Information technology to support the digital transformation of small and medium-sized businesses

Lyubomyr Mosiy[1,*,†], Halyna Kozbur[1,†], Iryna Strutynska[1,†], Olha Mosiy[1,†], Vasyl Yatsyshyn[1,†]

[1] *Ternopil Ivan Puluj National Technical University, Ruska str., 56, Ternopil, 46001, Ukraine*

Abstract

The digital transformation of small and medium-sized enterprises (SMEs) in Ukraine is an important priority to improve their competitiveness, efficiency and resilience in a dynamic digital landscape. However, many SMEs face difficulties in determining their current level of digital maturity and need guidance on how to implement appropriate digital technologies and strategies. To address these issues, a conceptual model of an online platform for expert assessment and analysis of the digital transformation of Ukrainian SMEs has been developed. The proposed platform has the potential to significantly accelerate the digital transformation of SMEs in Ukraine by providing them with valuable tools and resources to assess digital maturity, receive personalized guidance and access training materials. This is expected to increase the competitiveness of Ukrainian SMEs both locally and internationally, fostering innovation and economic growth in the country.

Keywords

digital transformation, small and medium-sized businesses, online platform, digital maturity, artificial intelligence, cloud solutions

1. Introduction

The digital transformation of small and medium-sized enterprises (SMEs) in Ukraine is a critical priority, as it contributes to improving the competitiveness, efficiency and resilience of enterprises in a dynamic digital landscape. However, many SMEs face difficulties in determining their current level of digital maturity and need guidance on how to implement appropriate digital technologies and strategies.

To solve these problems, a conceptual model of an online platform for expert evaluation and analysis of the digital transformation of SMEs in Ukraine was developed.

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* Corresponding author.

† These authors contributed equally.

lmosiy@gmail.com (L. Mosiy); kozbur.galina@gmail.com (H. Kozbur); strutynskairy@gmail.com (I. Strutynska) lmosiy@ukr.net (O. Mosiy); vyatcyshyn@gmail.com (V. Yatsyshyn)

0009-0000-9778-331X (L. Mosiy); 0000-0003-3297-0776 (H. Kozbur); 0000-0001-5667-6569 (I. Strutynska); 0000-0002-5131-761X (O. Mosiy); 0000-0002-5517-6359 (V. Yatsyshyn)

This platform consists of seven main blocks: Data Collection Module, Knowledge Base, Assessment Module, Recommendation Module, Explanation and Visualization Module, Learning and Onboarding Module, and User Interface.

The platform will be implemented using modern programming languages and technologies. User interface designs using framework React, JavaScript, HTML and CSS. Python will be use to implement recommendation engine to ensure high performance, scalability, and usability. In addition, cloud solutions, including Amazon Web Services (AWS) or Microsoft Azure, will be used to deploy the platform and manage its infrastructure. The use of cloud technologies will ensure the reliability, security, and flexibility of the platform.

The integration of artificial intelligence (AI) technologies, such as machine learning, collaborative filtering and natural language processing (NLP), will allow the platform to provide personalized recommendations and insights based on the analysis of large amounts of data. Expert knowledge in the field of digital transformation will be encoded in the platform's knowledge base, which will ensure the accuracy and relevance of assessments and recommendations. As a core of knowledge base now uses relational database implemented in the MS SQL Server environment.

2. International programs, policies, frameworks and online platforms for assessing the digital maturity of SMEs

The digital transformation of SMEs is considered at the international and European levels as a key priority that ensures their competitiveness and sustainable development in the new economy. In addition, the digitalisation of SMEs is recognized as an important factor for achieving the UN Sustainable Development Goals and building the EU's digital single market. With this in mind, a number of international and European programs and policies have been developed to promote the digital transformation of SMEs (Table 1).

