Assessing the Digital Level in Educational Institutions: Formal Model and Software Prototype

Silvia Gaftandzhieva [1], Mariya Docheva [1], Rositsa Doneva [1], George Pashev [1], George Totkov [1]

[1] *University of Plovdiv "Paisii Hilendarski", 24 Tzar Asen Str., Plovdiv, Bulgaria*

Abstract **– The increasingly widespread use of software solutions to digitize training and administrative processes in educational institutions of all levels increases the interest in offering models and software tools for measuring the level of digitalization of educational institutions. The article presents a formal model for evaluating the digital level of educational institutions and a developed prototype of a software tool. The DIGEdu tool enables external evaluators to assess the digital level of educational institutions, automatically calculates their digital levels and generates evaluation and comparative reports. Using the tool, evaluators assessed the digital level of 50 education institutions in Bulgaria. The results from the conducted experiment prove the applicability of the DIGEdu tool for evaluating the digital level of schools. It calculated the digital level of all assessed institutions. Findings showed that most institutions have high digital levels and highlighted a need for measures at the national level to encourage the digitalisation of student admission and administrative processes.**

Keywords **– Digital level, educational institutions, digitalization of education.**

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Corresponding author: Silvia Gaftandzhieva,
University of Plovdiv "Paisii Hilendarski", 24 Tzar Asen Str., Plovdiv, Bulgaria
Email: sissiy88@uni-plovdiv.bg

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1. Introduction

In the last decade, there has been a growing interest in the digital transformation of processes in educational institutions worldwide [1] and increasing the digital competencies of their employees. Modern digital solutions such as social software, data analysis software, clouds, the Internet of Things, and others are revolutionizing the daily operations of educational institutions at all levels and in all possible ways [2], [3]. The digitization of educational and administrative services offered by educational institutions has advantages for all stakeholder groups and increases their satisfaction with the quality of the services. So, for example, digitalization facilitates the work of the non-teaching staff and reduces the amount of paper used in the administration. Teachers can teach without limitation in space and fill out some documents electronically (data on classes held, grade reports, annual workload plans, etc.). It allows students to generate and submit various documents (such as grade reports, scholarship documents, etc.) online without visiting educational institutions and studying from everywhere, including during humanitarian crises (natural disasters, wars, etc.). According to UNICEF [4], if used correctly, digital technologies can be notably helpful for socially excluded students and empower them to be successful in a digital world.

Through its policies, the European Union (EU) promotes the development of "digitally mature" educational institutions with a high digitalization level of management and training processes [5], [6], [7], [8]. For example, in the Digital Education Action Plan (2021-2027) [9] initiative, the EU sets out a vision of high-quality, inclusive, and accessible digital education in Europe and its member states to adapt their education systems to the digital age.

The EU also allocates funds under programs for the digitization of educational institutions, which they can spend to modernize their infrastructure, implement new software tools to automate the service offered and track the ongoing processes, promote innovations, and encourage staff to enhance its digital competences.

To digitize their institutions to a full degree, managers of educational institutions must make continuous investments in digital technologies, equipment and professional development of staff, [10] and overcome challenges related to digital transformation competence, lack of clear vision for the whole digital transformation process, data structure and processing [11]. They should plan well the digital transformation of their educational institutions [12], taking into account the needs of all stakeholder groups and following national and international policies. In addition, to track the progress made on the way to the desired level of digitalization, it is crucial to measure the results obtained, compare the educational institution's achievements with those of other institutions, and set development goals.

This article is dedicated to assessing the digital level of educational institutions. It presents a large-scale review of research (Section 3), a formal model for evaluating the digital level of educational institutions and a corresponding software tool (Section 3).

The DIGEdu tool enables external evaluators to assess the digital level of educational institutions, automatically calculates their digital levels, and generates evaluation and comparative reports. Using the tool, evaluators assessed the digital level of 50 education institutions in Bulgaria (Section 4).

2. Literature Review

Assessing the digital level of educational institutions is of interest to many researchers and institutions. Most proposed frameworks and tools for measuring the digital level of educational institutions developed to date are designed for self-assessment and based on short and easy-answer questionnaires. The assessment results show the level of digitalization of educational institutions and enable their leaders to pinpoint priority areas for improvement and make informed decisions for developing digital transformation plans and increasing the digital competencies of employees. The public disclosure of results from the evaluation of a set of educational institutions allows comparisons of the progress of educational institutions on the way to digital transformation.

Table 1 systematizes information about known frameworks allowing the assessment of the digital level of educational institutions, core assessment areas, type of educational institution for which they are developed, and assessment type.

Table 1. Digital maturity frameworks

Framework	Core areas	Education Level	Type of assessment	Rating scale	Tool
DigCompOrg [3]	Leadership and governance practices; Professional Development; Teaching and learning practices; Assessment practices; Content and Curricula; Collaboration and networking; Infrastructure	Primary, Secondary, VET schools, and Higher education institutions	Self-assessment		No known
Education Technology Survey 20-21 [7]	Technology; Capability; Strategy	Primary and Secondary schools	Self-assessment	Likert	Questionnaire
Ae-MoYS [13]	Leadership & Vision; ICT in the Curriculum; School ICT Culture; Professional Development; Resources & Infrastructure	Primary and Secondary schools	Self-assessment	Choice	Questionnaire
Becta [14]	Leadership and vision; Contexts; Resources; Learning support; Teaching and Learning	Primary and Secondary schools	Self-assessment	Likert	Questionnaire
FCMM [15]	Learner; Teachers, Learning objectives and assessment; School capacity; Technology resources	Primary and Secondary schools	Self-assessment	Likert	Questionnaire
eLEMÉR [16]	Learning; Teaching; Operation; Infrastructure	Primary and Secondary schools	Self-assessment	Likert	Questionnaire
FDMS [17]	Planning management and leadership; ICT in learning and teaching; Development of digital competencies; ICT culture; ICT infrastructure	Primary and Secondary schools	Self-assessment External evaluation	Likert	Rubric
Opeka [18]	Digital environment; Devices and software; ICT skills	Primary and Secondary schools	Self-assessment	Choice	Questionnaire

