual elements (graphics, pictures, maps, etc.)
26	Availability of additional literature for reading
	Didactic aspects
27	The presence in the textbook of materials on applied, practice-oriented strategies for active and interactive learning
28	The presence in the textbook of various tasks and tasks for the development of critical thinking and analytical skills
29	The presence in the textbook of various tasks and tasks for the development of creative thinking
30	The presence in the textbook of personality-oriented tasks and tasks
	Methodological aspects
31	Orientation of tasks, assignments and exercises to achieve learning outcomes (LO)
32	Clarity in the wording of tasks and assignments
33	Implementation of the principle “from simple to complex”. Gradation of educational materials according to the level of complexity
34	Relevance, balance of tasks, assignments and exercises in quantity, compliance with learning objectives
35	The focus of the methodological apparatus and the assessment system on the implementation of learning outcomes (knowledge, skills and application)
36	Formation and development of functional literacy
37	Tasks that motivate and promote the active participation of students in the educational and cognitive process
38	The presence in the textbook of graphs, tables, diagrams that facilitate the perception of educational content
39	Tasks, tasks that provide motivation for independent educational, cognitive and research activities

40	The presence of tasks aimed at developing all levels of thinking skills according to Bloom's taxonomy
41	Opportunities for Formative Assessment
42	The presence of varieties of tasks, assignments and exercises
43	Tasks, tasks that provide motivation for joint educational and cognitive activities
44	Tasks and assignments that contribute to the use of various combinations of joint educational and cognitive activities (individual, pair, group, etc.)
45	Providing Self-Assessment Opportunities
46	Tasks that contribute to the development of communication skills (individual, student-student, student-teacher, students)
	Language level
47	Correspondence of the language of presentation to age and cognitive level
48	Unity in the interpretation of terms and definitions
49	Spelling Compliance
50	Accessibility and clarity of language
	Psychological and psycholinguistic aspects
51	Compliance of the content of the textbook with the age and psychological characteristics of students
52	The focus of the content of the textbook on the development of educational interests, intellectual and creative abilities of students
53	The focus of the content of the textbook on the development of students' motivation for in-depth study of educational materials
54	Correspondence of the visual and illustrative material of the textbook with the age, psycho-logical characteristics of students, ethical and aesthetic ideas
55	Correspondence of the text, sentence structure and phrase combinations to the age of students, the tasks of better understanding the content
56	Correspondence of new concepts, definitions and terms to the age and experience of students
57	The presence of a variety of tasks and exercises for the development of general and practice-oriented types of speech activity
	Cultural and value aspects
58	The focus of the textbook on the basic values defined in the state standards, the focus of topics and tasks on the implementation of educational tasks
59	Representation in the content of educational materials and illustrations about the natural and historical features of the country
60	Representation in the content of educational materials and illustrations about the national-cultural and family values of the country
61	Representation in the content of educational materials and illustrations about state priorities and socio-economic, technological achievements of the country
62	Representation in the content of educational materials and illustrations about universal values
63	Attention to issues of social equality, respect for ethnic and cultural groups and religions, tolerant attitude towards people with disabilities
	ICT integration
64	Opportunities for independent and collaborative work using ICT competencies
65	Integration of digital services and tools with the textbook
66	Motivating students to complete educational tasks (including independently) using ICT
67	Availability of a list of official sources of educational information for students (links)
	Aspects of differentiation
68	Providing support to students, taking into account different levels of knowledge and cognitive abilities
69	Promote educational materials to ensure equality in education and avoid social differentiation and infringement in educational content
	Layout and design
70	Consistency and convenience of the structure of the organization of educational materials on the pages
71	Compliance with sanitary and hygienic requirements for the weight and format (size) of the textbook
72	Readability and convenience of fonts and line spacing
73	Ease of navigation (table of contents, indexes and symbols)
74	The attractiveness of the textbook appearance (graphic organizers, images and illustrations, colors, etc.)
75	Ensuring the harmony of text and illustrative materials based on design principles (balance, hierarchy, contrast, space, scale and combination)
76	Technical quality of visual elements, use of colors
77	Content and visual difference between types of texts (main, explanatory and additional)
78	Headings and other navigational support (titles, headings, instructions, typographical notes)

As you know, a prerequisite for the effectiveness of multi-criteria assessment is the approbation and feedback of experts who evaluate textbooks in practice.

Approbation of the proposed initial list of criteria showed that due to the non-universality of textbooks, that is, different types of textbooks with the requirements for them are not always satisfied and need to be improved through the grouping of criteria with the necessary descriptions.

Therefore, in order to determine the importance of each proposed criterion as a qualitative feature and assign a weight share, a survey was conducted of 44 experts who have more than 5 years of experience as an expert. According to the results of the survey, the proposed criteria were improved and reformulated to adapt to the developed expert system.

At the next stage of the study, work was carried out to develop an expert system for evaluating the quality of textbook content (Fig. 2). An expert system embodies the experience of an expert in the intelligence of a computer, is able to generate recommendations, make an intelligent decision on a specific operation/function based on the knowledge base.

The expert system database was powered by the advanced, enterprise-class open-source relational database system PostgreSQL. It extends the SQL language, combined with many features to securely store and scale the most complex data work-loads. As an ORM (Object Relation Mapping) tool, Django ORM was used, which interacts with databases using high-level Python methods. When creating the data-base, the

code-first approach was applied (Fig. 3), which allows you to manage and focus on the subject area of the class creation platform.