Table 1

Review of International and European Programs, Policies, and Frameworks for Promoting Digital Transformation of SMEs

Name of the program, policy, framework	Beginning	Key features
A Digital Single Market Strategy for Europe [1]	6 May 2015	The strategy includes three main areas: improving access to digital goods and services for EU consumers and businesses, creating favorable conditions for the development of digital networks and services, maximizing the growth potential of the European digital economy
OECD Digital for SMEs Global Initiative (D4SME) [2]	2018	Covers the following topics: digital skills, access to finance, digital technologies for SMEs, digital trade
Digital Europe Programme [3]	2021-2027	The program provides comprehensive trans-European digital services based on mature

		technical and organizational solutions in e-procurement, cybersecurity, e-health, e-justice, online dispute resolution, secure internet, open data
Shaping Europe's Digital Future [4]	2020-2025	The program consists of 4 key components: digital infrastructures and support services, enhanced digital capabilities and interoperability, cybersecurity and trust, and advanced digital technologies
An SME strategy for a sustainable and digital Europe [5]	10 March 2020	The strategy focuses on the following areas: digitalization, innovation and skills development, green transformation, greening of production and operations, financing and investment, use of online platforms, growth in supply chains, and entry into international markets
The Digital Decade policy programme 2030 [6]	September 2021	The program includes 4 main areas: digital skills of the population, secure and sustainable digital infrastructure, digital transformation of business, and digitalisation of public administration
«SME digitalisation to «Build Back Better» Digital for SMEs (D4SME) policy paper [7]	December 2021	Priority areas: digital infrastructure, digital technologies, partnerships, innovations and startups, and facilitating SMEs' access to foreign markets through digital channels

Also, a number of online platforms for assessing digital maturity and generators of personalized recommendations have been developed in European countries. Here are some of the platforms (Table 2):

Table 2
Existing online platform Digital Maturity

Name of platform	Developer	Approach to the evaluation
Digital Maturity Assessment (DMA) Tool [8]	European Commission	The tool uses the following dimensions for assessment: Overall digital maturity level, Digital business strategy, Digital readiness, Human-centric digitalisation, Data management, Automation & Artificial Intelligence, Green digitalisation
SME Compass [9]	CEVES, Serbia	The tool includes 9 pillars: Business sentiment and performance, Business environment, Human resources, Business model, Digitalisation and Industry 4.0, Innovations, Green transition,

		Access to finance, Gender equality
IMPULS – Industry 4.0 Readiness Online Self-Check for Businesses [10]	IMPULS Foundation of the VDMA and Aachen University	The online platform consists of 6 maturity levels (Outsiders, Beginner, Intermediate, Experienced, Expert, Top performers) i 6 dimensions (Strategy & Organization, Smart Factory, Smart Operations, Smart Products, Data-driven Services, and Employees)
Industry 4.0 Competence Meter [11]	i4EU, Co-funded by the Erasmus Programme of the European Union	The Competence Meter performs a multidimensional analysis of the users' digital skills according to four different dimensions: Technology, People, Organization, Business. The tool assesses the level of maturity with respect to each of the assessed dimensions and estimates the distance with respect to the "ideal" level of maturity needed to successfully implement Industry 4.0 models
Industry 4.0 Maturity Index [12]	Consortium of research institutions together with industrial partners working under the umbrella of Acatech (Deutsche Akademie der Technikwissen-schaften)	Industry 4.0 Maturity Index defines 6 successive stages: Computerisation, Connectivity, Visibility, Transparency, Predictive capacity, Adaptability. The Maturity Index has a modular structure and covers five functional areas: development, production, logistics, services, marketing and sales.

These platforms have common features:

- Digital Maturity Assessment: They help SMEs understand their current level of digital development through online diagnostics.
- Personalized recommendations: Based on the results of the assessment, the platforms generate customized roadmaps and recommendations to improve the digital capabilities of SMEs.
- Learning Resources: They provide access to training materials, webinars, and courses to develop digital skills and knowledge.
- Expert support: Some platforms offer access to a network of experts and mentors to provide advice on digital transformation.

The study of problems related to the digital transformation of small and medium-sized enterprises (SMEs), the determination of the level of digital maturity, and the formulation

of recommendations regarding the implementation of relevant digital technologies and strategies have received attention from international and Ukrainian researchers [13-18], in particular, in terms of practical application in various industries [19-21].