Framework	Core areas	Education Level	Type of assessment	Rating scale	Tool
SELFIE [19]	Teaching and learning; School management; Infrastructure and equipment; Professional development; Assessment practices and students' digital competence	Primary and Secondary schools	Self-assessment	Likert	Questionnaire
Shanghai model [20]	Technology; Curriculum; Leadership/Management; Workforce; Inter/intra-institutional linkage; External linkage	Primary and Secondary schools	Self-assessment	Likert	Questionnaire
ICTE-MM [21]	Educational Management; Infrastructure; Administrators; Teachers; Students	Primary and Secondary schools	Self-assessment	Capability level	Questionnaire
Hargreaves [22]	Professional development; Partnership competence; Collaborative capital	Primary and Secondary schools	Self-assessment		No known
LIKA [23]	Business; Management; Infrastructure; Competence and use	Primary and Secondary schools	Self-assessment	Likert	Questionnaire
DMAT [24]	Governance and leadership; People and Culture; Capacity and capability; Innovation; Technology	Higher educational institutions	Self-assessment	Capability level	Rubric
HEInnovate [25]	Leadership and governance; Organizational capacity: funding, people, incentives; Entrepreneurial teaching and learning; Preparing and supporting entrepreneurs; Digital transformation and capability; Knowledge exchange and collaboration; The internationalized institution; Measuring impact	Higher educational institutions	Self-assessment	Likert	Questionnaire
DMFHEI [26]	Leadership, planning and management; Quality assurance; Scientific-research work; Technology transfer and service to society; Learning and teaching; ICT culture; ICT resources and infrastructure	Higher educational institutions	Self-assessment	Likert	Rubric
UniDigMaturity [27]	Policy for quality assurance; Design and approval of programmes; Student-centered learning, teaching and assessment; Student admission, progression, recognition and certification; Teaching staff; Learning resources and student support; Information management; Public information; On-going monitoring and periodic review of programmes; Cyclical external quality assurance	Higher educational institutions	Self-assessment	Likert	Questionnaire
Schreurs model [28]	The vision for ICT use in school; Secondary processes; Resources and partners; Primary processes; Desired results	Primary and Secondary schools	Self-assessment	Likert	Questionnaire
DigBGSchool [29]	School Management; Learning Documentation; Training; Admissions of Students; Administrative Processes; Information Infrastructure; Digital Competencies and Support of Teaching and Administrative Staff; Collaboration with Parents and Students; Public Information; Quality Assurance and Inspection	Primary and Secondary schools	Self-assessment	Likert	Questionnaire
OECD [30]	Digital leadership; Digital infrastructure; Digital Competence and Culture	Higher educational institutions	External evaluation	Binary	Questionnaire

The qualitative analysis showed that all the frameworks studied require the assessment of core areas, each containing a defined set of indicators. Each indicator should be assessed according to a predetermined rating scale - usually a Likert, a binary scale or a capability level. Most digital maturity frameworks reviewed allow for self-assessment by the managers and staff of educational institutions.

Only two of them can be used for external evaluation by experts. For most of the frameworks considered, tools have been developed, usually, online questionnaires or rubrics, allowing experts to assess the digital level of educational institutions. For a small part of the developed frameworks, no known developed tools support the evaluation according to them.

Despite the increased interest in the field, none of the developed tools allows for modelling the overall process for assessing the digital level of educational institutions by internal (self-assessment) and external evaluators (evaluation). Almost all designed tools allow assessments against a single assessment framework. Only Opeka [18] has an opportunity to model questionnaires for self-assessment. Because most of them are developed only for self-assessment, they do not allow the generation of reports to compare the results of different institutions. Automated assessment of the digital level of educational institutions requires the design, development and implementation of software tools for generating self-assessment reports, for generating evidence documents to be attached to the self-assessment reports based on data, extracted from the used information systems and other data sources, for performing expert evaluation and generation of evaluation reports and comparison of the results from the evaluation of different educational institutions. This paper closes the gap in the literature by proposing and validating a prototype of a software tool for modelling the overall process of assessing the digital level of educational institutions.

3. Material and Method

Formal model for assessing the digital level

This subsection presents a formal model of a process for assessing the digital level of educational institutions, which is the basis of the proposed software solution. The evaluation takes place in 4 phases:

Phase 1. Preparatory stage;

Phase 2. Self-assessment of the digital level;

Phase 3. External evaluation of the digital level;

Phase 4. Analysis and comparison of results of educational institutions.

Based on a thorough analysis of regulatory documents and good practices for evaluating the digital level during Phase 1, experts in the field must develop a criteria system for assessing the digital level. They must define:

- Areas (Q) in which expert will evaluate the digital level of the educational institutions and their weights when calculating the final score;
- Indicators ($L_Q = \{L_1, L_2, L_3, \dots, L_n\}$) to measure the digital level of educational institutions in the corresponding areas and their weights when calculating the area score;
- Appropriate scales (R) to measure to what extent the evaluated educational institution fulfils the indicator;
- Set of documents with evidence ($Proofs = \{ProofsQ1, ofsQ2, ProofsQ3, \dots, ProofsQn\}$), which allow experts to evaluate the compliance with the indicators in each area.

Within this phase, experts must also propose a methodology for assessing the digital level of the educational institutions using the developed criteria system. They define how evaluators should form the final evaluation score (CG) and develop templates of self-evaluation report (*SelfReport*), evaluation scorecard (*ScoreCard*), and evaluation report (*Report*). In the general case, evaluators should calculate the final score of the digital level of the educational institution for each area according to the formula $\sum_{i=1}^{n} L_i * T_i / MAX$, where n is the number of indicators in the area, L_i is the score given for the specific indicator, T_i is the indicator weight, and MAX is the maximum number of points for the evaluated area. As a result of the performed calculations, evaluators can calculate the final evaluation score by using the formula $CG = \sum_{i=1}^{n} QG_i * C_i$, where QG_i is the score of each evaluated area, and C_i is the area coefficient when forming the final evaluation score. The self-assessment report of the evaluated educational institution must have appendices *SuppDocs*, which allow evaluators to confirm the reliability of the presented information for evaluation of the indicators. The scorecard and the evaluation report to be prepared by evaluators are strictly formalized in almost all evaluation procedures. By considering the needs of all stakeholder groups, experts should also design templates for preparing reports for comparing the achievements of the evaluated educational institution and ranking them based on their scores (*CompReport*). These reports may include one or more elements (general information about the procedure, evaluators, final scores, etc.). At the end of this stage, the evaluating body publishes the criteria system, the evaluation body, and templates of reports, including forms and instructions for filling them out.

Phase 2 implies the implementation of a repository of information resources (W) in an electronic or conventional format, in which the evaluated educational institution stores the necessary documents for the current procedure of the assessment of the digital level. Once the educational institution creates the repository, it can use the repository to store information resources for subsequent assessment procedures. The educational institution under evaluation must form an internal inspection committee responsible for writing and submitting the self-assessment report. Much of the needed evidence requires the committee members to collect, analyze, and interpret data about students, faculty and administrative staff, and processes in the educational institution.