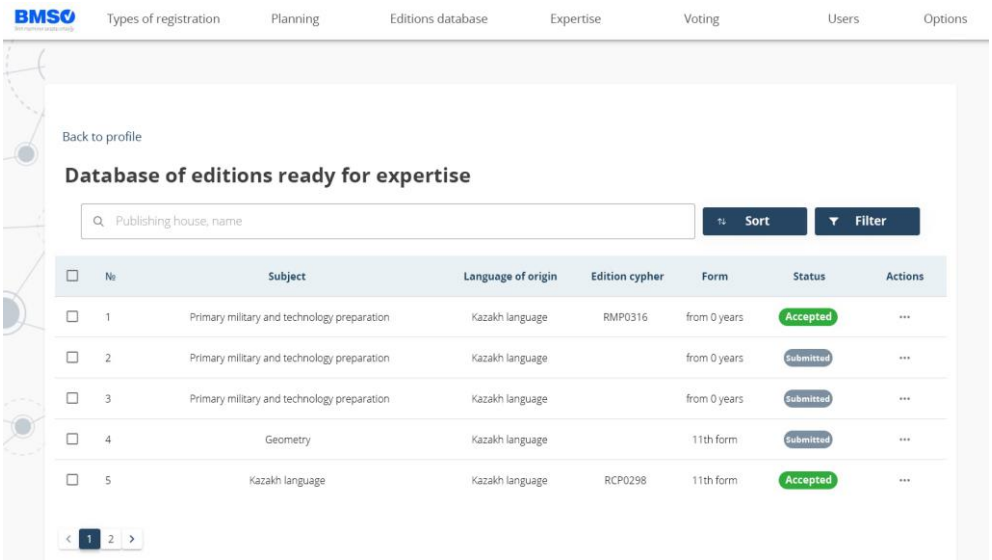

Fig. 2. Expert system interface.

Fig. 3. The code-first approach.

In the course of constant refinement of the back-end part of the platform, a normalization approach was used for the correct functioning of the database. Normalization aims to eliminate redundant (repetitive) data and provide logical data storage.

The developed expert system includes many modules that automate and optimize the work of experts, positively affecting their productivity. Nevertheless, a full assessment of the content component of textbooks is impossible without the physical participation of experts who embody the approach of human-computer interaction, taking into account the contextual, semantic load. Therefore, the expert system pro-vides experts with digital intellectual services for conducting examination and making objective decisions, as well as monitoring the examination process. A feature is the introduction of the above proposed multi-criteria assessment based on a multivariate analysis of the examination process with the selection of the main vectors and components of the expert assessment.

In general, the expert system contributes to a deeper understanding of inductive reasoning and machine learning, allows you to implement the organization and presentation of data, interpret, search and apply expertise data to gain knowledge, make decisions and, ultimately, make predictions, avoiding bias. The snippet below shows the detection of errors and the definition of error types (Fig. 4).

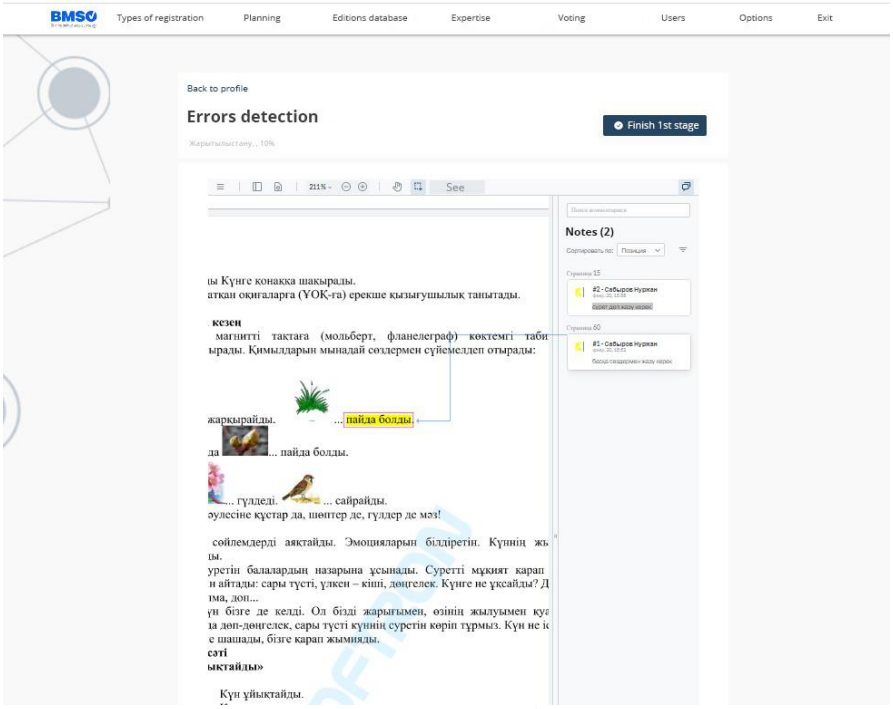

Fig. 4. Error detection and brief comment.

At this stage, experts look through textbooks and, if errors are found, select the necessary fragments and select the type of error from the list proposed by the system by entering their comments. All entered comments are displayed on the right side with a page indication. In the future, all comments and errors will be included in the expert decision.

Depending on the type of textbook, each section is assigned a weight share, which helps to prioritize the assessment criteria (Fig. 5).