But despite this, it should be noted that the direct application of these tools to support the digital transformation of SMEs in Ukraine requires adaptation to the specifics of Ukrainian SMEs due to the difference in business conditions, levels of technological readiness and legal environment. After all, in Ukraine, SMEs have different levels of digital readiness, there are differences in legislation and regulatory environment, language adaptation is needed, industry specifics and the impact of the war must be taken into account.

3. Proposed methodology/model/technique

Based on the analysis of international programs, policies, frameworks, and online Digital Maturity platforms, the authors developed a model for the development of SMEs in Ukraine (Figure 1) and a conceptual model of an online platform for expert evaluation and analysis of digital transformation of SMEs in Ukraine (Figure 2).

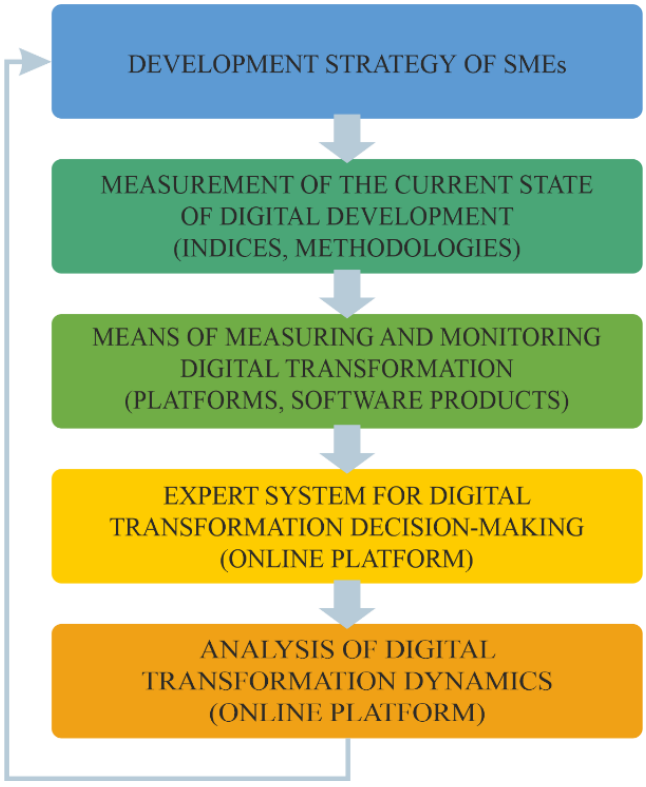

Figure 1: Model SME development of Ukraine

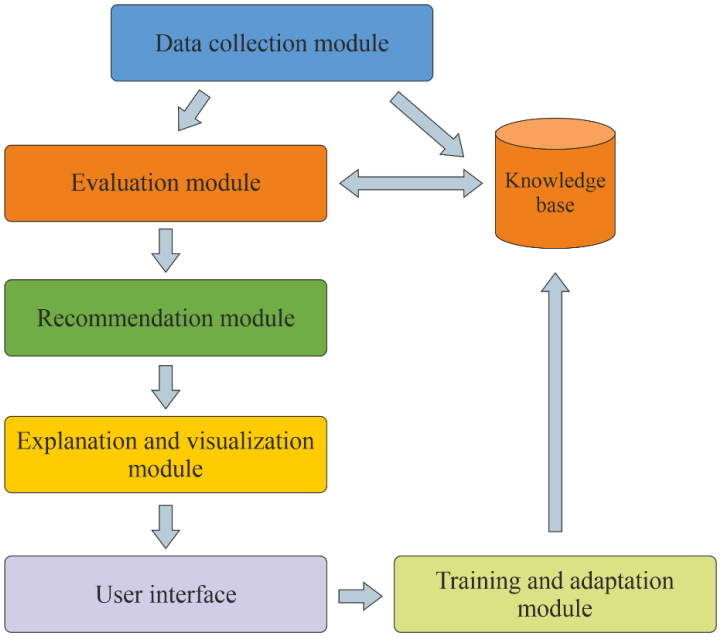

Figure 2: Conceptual model of the online platform for expert evaluation and analysis of digital transformation of SMEs in Ukraine

The proposed conceptual model of the online platform for expert evaluation and analysis of digital transformation of SMEs in Ukraine consists of 7 blocks that perform the following functions (Table 3):