The technologies and tools for intelligent analysis of data accumulated in the information systems used in the institution allow the committee members to increase the effectiveness of the monitoring processes, as well as the processes for collecting evidence for indicators. The educational institution stores the final self-assessment report *SelfReport* and the appendices *SuppDocs* in the digital repository with authorized access. At the end of this stage, the institution subject to evaluation submits the self-assessment report to the evaluation body together with the evidentiary documents needed to start the external evaluation procedure.

During Phase 3, the evaluation agency that performs external evaluation has to implement a repository (*EW*) for archiving evaluation reports and provide access to all stakeholders according to their position. When starting an evaluation procedure, the agency appoints a group of experts to carry out the evaluation. The expert group familiarizes itself with the documents submitted by educational institutions under evaluation - *SelfReport* and *SuppDocs*. According to the rules for the current evaluation procedure, the group can also carry out an on-site inspection to verify the truth of the facts stated in the self-assessment report. Then, the experts fill out the scorecards and apply the methodology to calculate the digital level of the educational institution and formulate recommendations for improvements. The prepared final evaluation report is sent to the evaluated institution and archived in its repository. The evaluation agency has to archive all completed *ScoreCards* and evaluation reports *Report* in the *EW* repository.

After completion of the evaluation procedure, within Phase 4, experts from the evaluation agency analyze the results and prepare comparative reports and rankings of the educational institutions by filling out the templates (*CompReport*) manually or using specially developed software tools for data analysis and visualization. Then, the agency stores all comparative reports in the *EW* repository and gives stakeholders access to them who can take measures to increase the digital level of the educational institutions. After the evaluation, the experts who developed and proposed the criteria system and the methodology can analyze the results to improve the criteria system and the evaluation methodology. Based on the analysis, they can suggest the addition of new valuation indicators (L_{new}) to the criteria system and(or) modify and(or) remove existing indicators (L), update weights of indicators (T) and(or) coefficients of the areas (C), changes in the methodology for forming the complex score (CG), etc.

Prototype of software tool

The proposed software tool for assessing the digital level of educational institutions DIGEdu has 6 subsystems:

Subsystem 1. Conceptual modelling of a criteria system for assessing the digital level of educational institutions;

Subsystem 2. Modelling, organization and management of procedures for evaluation of the digital level of educational institutions;

Subsystem 3. Evaluation of the digital level of educational institutions;

Subsystem 4. Document modelling (templates of reports for assessing the digital level of educational institutions and comparing the scores of different institutions);

Subsystem 5. Generated reports (individual institution and summary reports) evaluating the digital level of educational institutions;

Subsystem 6. Access to reports for assessing the digital level generated during previous procedures.

The proposed software tool for assessing the digital level of educational institutions has 6 subsystems:

The software prototype has been implemented by using the following solutions and technologies:

- server technologies PHP 7, MySql, HTML, Bootstrap, JavaScript, jQuery;
- technologies and tools of the TIBCO company (JasperServer, JasperSoft and PHP Client);
- development tools and environments – PHPMaker, Zend Framework (Laminas Project), MySql Server, ODBC driver for Ubuntu, Apache Server for Ubuntu, Ubuntu 22.04.

The database of the developed prototype consists of 21 tables, storing information about the modeled criteria system, indicators, areas, user registrations and scores from external evaluation by experts.

The prototype of the DIGEdu software tool is intended for use by 4 groups of users - administrator, evaluator, head of educational institution, stakeholders from government institutions. According to the assigned role, each user has access to various functionalities of the system:

- Administrator can create user profiles for different groups of users, register educational institutions, model criteria systems for evaluating the digital level of educational institutions, add indicators and areas for evaluation, model report templates for assessing the digital level of educational institutions and comparing the results of educational institutions, organizes assessment procedures, provides access to all generated evaluation reports and reports for comparing the evaluations of schools stored in the EW repository.

- Evaluator can view a list of educational institutions subject to assessment, fill out evaluation cards for a selected school, and view accessible reports to compare the scores of schools stored in the EW repository.
- Head of educational institutions can upload self-assessment report with proofs, view generated assessment reports for the educational institution they lead, and access reports to compare the results of educational institutions stored in the EW repository.
- Registered representatives of government institutions can view generated assessment reports and reports to compare the results of all educational institutions stored in the EW repository.

Non-registered users (e.g. parents and prospective students) can view publicly available reports for ranking educational institutions stored in the *EW* repository.

Using the *JasperSoft Server* a repository *EW* for storing the templates of reports and generated reports is developed, and an organization for storing documents in it is introduced. DIGEdu and the repository are integrated through web services.

Subsystem 1 allows the administrator to model a criteria system for assessing the digital level. The creation of a new criteria system proceeds in 5 steps:

- Adding base indicators needed to calculate the score of quantitative indicators;
- Adding areas of evaluation;
- Adding quantitative and qualitative indicators from a chosen type;
- Creating a criteria system and selecting areas and indicators that will be included in it;
- Defining indicators weights and areas coefficients when forming the final score.

Figure 1 presents a screenshot of the add indicator screen. The administrator must select an indicator type from the system's built-in options when adding a new indicator. If the administrator adds a qualitative indicator evaluated on a 5-point scale, s(he) must define a measurement scale and criteria upon the fulfilment of which the expert can place the corresponding numerical score. If the administrator adds a quantitative indicator, s(he) must define a relationship between the quantitative and the base indicator that DIGEdu will use to calculate the score for this quantitative indicator (if applicable). Information about all indicators and areas are stored in the tool's database. Once stored in the database, the administrator can use all indicators repeatedly by including them in different criteria systems. When the administrator adds areas with a set of indicators to a criteria system, he (she) must assign to each area coefficient and each indicator weight, and these assigned coefficients and weights are used only in calculating the numerical level of the evaluated education institution according to the relevant system of criteria. A criteria system already used for evaluation procedures cannot be changed.