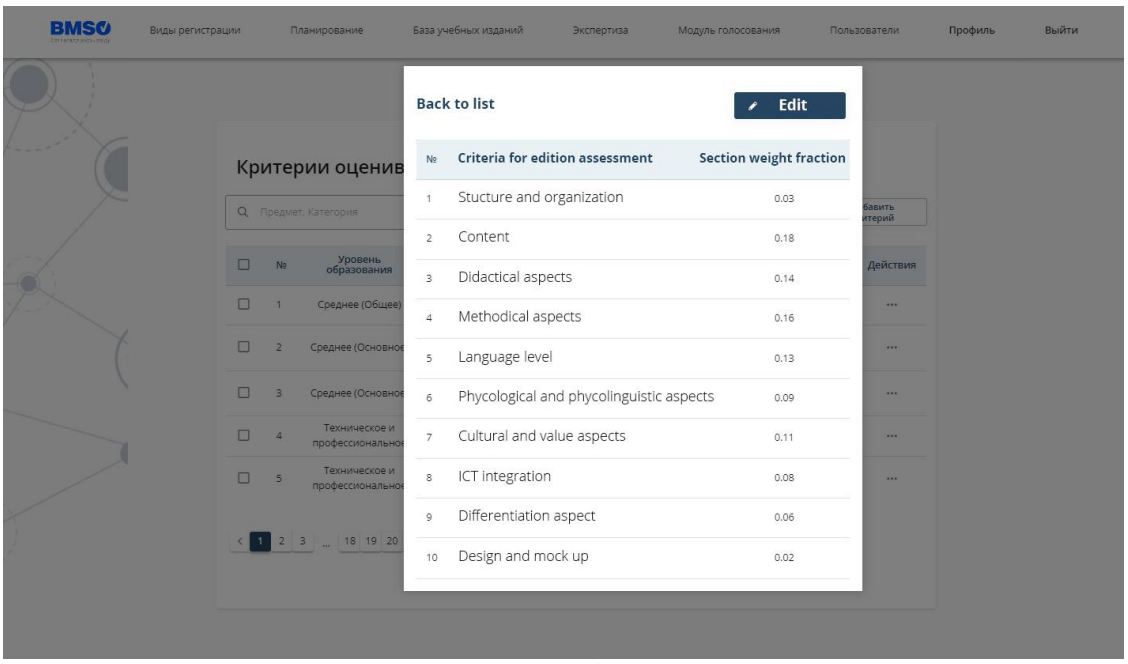

Fig. 5. Weight fraction.

The ability of an expert to justify his choice with the help of an appropriate commentary, example, or scientific argument, where the expert considers it necessary. Brief written notes are specific and concise and in most cases are the main benefit of a particular criterion. Experts do not have the opportunity to score at random, as they may have to justify their choice. So, in the case of setting less than three points according to the evaluation criterion, in the "Comment" column, the experts briefly and concisely justify the reasons for the decrease. In the code of errors and shortcomings, the reasons for the decrease are indicated in more detail. The methods used in this study led to the formation of clear criteria with the necessary descriptors based on the results of a survey of experts and the implementation of the development of an expert system for evaluating the quality of textbook content.

IV. Results and Discussions

As a result of the research work, a positive effect was obtained from the implementation of a multi-criteria assessment of the quality of a textbook in an expert system. This is confirmed by the fulfillment of research tasks and the achievement of the goal.

A detailed survey of 44 experts made it possible to identify more significant criteria that help in evaluating and determining the weight share of each criterion in the expert system.

The first question was supposed to identify the most important aspect of the text-book evaluation from the proposed 10 sections. Experts rated on a scale from 1 to 10, where 1 is the lowest importance, 10 is the highest importance (Fig. 6).

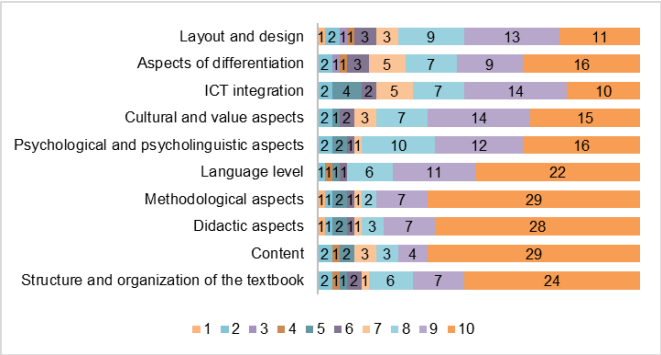

Fig. 6. Rating the importance of each section of textbook evaluation aspects.

As a result, it turned out that the most important sections, according to experts, were "Content" and "Methodological aspects" of the textbook. The maximum number, that is, 29 respondents out of 44, rated these sections at 10 points.

The following questions helped uncover the criteria for each section.

The questions in Section 1 "Structure and organization" were intended to identify the significance of each criterion, on a scale from 0 to 6. Respondents rated 1 for the lowest importance, 6 for the highest importance, and 0 if the criterion is not needed or not measurable (Fig. 7).

According to the results of the survey, 26 experts rated the "Table of Contents" at 6 points, thereby determining this criterion as the most significant for this section. The second most important criterion was "Learning objectives, description at the beginning of each chapter", which was rated by 24 experts at 6 points. The "Applications" criterion received the 11th lowest number of top scores.

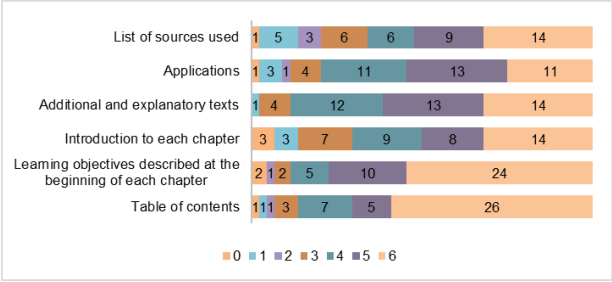

Fig. 7. Section 1 "structure and organization".

The results for Section 2 "Content" showed that the criterion "Implementation of the learning objectives specified in the curriculum (knowledge, skills and application)" turned out to be the most significant, because 33 experts rated it with the maximum score. The criterion "Clarification of common misconceptions, erroneous versions" turned out to be the least significant, since only 7 experts voted for it (Table II).

TABLE II: SECTION 2 "CONTENTS"

Criteria	Score
Implementation of the learning objectives specified in the curriculum (knowledge, skills and application)	33
Availability of basic knowledge (themes and subtopics provided for by the curriculum)	31
Reliability of information. Correspondence of the presentation of the content to scientific and problematic approaches	31
Logical sequence in the content of the textbook (logicality and interconnection of chapters, sections, paragraphs and topics)	29
Relevance of information	28
Compliance of the level of complexity of the content with the age characteristics and cognitive abilities of students	26
Correspondence of visual elements (graphics, pictures, maps, etc.) to the educational content	23
Using Appropriate Units and Metric Symbols	21
Adaptation of the content to the conditions of real life and activity	21
The presence of correct and understandable labels for visual elements (graphics, pictures, maps, etc.)	20
Intra-subject communication in the content of the textbook	19
Using the previous knowledge of students	18
Balance between the volume and depth of the stated subject content	17
The presence of new (non-standard) situations / examples in the textbook	16
Specify the resources needed to complete the learning tasks	14
Interdisciplinary integration of educational content	14
A variety of forms of presentation of educational content in the main, additional and explanatory texts	14
Availability of additional literature for reading	9
The degree of localization of the context (local history aspects)	8
Clarification of common misconceptions, erroneous versions	7

The results in Section 3 "Didactic Aspects" showed that the criteria "The presence in the textbook of various tasks and tasks for the development of critical thinking and analytical skills" and "The presence in the textbook of various tasks and tasks for the development of creative thinking" are of the greatest importance (Fig. 8).

The criterion "Orientation of tasks, assignments and exercises to achieve learning outcomes (LO)", which refers to Section 4 "Methodological Aspects", turned out to be the most significant. For this criterion, 31 experts gave the maximum score. The criterion "Tasks that promote the development of communication skills (individual, student-student, student-teacher, students)" received only 11 maximum points, which showed the least significance of all proposed (Table III).

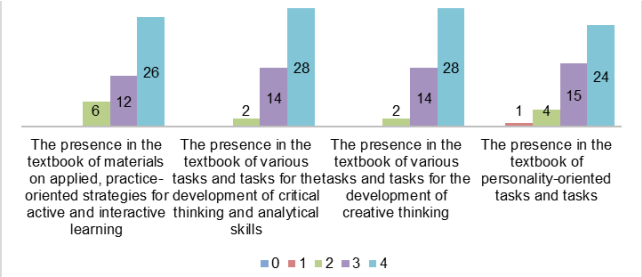

Fig. 8. Section 3 "didactic aspects".

TABLE III: SECTION 4 "METHODOLOGICAL ASPECTS"

Criteria	Score
Orientation of tasks, assignments and exercises to achieve learning outcomes (LO)	31
Clarity in the wording of tasks and assignments	30
Implementation of the principle "from simple to complex". Gradation of educational materials according to the level of complexity	30
Relevance, balance of tasks, assignments and exercises in quantity, compliance with learning objectives	26
The focus of the methodological apparatus and the assessment system on the implementation of learning outcomes (knowledge, skills and application)	26
Formation and development of functional literacy	26
Tasks that motivate and promote the active participation of students in the educational and cognitive process	25
The presence in the textbook of graphs, tables, diagrams that facilitate the perception of educational content	24
Tasks, tasks that provide motivation for independent educational, cognitive and re-search activities	23
The presence of tasks aimed at developing all levels of thinking skills according to Bloom's taxonomy	22
Opportunities for Formative Assessment	18
The presence of varieties of tasks, assignments and exercises	17
Tasks, tasks that provide motivation for joint educational and cognitive activities	16
Tasks and assignments that contribute to the use of various combinations of joint educational and cognitive activities (individual, pair, group, etc.)	14
Providing Self-Assessment Opportunities	14
Tasks that contribute to the development of communication skills (individual, student-student, student-teacher, students)	11

In section 5 "Language level", the criterion "Accessibility and clarity of presentation" turned out to be the most important, because it received 38 highest votes of experts (Fig. 9).

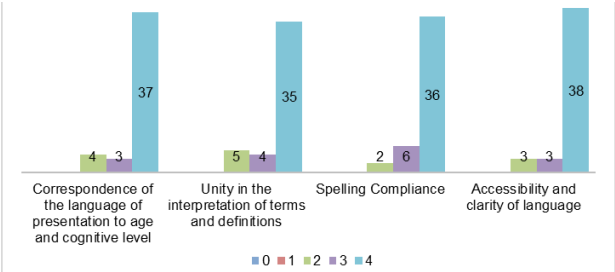

Fig. 9. Section 5 "language level".

In Section 6 "Psychological and psycholinguistic aspects", the criterion "Compliance of the visual and illustrative material of the textbook with the age, psychological characteristics of students, ethical and aesthetic ideas" received 34 points, which is the highest number of maximum points (Fig. 10).

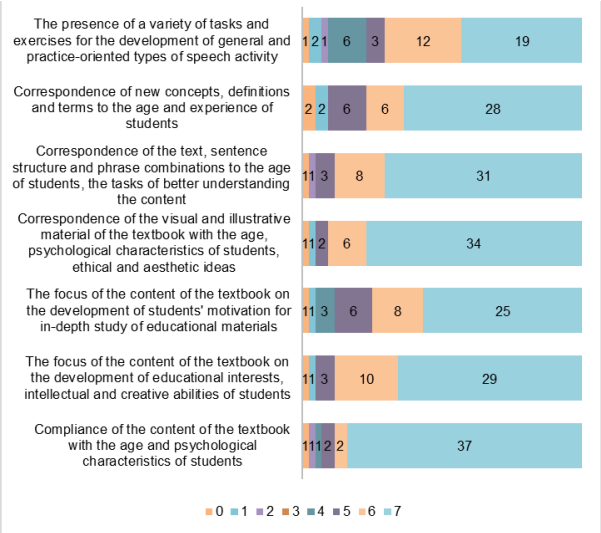

Fig. 10. Section 6 "psychological and psycholinguistic aspects".

The results of the survey on Section 7 "Cultural and Value Aspects" showed that the criterion "The focus of the textbook on the basic values defined in the State Compulsory Standard of Education (SCSE), the focus of topics and tasks on the implementation of educational tasks" is of significant importance (Fig. 11).