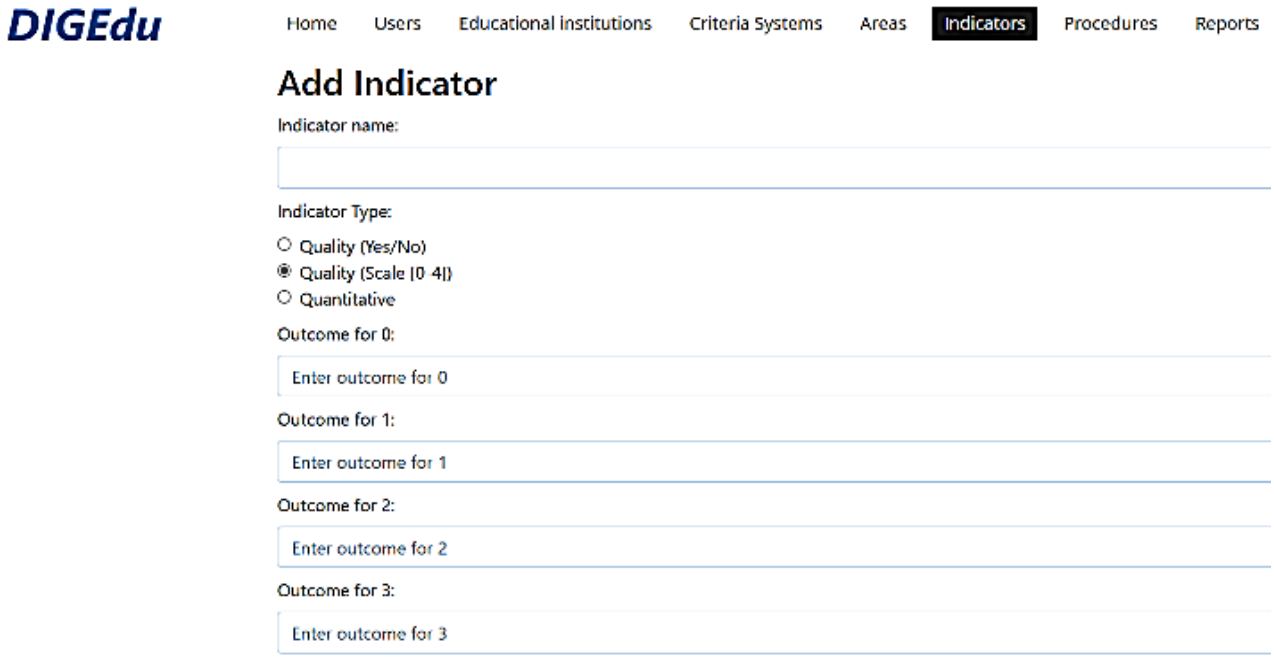

Figure 1. Add indicator screen

The methodology for calculating the digital level of the educational institution is embedded in the DIGEdu prototype. The tool calculates the quantitative indicator scores by dividing the value of the quantitative indicator by the value of the corresponding base indicator. The calculation of the final assessment of the educational institution takes place in 4 steps:

- Step 1. Calculating the maximum number of points, the evaluator can give on each evaluated area according to the formula $MAX = \sum_{i=1}^{n} LMax_i * T_i$ where $LMax_i$ is the maximum score for the specific indicator, T_i - indicator weight;
- Step 2. Calculating the actual number of indicator points in the area given by the evaluator by the formula $Actual = \sum_{i=1}^{n} L_i * T_i$ where L_i is the score given for the specific indicator, T_i - indicator weight;
- Step 3. Calculating each area score according to the formula $QG{=}Actual/MAX$ where Actual is the actual number of indicator points, MAX - maximum number of points for the evaluated area;
- Step 4. Calculating the final score CG according to the formula $\sum_{i=1}^{n} QG_i * C_i$ where QG_i is the score of each evaluated area, and C_i – the area coefficient.

Figure 2 presents a part of the program code for calculating the final score. Triggers fired after the evaluator fills out the score card calculate the actual score values by area and the final score.

```
CREATE TRIGGER before_area_grades_update
BEFORE UPDATE ON area_grades FOR EACH ROW
BEGIN
DECLARE maxval_sum DECIMAL(5,2) DEFAULT 0;
DECLARE val_sum DECIMAL(5,2) DEFAULT 0;
SELECT SUM(inn.Max_Value*it.teglo) INTO maxval_sum
 FROM procedures p, c_system cs, indicators inn,
     ind_teglo it, ind_grades ig
 WHERE p.csystem_id=cs.ID AND inn.C_System_ID=cs.ID AND
    inn.Area_ID=NEW.area_id AND NEW.procedure_id = p.id AND
    it.indicator_id=inn.ID AND it.procedure_id=p.id
    AND ig.procedure_id=p.id AND ig.indicator_id=inn.ID
    AND ig.graded_school_id=NEW.graded_school_id;
SELECT SUM(it.teglo * ig.grade) INTO val_sum
 FROM procedures p, c_system cs, indicators inn,
    ind_teglo it, ind_grades ig
 WHERE p.csystem_id=cs.ID AND inn.C_System_ID=cs.ID AND
    inn.Area_ID=NEW.area_id AND NEW.procedure_id = p.id AND
    it.indicator_id=inn.ID AND it.procedure_id=p.id AND ig.procedure_id=p.id
    AND ig.indicator_id=inn.ID AND ig.graded_school_id=NEW.graded_school_id;
SET NEW.grade = val_sum / maxval_sum;
END$$
```

Figure 2. Part of program code for calculating final scores

Using *Subsystem 2* the administrator can organize and manage procedures for assessing the digital level of educational institutions. Before launching the assessment procedure, the administrator can select a criteria system per which the evaluators will inspect educational institutions.

The subsystem extracts from database data for indicators from the chosen criteria system, their types, and the possible evaluation values to generate the scorecard. Then, it dynamically generates a scorecard with all indicators from the criteria system and input fields in which experts should enter their scores. The administrator must select educational institutions for inspection from the list of registered institutions.

During the assessment procedure, the administrator can add educational institutions to the list of initially chosen institutions. Then, the administrator must select evaluators who will assess each educational institution from a list of registered evaluators from which are excluded evaluators who work at the educational institution. Finally, the subsystem starts a web service to create a folder in the *EW* for storing reports generated during the assessment procedure. When the administrator launches the assessment procedure of one or more educational institutions, the subsystem sends the notification to the heads of educational institutions chosen for inspection and evaluators. The head of the educational institution must upload the self-assessment report and its appendices in the DIGEdu tool.

Subsystem 3 allows the evaluators to assess the educational institutions. The subsystem visualizes a list of all uninspected educational institutions that the evaluator should evaluate from which s(he) must select an educational institution for assessment. The evaluator has access to the self-assessment report and its appendices. After the evaluator familiarizes with the documents, s(he) fills out the scorecard for assessing the digital level of the educational institution. Then, the subsystem calculates the score of each area and the final score and stores all scores (per indicator and area as well as the final score) in the DIGEdu database.