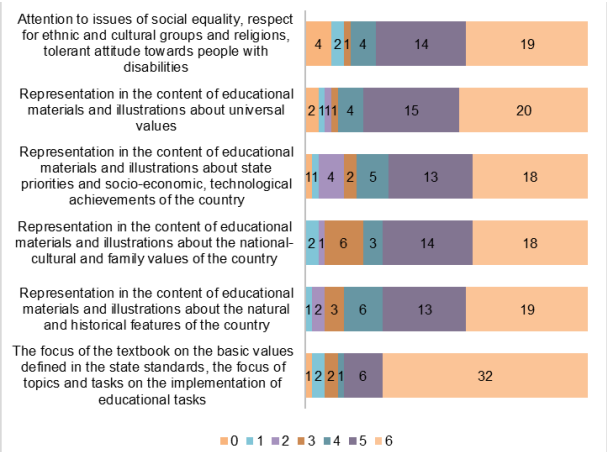

Fig. 11. Section 7 "cultural and value aspects".

In Section 8 "Integration of ICT", the criterion "Motivation of students to complete educational tasks (including independently) using ICT" turned out to be the leading one with 22 highest expert scores (Fig. 12).

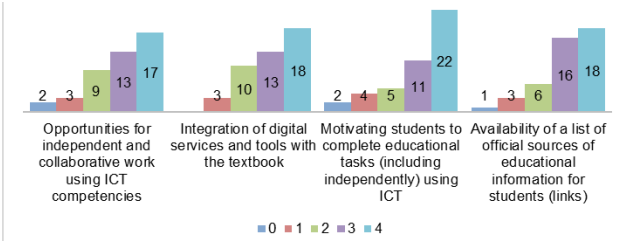

Fig. 12. Section 8 "ICT Integration".

In Section 9 "Aspects of differentiation", the criterion "Providing support to students taking into account different levels of knowledge and cognitive abilities" received 34 maximum votes (Fig. 13).

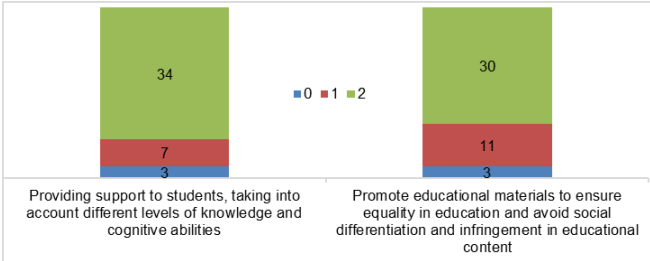

Fig. 13. Section 9 "aspects of differentiation".

In the last Section 10 "Layout and design", the criteria "Logic and convenience of the structure of the organization of educational materials on the pages" and "Compliance with sanitary and hygienic requirements for the weight and format (size) of the textbook" turned out to be the most important with 29 expert votes (Table IV).

TABLE IV: SECTION 10 "LAYOUT AND DESIGN"

Criteria	Score
Consistency and convenience of the structure of the organization of educational mate-rials on the pages	29
Compliance with sanitary and hygienic requirements for the weight and format (size) of the textbook	29
Readability and convenience of fonts and line spacing	23
Ease of navigation (table of contents, indexes and symbols)	22
The attractiveness of the textbook appearance (graphic organizers, images and illustrations, colors, etc.)	21
Ensuring the harmony of text and illustrative materials based on design principles (balance, hierarchy, contrast, space, scale and combination)	19
Technical quality of visual elements, use of colors	19
Content and visual difference between types of texts (main, explanatory and addition-al)	18
Headings and other navigational support (titles, headings, instructions, typographical notes)	17

In general, the results of the survey showed a positive trend, since, according to experts, many of the proposed criteria are very important. Moreover, the experts identified the most significant criteria for each section, which helped to approve the final 39 criteria by grouping them into 10 sections (Table V). Explanations for each criterion were reflected in the descriptors, which helped the experts in the assessment.

TABLE V: CRITERIA FOR ASSESSING THE QUALITY OF TEXTBOOKS WITH DESCRIPTORS

№	Criteria	Descriptors
		Section 1. Structure and organization
1	Introduction to the section	1. described learning objectives that are understandable and motivating for learners 2. brings students to the main topic 3. reveals the sequence of the content of the educational mate-rial, explains the features of the study of the section
2	Availability of applications (dictionaries, glossaries, reference materials, indexes)	1. dictionaries, glossaries and indexes are formed: - in accordance with sections and topics - in alphabetical order - the meaning of words, phrases, concepts and terms are given in accordance with current dictionaries and the nature of the subject - the meanings of words, concepts and terms correspond to the level of development of students, are clear and understandable and are not divorced from the context 2. reference materials are formed: - in accordance with sections and topics - short and concise - provide quick access to information
3	List of sources used, availability of links to additional sources	1. design according to requirements 2. used modern and relevant sources 3. recommended sources are in the public domain 4. the resources needed to complete the training tasks are indicated 5. links to official and special educational Internet sources are given
		Section 2. Contents
4	Implementation of the learning objectives specified in the curriculum	1. focused on achieving learning outcomes 2. the content is aimed at developing educational interests, intellectual and creative abilities of students
5	Logical sequence in the content of the textbook	1. basic knowledge is presented (topics and subtopics provided for by the curriculum) 2. there is an intrasubject connection in the content 3. the previous knowledge of students is taken into account 4. the gradation of training materials according to the level of complexity is observed
6	Scientific content	1. facts, concepts, principles, theories, etc. are accurate and generally accepted 2. Contents are based on sources that are scientifically proven to be reliable 3. there are no unreliable, scientifically unconfirmed and fabricated facts (including in the illustrative material) there are no facts that allow ambiguous interpretation, contribute to erroneous generalizations, inconsistencies and contradictions (including in illustrative material)
7	Relevance of information	1. place names, maps, photographs, illustrations, statistics, charts (graphs) and other materials are accurate, with a clear indication of the source 2. information corresponds to the current moment in time
8	Adaptation of the con-tent to the conditions of real life and activity	1. the content includes connections with everyday life, in accordance with the peculiarity of the subject 2. Real-life content and topics stimulate interest and attention 3. Pictures reflect real situations depending on the nature of the item
9	Correspondence of visual elements (graphics, pictures, images, icons, drawings, diagrams, diagrams, maps, etc.) to the educational content	1. visual elements are located on the same page as the text, clear and clearly convey information 2. there are correct and understandable labels for visual elements 3. image subtitles are reflective and concise 4. visual elements are numbered 5. information in illustrations does not contradict the text 6. increase the level of clarity, accuracy of textual information 7. perform motivational and emotional functions perform an aesthetic function
		Section 3. Didactic aspects
10	Using different learning strategies	1.Supports both independent and collaborative learning for students 2. contain practice-oriented learning materials 3. contain learning materials for active and interactive learning
11	Compliance of the textbook with the requirements of a differentiated approach	1. the presence of tasks of various levels of complexity (ac-cording to Bloom's taxonomy) to identify and consolidate the educational achievements of students on topics and sections 2. providing an opportunity for in-depth study of the material 3. providing opportunities to take into account the individual characteristics and interests of students
12	Orientation of tasks for the implementation of various forms of education	1. availability of tasks for using an individual form of organization of educational activities 2. the presence of tasks for working in pairs 3. the availability of tasks for the use of group work 4. the presence of tasks for the use of a collective form of organization of educational activities
13	The orientation of the educational content, tasks and assignments for the assimilation of the methods of science	1. included examples of research on solving various problems that arise in everyday life 2. the presence of tasks for the selection, analysis and synthesis of information on a specific topic 3. there are simple and compound tasks for comparison, high-lighting the main thing, explaining the cause and effect, identifying connections, interpreting text, diagrams, charts, graphs
		Section 4. Methodological aspects

14	Orientation of tasks, assignments and exercises to achieve learning outcomes (LO)	1. balance of tasks, assignments and exercises in quantity, compliance with learning objectives 2. availability of tasks for independent learning activities 3. the focus of tasks on the development of cognitive interests, intellectual and creative abilities
15	The presence of questions, tasks, exercises for the formation and development of competencies	1. tasks for the development of communication skills are presented 2. tasks for the development of mathematical competence and competence in the field of science and technology are present-ed 3. tasks for the formation of digital competence are presented 4. tasks for the development of social and civic competencies are presented
16	The presence in the textbook of various tasks and tasks for the development of critical thinking and analytical skills	1. content structured around problem solving 2. different points of view are shown 3. sources of information are given, a comparison of arguments and theses for each point of view 4. various facts and their interpretations are given 5. logically inferred causal relationships are outlined
		Section 5. Language Level
17	Correspondence of the language of presentation to age and cognitive level	1. at least 90% of the text is clear on first reading 2. texts are fascinating and interesting, contribute to the enrichment of vocabulary 3. tasks are given in short sentences understandable for this age group 4. definitions, rules clear and concise
18	Unity in interpretation and correspondence of terms to generally accepted scientific terminology	1. used concepts and terms corresponding to the field and nature of the subject 2. concepts and terms are used in accordance with the terminological dictionaries approved by the terminological committee 3. generally accepted units and symbols of the metric system (SI) are used 4. new concepts, definitions and terms correspond to the age and experience of students
19	Language Compliance	1. texts comply with the norms of literary speech and the rules of speech etiquette 2. sentences are built correctly, without stylistic and semantic violations 3. no spelling errors 4. no punctuation errors
20	Optimal structure and volume of sentences in texts	1. one judgment is formulated 2. the sentence is simple and understandable without unnecessary phrases and repetitions that hinder reading fluency 3. the words and phrases used in the text correspond to the context
		Section 6. Psychological and psycholinguistic aspects
21	Correspondence of the text, sentence structure and phrase combinations to age, tasks of better understanding of the content	1. the volume and content of the educational material for one lesson correspond to the cognitive abilities of students and does not require the use of additional time than provided for in the curriculum 2. texts consist mainly of frequently used words 3. a limited number of new concepts and terms are used on one-page, new concepts are explained with examples or visual elements 4. new words and concepts are mentioned at least 5-6 times in the textbook
22	The focus of the con-tent of the textbook on the development of students' motivation for in-depth study of the subject	1. the presence of tasks for students to work together on a common goal, motivating and supporting each other (role-playing games, dialogues, joint presentations) 2. the presence of tasks and tasks for self-selection of a topic of interest, introductory questions that arouse curiosity 3. tasks and exercises allow you to establish a connection between the student's knowledge and new material 4. the presence of samples of tasks and assignments, tips to facilitate its implementation
23	Correspondence of the visual and illustrative material of the textbook with the age, psycho-logical characteristics of students, ethical and aesthetic ideas	1. illustrations are related to learning objectives and make texts easier to understand 2. there is no excessive use of colors that scatter the student's attention 3. there are no images of extreme forms of wealth or poverty 4. there are no images of trademarks and products that can serve as advertising for a particular product
24	The focus of practice-oriented tasks and exercises on the development of types of speech activity	1. the presence of contextual tasks (the situations described in the conditions of tasks and tasks are related to real life and the interests of students) 2. the presence of pre-text and post-text tasks for discussion and understanding of the topic 3. availability of tasks and exercises for self-interpretation
25	Absence of materials or information that poses a psychological, physical threat to health and life	1. the presence in the content of information that instills feelings of intolerance towards corruption and immoral behavior 2. there are no materials that induce fear, suicide, justify cruel-ty, violence, extremism and terrorism 3. there are no images reflecting bad habits, only if it is not related to the learning goals 4. there are no illustrations reflecting violence against people or animals 5. in illustrations, preference is given to public transport, cy-cling
		Section 7. Cultural and valuable aspects
26	The focus of the con-tent on the basic values defined in the SCES, the focus of topics and tasks on the implementation of educational tasks	1. The content has been prepared taking into account the principles and provisions of the legislation of the country, which supports fundamental human rights and freedoms 2. The content contains educational materials and illustrations about the national-cultural, universal and family values of the country 3. the content contributes to the development of ethical, spiritual and moral qualities of students (feelings of humanism, kindness, mercy, duty, honor, conscience, dignity, diligence) 4. there are no materials in the content that are contrary to national traditions and family values, moral standards and a healthy lifestyle