Subsystem 4 uses the capabilities of *JasperSoft Studio* for designing templates of evaluation reports and reports for comparing the results of educational institutions. In the current version of the DIGEdu templates of 10 reports are designed:

- *Detailed evaluation report* that will visualize the score of each indicator and the final score of the educational institution;
- *Summary evaluation report* that will visualize the calculated score of each assessed area and the final score of the educational institution;
- *Educational institution rank report* that will visualize the final score of assessed educational institutions;
- *Detailed report with indicator scores* that will visualize the number of educational institutions that have each possible indicator score;

- *Summary report with indicator scores* that will visualize the average score for each indicator;
- *Detailed report with area scores* that will visualize the number of educational institutions that have a set percentage of the maximum score for each area (0-20%, 21-40%, 41-60%, 61-80%, 81-100%);
- *Summary report with area scores* that will visualize the average, minimum and maximum score for each area;
- *Comparative report of results by indicators* that will visualize the score received by each educational institution for each indicator;
- *Comparative report of results by areas* that will visualize the score received by each educational institution for each area;
- *Summary report with scores of the evaluated institutions by districts* that will visualize the average, minimum and maximum scores of educational institutions located in each district.

Designed templates allow the accumulation of data, presented in tables or diagrams.

They contain static and dynamic elements. Static text fields in the template of each report visualize the report name, column names, and other labels (e.g. educational institution, evaluator, evaluation period, district, etc.).

The dynamic elements are populated with data for the modelled assessment procedure and scores of the educational institutions stored in the DIGEdu database. In some templates of the comparative reports, there is conditional formatting of the visualized summary data – different colouring of indicators/areas with scores in the specified range, highlighting educational institutions with scores in the specific range or with scores below/above the average. All developed templates of comparative reports have a required parameter that sets the ID of the procedure for which data to populate the dynamic elements will be retrieved. The evaluation reports have an additional parameter (ID of the educational institution), the value of which specifies the scores of which institution to populate the dynamic elements. All designed templates are stored in the *EW* repository.

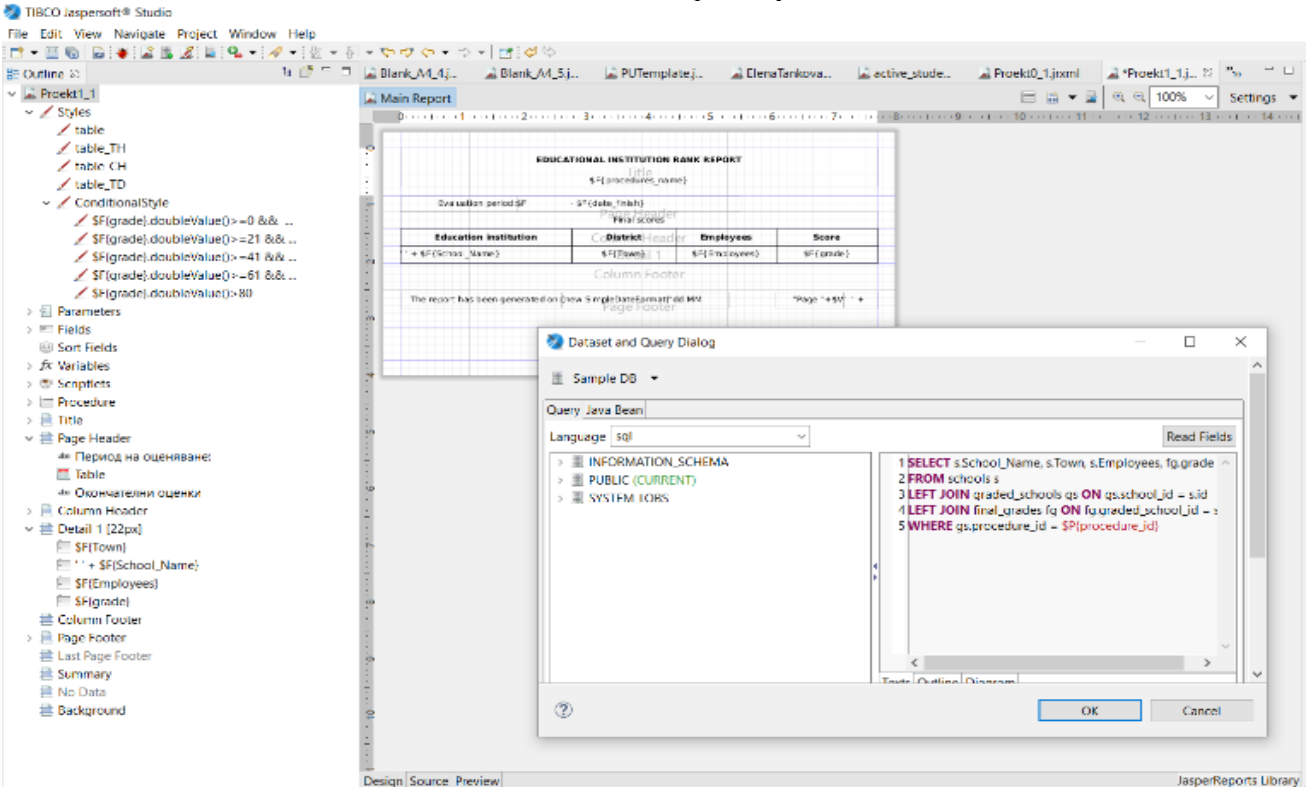

Figure 3. Template of summary score report

Figure 3 shows a screenshot of the designed template for generating the Educational institution rank report with the formal parameter - procedure ID. The template contains some static elements – 'Summary score report', 'Evaluation period', 'Final scores', 'Education institution', 'District', 'Employees', 'Score', 'The report has been generated on', 'Page'. The values of all other dynamic elements ($F{procedures_name}, $F{date_start}, $F{date_finish}, $F{School_Name}, $F{Town}, $F{Employees}, $F{grade}) are populated with data from the result data set returned after executing a query to the database on a supplied fact parameter value.

In such a way, the generated report using this template always contains the data for the chosen procedure for assessing the digital level of educational institutions. There is conditional formatting built into the report template based on the score, so data for each educational institution will be highlighted according to the range where the calculated final score falls.

Subsystem 5 models the processes for generating evaluation reports and reports for comparing the scores of educational institutions. After filling in the expert card for evaluating the digital level of a selected school, the subsystem automatically starts a web service for launching templates for generating evaluation reports for an evaluated educational institution.

The *EW* repository processes the request, generates reports as filling all dynamic elements in them with scores of the assessed educational institution retrieved from DIGEdu database, archives them and returns generated reports as a response to DIGEdu. DIGEdu visualizes the generated reports and allows the evaluator to download them in a PDF format. The subsystem sends a notification to the e-mail of the head of the educational institution about generated evaluation reports. The head of the educational institution has access to the generated evaluation reports after logging into the system.