27	The focus of the con-tent of the textbook on the formation of students of Kazakhstani civic identity, a sense of patriotism and pride in the Motherland	1. The image of the flag and coat of arms does not cause any disputes in significance and complies with the Law of the country 2. there are no materials that harm the international image of the country and national interests 3. The content contains educational materials and illustrations about the natural and historical features of the country 4. The content contains information and scientific and educational information about the advanced achievements of modern science, engineering and technology of the country 5. The content contains information about the figures of science, technology, culture and sports who have contributed to the scientific, technical, socio-economic and cultural development of country
28	Compliance with gender and social equality, respect for ethnic and cultural groups and religions, tolerant attitude towards people with disabilities	1. in the examples given and the characters used, a reasonable balance of the roles of men and women is observed 2. balance is maintained in examples and situations that reflect the characteristics of life and activities of the village and the city 3. the content does not contain materials that discriminate on the basis of age, race, language, religion, political preferences and ethnicity 4. there are no materials in the content that indicate the social and material status of people 5. content reflects equal access of people with disabilities to social processes and public life
29	Educational materials contribute to the formation of respect for the work of people of different professions and are aimed at the professional orientation of students	1. there are no materials that limit the individual, social, professional identity of a person, violate or damage the social worldview 2. materials about various professions are included, a balance is observed in the images of workers of mental and physical labor 3. there are no materials that contradict the rules of environ-mental protection, the principles of respect for any kind of profession
		Section 8. ICT integration
30	Opportunities for independent and collaborative work using ICT competencies	1. The electronic application is related to the structure and content of the textbook 2. motivates students to complete educational tasks (including independently) using ICT 3. electronic application has a friendly interface 4. educational materials are aimed at developing an information culture
31	Availability and quality of electronic additions and options to the main content of the textbook	1. listening to audio texts, demonstration of augmented reality is carried out through QR codes 2. Reading QR codes is simple and convenient 3. electronic options are available and open on any computer and mobile devices
		Section 9. Aspects of differentiation
32	Providing support to students, taking into account different levels of knowledge and cognitive abilities	1. the features of the educational process of different types of innovative educational organizations (gymnasiums, lyceums, classes for in-depth study of individual subjects, etc.) are taken into account. 2. the possibility of working in groups is provided, taking into account different levels of knowledge and cognitive abilities 3. providing opportunities to take into account the individual characteristics and interests of students
33	Promote educational materials to ensure equality in education and avoid social differentiation and infringement in educational content	1. lack of materials that separate people according to material well-being: highly paid and low-paid layers; rich, middle-income, poor. 2. equal representation of the spheres of labor activity: the type and nature of labor, workers in various spheres of social pro-duction, highly skilled and low-skilled 3. equal representation of the scope of power: ordinary workers, managers at various levels, heads of public administration at various levels
34	Promote educational materials for equality in education, taking into account the level of development of culture and its diversity	1. Materials about the culture of different ethno-national groups are presented. Characteristics 2. different cultural and ideological positions are presented
		Section 10. Layout and Design
35	The appearance of the textbook (attractive-ness, compliance with the content of the subject)	1. cover design is attractive, consistent with the general principles of design and age characteristics of students 2. elements used in the design of the cover correspond to the content of the textbook 3. the name of the textbook corresponds to the typical curriculum
36	Consistency and convenience of the structure of the organization of educational materials on the pages	1. page design facilitates visual perception 2. illustrations do not interfere with reading 3. the color of the background and visual elements used on the page, make it easier to read and perceive
37	Ease of navigation	1. the topics and sections indicated in the table of contents correspond to a typical curriculum 2. The page numbers in the table of contents match the headings in the table of contents. 3. the conventions used (icon, symbol, vignette, etc.) correspond to the function they represent 4. main headings and subheadings have a separate color and font
38	Readability and convenience of fonts and line spacing	1. the selected font is appropriate for the level of the student and is easy to read 2. capital letters are not used in the text for emphasis 3. The text does not use automatic alignment to prevent inconsistent spaces
39	Ensuring the harmony of text and illustrative materials based on design principles (balance, hierarchy, contrast, space, scale and combination, colorful-ness and a unified design style)	1. the presence of correct and understandable signatures of visual elements (taking into account methodological expediency) 2. visual elements are clear and convey information clearly 3. images and objects used in them are of high resolution and quality 4. symmetrical and asymmetrical balance is used appropriately in visual effects

The implementation of multi-criteria evaluation in the developed expert system has optimized the work of experts, adding clarity and efficiency in completing tasks. Using the developed multi-criteria approach in the expert system, the experts were able to fully assess the quality of the textbook content. The expert system was provided with an advanced database where the Code-First approach was applied. As a result of applying the Code-First approach, the workflow looked like this (Fig. 14).

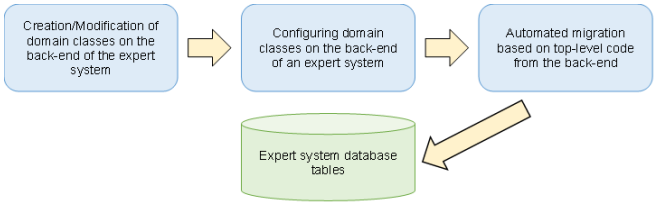

Fig. 14. Workflow (workflow) applying the Code-First approach.

Moreover, applying database normalization yielded the following results:

- freeing a set of relationships from unwanted insert, update, and delete dependencies
- reduced the need to restructure the set of relationships as new data types are introduced and thus the lifespan of application programs is increased
- the relational model has become more informative for requests from the back-end
- relation sets became neutral with respect to query statistics

The textbooks were evaluated by experts on each criterion using a 4-level assessment scale (Table VI).