Considering the diversity of the needs of each group of users, the subsystem enables users to generate reports for comparing the results of the inspected educational institutions based on the designed templates. For this purpose, DIGEdu runs a web service that retrieves the names of all templates from the *EW* repository on which the respective user has the right to generate reports and their list of parameters. To avoid the possibility of submitting incorrect parameter values, DIGEdu retrieves possible values for parameters from its database. After the user selects which report to generate and a parameter value from a drop-down list, DIGEdu starts a web service for report generation. The *EW* repository processes the request by filling in the values for all the dynamic elements of the chosen template, generates the report, and returns it as a response to the query. DIGEdu visualizes it and allows users to download it in PDF format.

Upon completing the assessment of all education institutions, the administrator can generate comparative reports across all templates for archiving in the *EW* repository. For this purpose, the administrator starts a web service via the DIGEdu interface. Then, the *EW* repository performs the request, generates comparative reports and archives them in the folder created for the procedure.

Subsystem 6 allows users to access already generated reports for a chosen assessment procedure, visualize them on the screen, and export them in various file formats. For this purpose, the DIGEdu tool starts a web service that extracts all the comparative reports from the folder in the *EW* repository that stores archived comparative reports containing scores of the educational institutions assessed within the selected procedure.

4. Result

Using the DIGEdu tool, evaluators assessed the digital level of 50 Bulgarian primary and secondary schools.

The criteria system is developed after an in-depth analysis of 16 models for measuring the digital level, together with national and international strategic and normative documents related to digitalization. With few exceptions, the reviewed frameworks/tools focus mainly on teachers' competence in developing digital learning resources and creating online courses, training, evaluation and learning support activities. Only three of them (SELFIE [19], Shanghai [20] and LIKA [23]) allow assessment of the digital level of the administrative services and business processes. None of the examined frameworks offers a comprehensive concept suitable for assessing the digital level of Bulgarian primary and secondary schools. The review and in-depth analysis of the known frameworks and consultations with principals and teachers allowed the identification of crucial areas, allowing assessment of the digital level of the educational institutions to a full degree. The first version of the criteria system contained ten areas with sets of indicators for each evaluated area (90 in total). After consultation with principals and teachers, new indicators were added [29]. Evaluators should assess all indicators by a 10-point Likert scale. The final version includes 100 quality indicators for evaluating the digital level in the following 10 areas:

- Management – 11 indicators assessing digital strategy, the use of e-services in administrative processes, encouraging the digitalization of services and the staff to use digital solutions, digital policy, the digitalization possibilities provided, use of digital solutions for information management and document dissemination, participation in digitalization projects and networks;

- Learning documentation – 16 indicators assessing the way for development and storing documentation, the use of digital solutions for completing documents (e.g. student diaries, annual plan, personal student cards, general class book, etc.) and planning the educational process (class schedule, schedule for exams), the use of digital solutions for generating and sending reports to institutions (absences, dropped out students, GPA, teachers' workload, students without final grade, teaching activity, etc.);
- Training – 13 indicators assessing whether the school integrates digital solutions to support the training to a full degree (incl. extracurricular activities), teacher use digital solutions in the learning process (for developing e-learning materials which are available for students, conducting and evaluating exams, video conferences, giving homework, guiding students with special needs, providing personal support, tracking students at risk of drop out, etc.);
- Admission of students – 5 indicators assessing the use of digital solutions for organizing student admission, submitting documents, notifications for results, attracting students, conducting procedures for student enrolment, training and graduation;
- Administrative processes – 13 indicators assessing the use of digital solutions for managing administrative services, human resources management, financial management, accounting, assets management, document flow, a register of graduates, ranking for scholarships; submitting documents by employees (employment, going on leave, declarations for lectures, etc.) and students (receiving scholarships, admission and transfer, official note for taking the state matriculation exam, different kinds of certificates, etc.);
- Information infrastructure – 13 indicators assessing plans for developing the information infrastructure, material and technological base, network infrastructure, video surveillance system, access regime, available software tools (for management of administrative processes, teaching and learning, conducting meetings, digital archive), integration of software solutions with software systems of regional and national institutions, measures (authorized and reliable access, restore data, protect personal data, etc.), system support;
- Digital competencies and support of teachers and employees - 9 indicators assessing the monitoring and improvement of the digital culture, staff training, staff digital competencies, using digital solutions in daily work, and access to electronic libraries;
- Interaction with parents and students – 5 indicators assessing whether the school uses digital solutions to communicate with parents and students, include sending information about student absences, assessment results ranking for scholarships, and notifications for upcoming meetings electronically;
- Public information – 6 indicators assessing whether the school provides information on its official site and social network page, uses digital solutions to support cooperation with external stakeholders, and gives remote access to curricula for the offered study programmes;
- Quality assurance and inspection – 9 indicators assessing whether the school stores all inspection documents in a digital archive; monitors and reviews the curricula and learning, studies stakeholder's satisfaction, prepares self-assessment reports, performs the audit of the quality of the educational product, reports results of audits via digital solutions, provides remote access to conduct external audits.

For each area, a set of evidential documents has been determined, which allows evaluators to give scores on the individual indicators.

In the final version of the criteria system, there are two scales for assessing the indicators - evaluators should assess one part through Yes/No and another part using a Likert scale. The maximum possible score is the same for all indicators - 4. The expert who performs the evaluation should give a score of 0 when the primary or secondary school takes no measures to fulfil the assessed indicator and a score of 4 when the school implements it to a full degree. To objectively evaluate the indicators evaluated on the Likert scale, it is determined what scores can be given for each of them when the school meets specific criteria. Table 2 gives an example of a possible score that experts must set when the school meets a set of requirements for the first 5 indicators from Area 1 Management.

Table 2. Indicators and possible scores

Indicator	**Possible scores**
The integration of ICT into the institutional activities is an element of the school's strategic planning	Yes (4)/No(0)
E-services and ICT are used in the institution's administrative processes	Likert scale from 0 to 4 0 - Between 0 and 20% of the administrative processes are performed using e-services and ICT 1 – Between 20 and 40% of the administrative processes are carried out using e-services and ICT 2 - Between 40 and 60% of the administrative processes are performed using e-services and ICT 3 - Between 60 and 80% of the administrative processes are performed using e-services and ICT 4 - Over 80% of the administrative processes are performed using e-services and ICT
The new or restructuring processes are digitized and delivered as e-services to the users, by ICT	Likert scale from 0 to 4: 0 - Between 0 and 20% of the new or restructuring processes are digitized 1 - Between 20 and 40% of the new or restructuring processes are digitized 2 - Between 40 and 60% of the new or restructuring processes are digitized 3 - Between 60 and 80% of the new or restructuring processes are digitized 4 – Over 80% of the new or restructuring processes are digitized
Adequate information infrastructure, resources, budget and financial investments are provided for digitalization of the institutional processes.	Likert scale from 0 to 4: 0 – digitalization of the processes is not provided; 1 – one of the listed sub-indicators/infrastructure; resources; budget; investments/is provided 2 – two of the listed sub-indicators provided 3 – three of the listed sub-indicators provided 4 – all sub-indicators provided
Information management, adoption and monitoring of management decisions are carried out with the help of digital solutions, including for intelligent data analysis	Likert scale from 0 to 4: 0 – no digital solutions are used for information management, adoption and monitoring of management decisions 1 - digital solutions are used for information management 2 – the adoption and monitoring of management decisions is carried out with the help of digital solutions 3 - digital solutions are used for information management, adoption and monitoring of management decisions 4 - digital solutions and tools for intelligent data analysis are used to manage information, adopt and support management decisions
…	…