TABLE VI: 4-LEVEL ASSESSMENT SCALE

Points	Description
0	complete discrepancy between the educational publication and the criteria parameters
1	partially and significant inconsistencies with the criteria parameters
2	compliance with the criterion, but the presence of individual comments
3	full compliance of the educational publication with the parameters of the criterion

In the case of setting less than 3 points according to the evaluation criterion, in the "Comment" column, the experts briefly and concisely substantiated the reasons for the decrease. In the code of errors and shortcomings, the reasons for the decrease were indicated in more detail. An indicative result of the optimization of the work of experts was a pre-formulated base of errors that can be selected for filling in the "Comments" (Table VII).

The final stage is a general analytical conclusion, which serves as the basis for an expert decision. Experts are invited to express in detail their opinion on educational publications in a descriptive form, make suggestions for its improvement and justify their expert decision in detail.

Processing of assigned evaluation points:

- the average score of each of the 10 sections is determined;
- The average score of the educational publication is determined in 10 sections.

The resulting number is not rounded.

In the case of an examination of an educational publication by 3 (three) experts, based on their average marks, an arithmetic mean is determined, which is the overall assessment of the expert group for this publication.

Making expert decisions on textbooks:

1) with an average score of 0 to 1.3 points, the textbook is not recommended for use in educational institutions
2) with an average score of 1.4 to 2.7 points, the textbook needs to be improved
3) with an average score of 2.8 to 3 points, the textbook is recommended for use in educational institutions.

TABLE VII: TYPES OF ERRORS ALLOWED

For illustration, QR codes	For texts	Technical errors
- Illustration is fuzzy - No relationship with text - Not consistent design style - Missing captions for illustrations - Do not meet ethical and aesthetic standards - There are distortions and inaccuracies that cause anxiety and/or confusion - Proportions are not maintained when placing illustrations relative to the text - QR code link not opening	- Syntax error - grammatical error - Speech error - Spelling error - Punctuation error - Lexical error - Graphic bug - Technical error - The logic of presentation is bro-ken - Not age appropriate Contains false in-formation	- It is not possible to mark the necessary fragments of the text and make notes in the margins - It takes a lot of time to open the necessary texts - Inability to work with two or three pages at once - Incorrect operation of the "voicing text" function - Slow operation and frequent shutdowns or freezes - Lack of support for test mate-rials - Lack of support for hyper-links, hypertext
For the language of presentation	**Content errors**	**Errors for multimedia objects**
- Not age appropriate - Contains terms and definitions that do not correspond to generally accepted norms of terminology - All types of speech activity are not used (reading, writing, listening, speaking)	- The logic of presentation is bro-ken - Not age appropriate - Contains incorrect information	- Takes a long time to open - Pop up ad windows - Incorrect operation of the "voicing text" function - No relationship with text - Poor image quality - Does not meet ethical and aesthetic standards - There are distortions and inaccuracies that cause anxiety and/or confusion

V. DISCUSSION

The data obtained indicate that the original version of the criteria for evaluating textbooks was less effective due to the too large and unstructured enumeration of criteria that do not take into account the characteristics of the types of textbooks, which leads to unsatisfactory indicators for several criteria in practice. Since the multi-criteria approach calculates the average score for all the proposed criteria, the presence of extra criteria can negatively affect the overall result.

Despite this, listing the maximum number of criteria helped to determine the main criteria and offer a new version in which they are grouped by semantic content and supplemented with descriptors, which increases the versatility of its application to different types of textbooks.

The results of the expert survey helped to reveal the importance of certain aspects of textbook evaluation, the significance of criteria, to pay special attention to the content,

to highlight the didactic and methodological components, to assess the clarity of presentation, the cultural and value orientation of textbooks, etc.

All this helped to adapt the proposed criteria to the developed expert system for evaluating textbooks, which optimizes the work of experts, simplifying and automating the identification of frequently made mistakes in textbooks. Moreover, the introduction of a weight share for each criterion in the expert system helps to determine its significance based on the type of textbook being evaluated, which increases the objectivity of expert decision-making.

VI. Conclusion

Nowadays, textbooks do not lose their relevance due to the value of their content and the definition of the main guidelines in learning. This raises the requirements for the quality of textbooks and raises questions about the objectivity of expert evaluation, taking into account comprehensive criteria. In addition, the workload of the experts themselves is an important factor affecting the quality of the examination.

The conducted study proposes the use of a multi-criteria approach to assess the quality of a textbook with the maximum coverage of criteria. As a result of the study, 39 criteria were formulated, grouped into 10 sections. Each criterion contains descriptors that help experts in their work. Moreover, with the help of a survey of experts, the most significant criteria for each section were determined for assigning a priority weight share. The implementation of the multi-criteria approach in the expert system helped the experts more objectively and quickly identify the mistakes made, comment and justify their decisions on evaluating the quality of textbooks.

The implementation of the multi-criteria approach in this expert system will allow accumulating of multi-criteria expert data and expand the knowledge base. The accumulation of a sufficient volume of data sets for evaluating the quality of textbooks opens up the prospect of researching the use of artificial intelligence methods in evaluating the quality of textbooks and digital content, thereby expanding the intellectual capabilities of an expert and improving the quality of evaluating a textbook and educational content in general. The present work may be further extended using uncertainty based analysis in a fuzzy or rough environment with a group-decision making set up.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Zhanat Nurbekova managed the project, developed the main concept of the research, conducted a review and editing, and provided supervision. Talgat Sembayev wrote an original draft version of the paper, contributed to the analytical interpretation of the findings, results, and discussions of the research. Dauren Dossymbek contributed by developing the software and translating the paper. Kanagat Baigusheva contributed to the methodology of the study and analyzed the data obtained. Sayat Omarov and Yeldos Nurlanov were involved in data curation and visualization; all authors had approved the final version.

Acknowledgment

This research was conducted by the Republican Scientific and Practical Center for Educational Content Expertise together with the National Academy of Education named after Y. Altynsarin of the Ministry of Education of the Republic of Kazakhstan as part of the program-targeted financing of the research OR 11465474 “Scientific foundations of modernization of the education system and science”.

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