The relative weight of each indicator is 1. The coefficient of each evaluated area has a different value given by experts' judgment of their significance. The evaluation score of each area is obtained by the formula $\sum_{i=1}^{n} LG_i /MAX$, where LG is the obtained evaluation score for each indicator, i=1, 2, ……n, n – the number of indicators in the evaluated area, and MAX is the maximum evaluation score of the area. Table 3 presents the coefficient and maximum score of each area.

Table 3. Areas coefficients and max scores

Area	Coefficient	Max. score
Management	0,11	44
Learning documentation	0,16	64
Training	0,13	52
Student admission	0,05	20
Administrative processes	0,13	52
Information infrastructure	0,13	52
Digital competencies and support of teachers and employees	0,09	36
Interaction with parents and students	0,05	20
Public information	0,06	24
Quality assurance and inspection	0,09	36

The final evaluation score is calculated according to the formula $\sum_{i=1}^{10} QG_i * C_i$, where QG is the calculated score of the evaluated area, and C is the coefficient of the corresponding area when forming the final score. The resulting complex score is a number in the range 0-100 rounded to two decimal places.

Based on the calculated final score, evaluators determine the digital level of the institution. Table 4 presents the defined five digital levels reached by the school.

Table 4. Digital level

Score	Digital Level	Interpretation of the results
0-20	Initial Level	The top management is not familiar with the possibilities to implement digital solutions in school activities, staff does not perform activities using digital solutions and(or) use them in a few activities.
21-40	Pre-intermediate Level (Project)	The top management is familiar with the possibilities to implement digital solutions in school activities, but digital solutions are used in a few activities.
41-60	Intermediate Level (Growth)	The top management is familiar with the possibilities to implement digital solutions in school activities and makes investments to digitalize basic processes.
61-80	Advanced Level (Integration)	The top management is familiar with the possibilities to implement digital solutions in school activities, makes investments in the digitalization of basic processes and staff training, and encourages staff to use digital solutions.
81-100	Expert Level (Institutionaliza-tion)	The top management is familiar with the possibilities to implement digital solutions in school activities, makes investments in the digitalization of all processes and staff training, and encourages the staff to use digital solutions in all activities.

The developed criteria system is modelled using DIGEdu. Fig. 4 presents the modelled scorecard for filling out by evaluators.

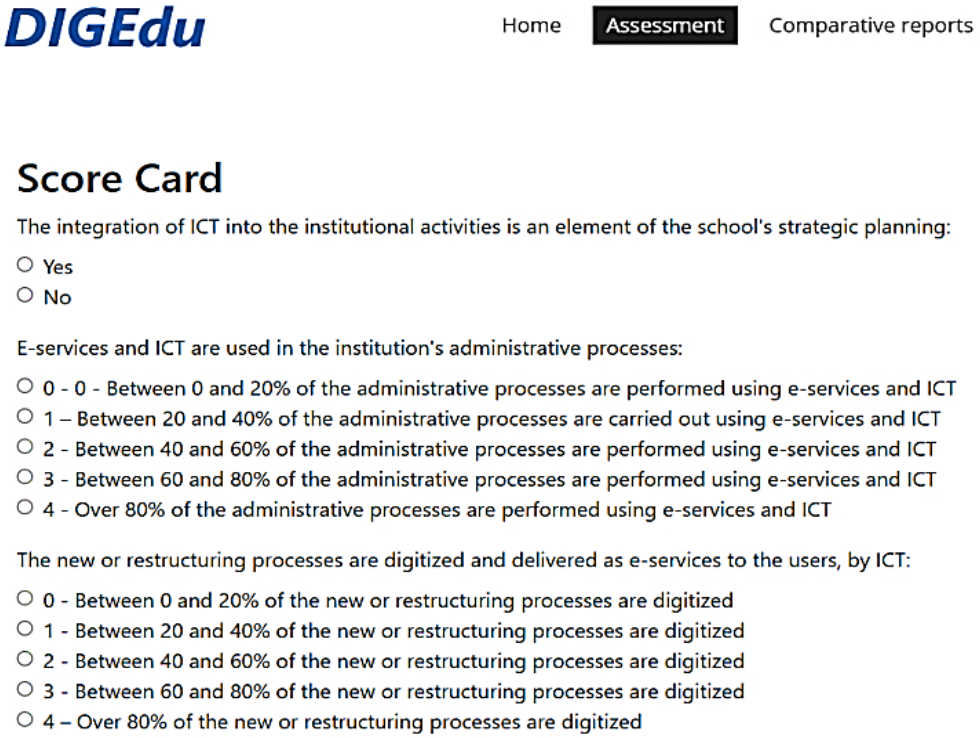

Figure 4. Part of a scorecard for assessing the digital level

After the start of the evaluation procedure, selected experts evaluated the digital level of the schools by reviewing the evidence and filling out scorecards. Then, the DIGEdu tool calculated the final scores of the primary and secondary schools under evaluation and generated evaluation reports.

The following figures present some reports generated via the DIGEdu after the evaluation procedure was completed for all schools.

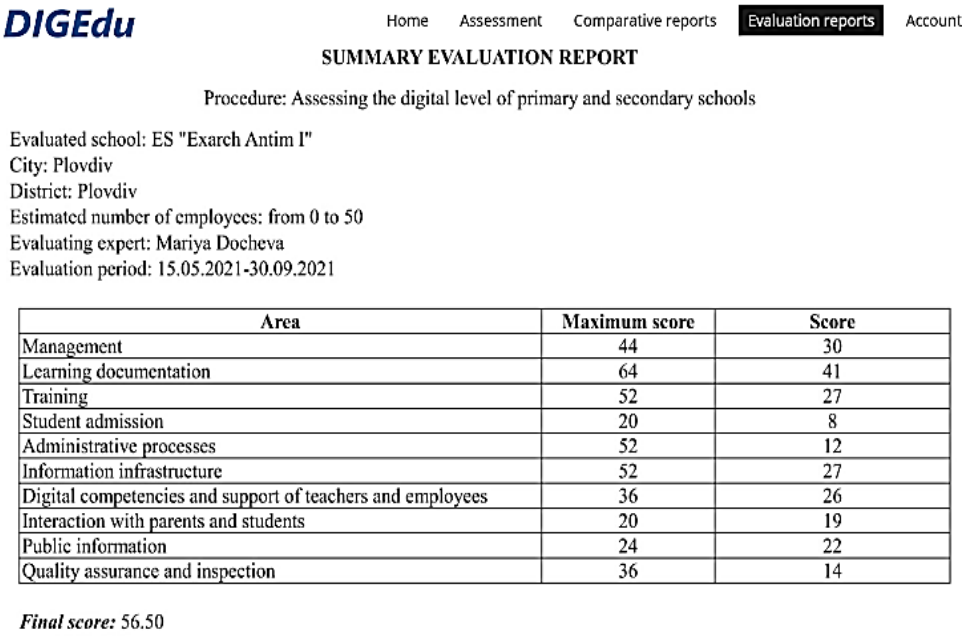

Figure 5. Generated summary evaluation report

Figure 5 presents the generated concise evaluation report of one of the evaluated schools – the elementary school "Exarch Antim I", city of Plovdiv.

Fig. 6 presents the generated report with the final evaluation scores of the schools and the determined digital levels.

The reached digital levels are marked with a different background colour – red (Initial Level), orange (Pre-Intermediate Level), yellow (Intermediate Level), green (Advanced Level), and grey (Expert Level).

From the generated report, it becomes clear as a whole, the digital level of the evaluated schools is high – there are only 3 schools (6%) at the Initial Level, 1 school (2%) at the pre-intermediate level and 8 schools (16%) at the intermediate level. The majority of the evaluated schools participating have high digital levels - 13 schools (26%) have achieved the advanced level and 25 schools (50%) - the expert level. Two of the evaluated schools received the highest possible score of 100, which shows that their governing body is fully aware of the advantages of using digital solutions, makes investments in the digitalization of all processes and staff training, and encourages staff to use digital solutions.

DIGEdu Home Comparative reports Evaluation reports Account setl

EDUCATIONAL INSTITUTION RANK REPORT

Procedure: Assessing the digital level of primary and secondary schools

Evaluation period: 15.05.2021-30.09.2021

Final scores

Educational institution	District	Employees	Score
Vocational school of agriculture	Plovdiv	0-50	12,25
St Kliment Ohridski Elementary School	Veliko Tarnovo	50-100	13,00
Petar Bonev Elementary School	Plovdiv	0-50	15,50
St. Knyaz Boris I Elementary School	Burgas	50-100	32,75
Hristo Smirnenski Elementary School	Kurdzhali	0-50	46,25
Vassil Levski Secondary School	Plovdiv	above 100	49,00
73th Secondary School "Vladislav Gramatik"	Sofia city	above 100	49,25
Vocational School "Acad. S.P. Korolyov"	Kyustendil	0-50	49,75
Hristo Botev Secondary School	Stara Zagora	0-50	50,75
23 Secondary School	Sofia city	50-100	56,00
Exarch Antim I Elementary School	Plovdiv	0-50	56,50
Hristo Botev Secondary School	Vratsa	50-100	58,00
Panayot Volov Secondary School	Shumen	50-100	60,25
Vassil Levski Elementary School	Plovdiv	0-50	61,25
4th Elementary School "Prof. John Atanassof"	Sofia city	50-100	62,25

Figure 6. Part of the educational institution rank report

Fig. 7 presents part of a detailed summary report with scores by the evaluated areas. The report shows the number of evaluated schools achieved a percentage score within a given range (0-20, 21-40, 41-60, 61-80, 81-100) of the maximum possible score for the area. The largest number of schools achieved high results in the areas of public information (72%), Interaction with parents and students (66%), Learning documentation (64%) and Information infrastructure (62%).

More than half of the schools have high scores in the areas of Management and Digital competencies and support of teachers and employees (58%), Training (56%) and Quality assurance and inspection (54%). There is a need for measures at the national level to encourage schools to digitalize their student admission and administrative processes where the percent of schools with results in the highest range is the smallest – 36% and 34%.

DETAILED REPORT WITH AREA SCORES

Procedure: Assessing the digital level of primary and secondary schools

Number of evaluated educational institutions: 50
Evaluation period: 15.05.2021-30.09.2021

Summary scores by area

Evaluated area	*Maximum score*	*Number of schools receiving a percentage rating from the maximum*				
		0-20	*21-40*	*41-60*	*61-80*	*81-100*
Management	44	2	5	2	12	29
Learning documentation	64	1	0	6	11	32
Training	52	2	2	9	9	28
Student admission	20	8	8	10	6	18
Administrative processes	52	6	6	12	9	17
Information infrastructure	52	3	4	6	6	31
Digital competencies and support of teachers and employees	36	3	3	6	9	29
Interaction with parents and students	20	3	4	4	6	33
Public information	24	2	4	4	4	36
Quality assurance and inspection	36	8	6	4	5	27

Figure 7. Detailed report with scores by evaluated areas

Using the tool, stakeholders can generate more detailed reports, allowing them to make specific recommendations on how inspected schools can increase their digital level.

5. Conclusion

This study contributes to the field of digital transformation of educational institutions by proposing and validating a tool to assess the digital level of educational institutions, regardless of their type and the evaluation framework used.

The results from the conducted experiment prove the applicability of the DIGEdu tool for evaluating the digital level of schools. The DIGEdu tool allows the stakeholders to monitor the school's digital progress, identify areas to be improved and plan the use of digital technologies, as well as to compare the educational institution's progress with that of other educational institutions. The proposed criteria system can be used both within procedures for self-assessment of the degree of digitalization by experts in educational institutions and for evaluation of the degree of digitalization of a set of educational institutions by external parties, including governing bodies and external institutions. It allows us to (self-)assess both the current degree of digitalization and the capacity of the institution to effectively implement institutional changes concerning digitalization by identifying the strengths of the educational institution and its weaknesses. Carrying out a re-evaluation after a certain period allows us to measure the progress made in terms of digitalization of the services offered. Ideally, the proposed model is used as a tool for monitoring the progress in the process of digitalization of the offered services.

The proposed tool can be used to evaluate the digital maturity of educational institutions, offering training at different levels. It is necessary to model an appropriate criteria system and methodology of scoring for this purpose. Experiments to assess the digital maturity of higher educational institutions are going to be conducted.

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