Table 3
User-friendly and intuitive interface for interacting with the system

Platform blocks	Features
1. Data collection module	Interface for entering data about an SME company Integration with external data sources (financial reports, operational data, etc.) Data pre-processing and normalization
2. Knowledge base	Storing expert rules and criteria for evaluating digital transformation SME digital transformation ontology (key concepts, relationships) Methodologies and best practices for digital transformation
3. Evaluation module	Assessment of the current level of digital maturity of SMEs based on collected data Application of expert rules and criteria from the knowledge base Use of AI algorithms (e.g., machine learning) for data analysis and forecasting
4. Recommendation module	Generation of personalized recommendations for

	digital transformation based on assessment results Proposals for the introduction of new technologies, process optimization, digital skills development, etc. Use of AI to prioritize and adapt recommendations to the specifics of the company
5. Explanation and visualization module	Providing clear explanations of assessment results and recommendations Visualization of key indicators, trends and progress of digital transformation Interactive interface for research and analysis of results
6. Training and adaptation module	Continuous training and improvement of AI models based on feedback and new data Adaptation of expert rules and criteria in accordance with changes in the industry and new knowledge Ability to add new rules and knowledge by experts
7. User interface	Convenient and intuitive interface for interacting with the system Ability to enter data, view results and receive recommendations Access to educational materials and resources on digital transformation

The core of knowledge base is implemented relational database, which consists with 30 tables. In the Figure 3 showed main entities of domain which were displayed into the tables on the physics level.

Figure 3: Main entities of domain

Entity “Company” includes general information about the field in which concrete company work, structure of the company and information about worker’s space.

Entity “Company Infrastructure” describes the set of data about characteristics of workspaces digitalization, which include information about hardware, software and communication.

Entity “Methodology” includes information about methodologies, which can be used in the process of company’s level digitalisation defining. Each methodology designed on expert’s questionnaires.

Entity “Human Resource” describes a set of data about workers and their workspaces’ digitalization.

Entities “Experts”, “Expert Assessments” and “Expert Recommendations” describes evaluation process of company’s level digitalization.

In the physical level of database management system was implemented tables and relationships, which display all the entities in the Figure 3.

In the Figure 4 we showed the part of relational database that is responsible for the entity “Company” implementation.

This part of the database oriented for saving data about company name and location, fields, in which company works, departments, workers and workspaces. Table “CompanyFieldsDetails” was created to implement relationships many-to-many between tables “Company” and “CompanyFields”.

In the Figure 5 showed the part of database, which is responsible for the description of company digital infrastructure.

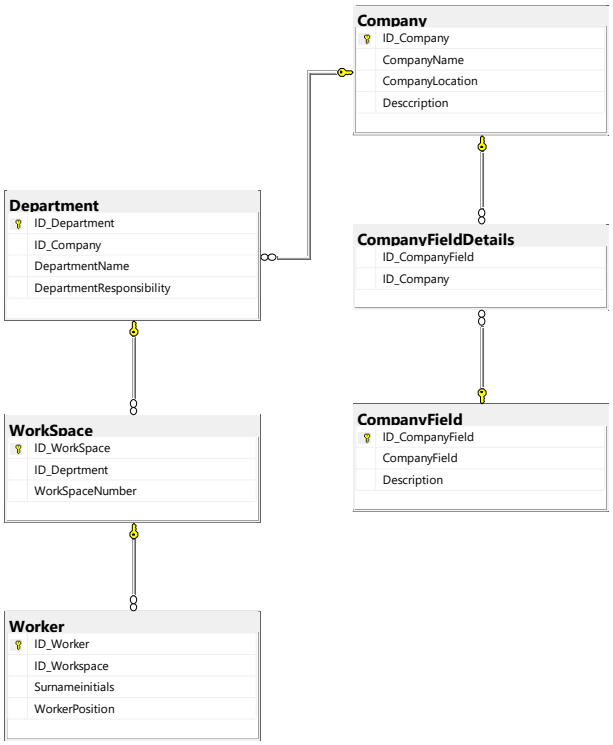

Figure 4: A part of the relational database that describes entity “Company”

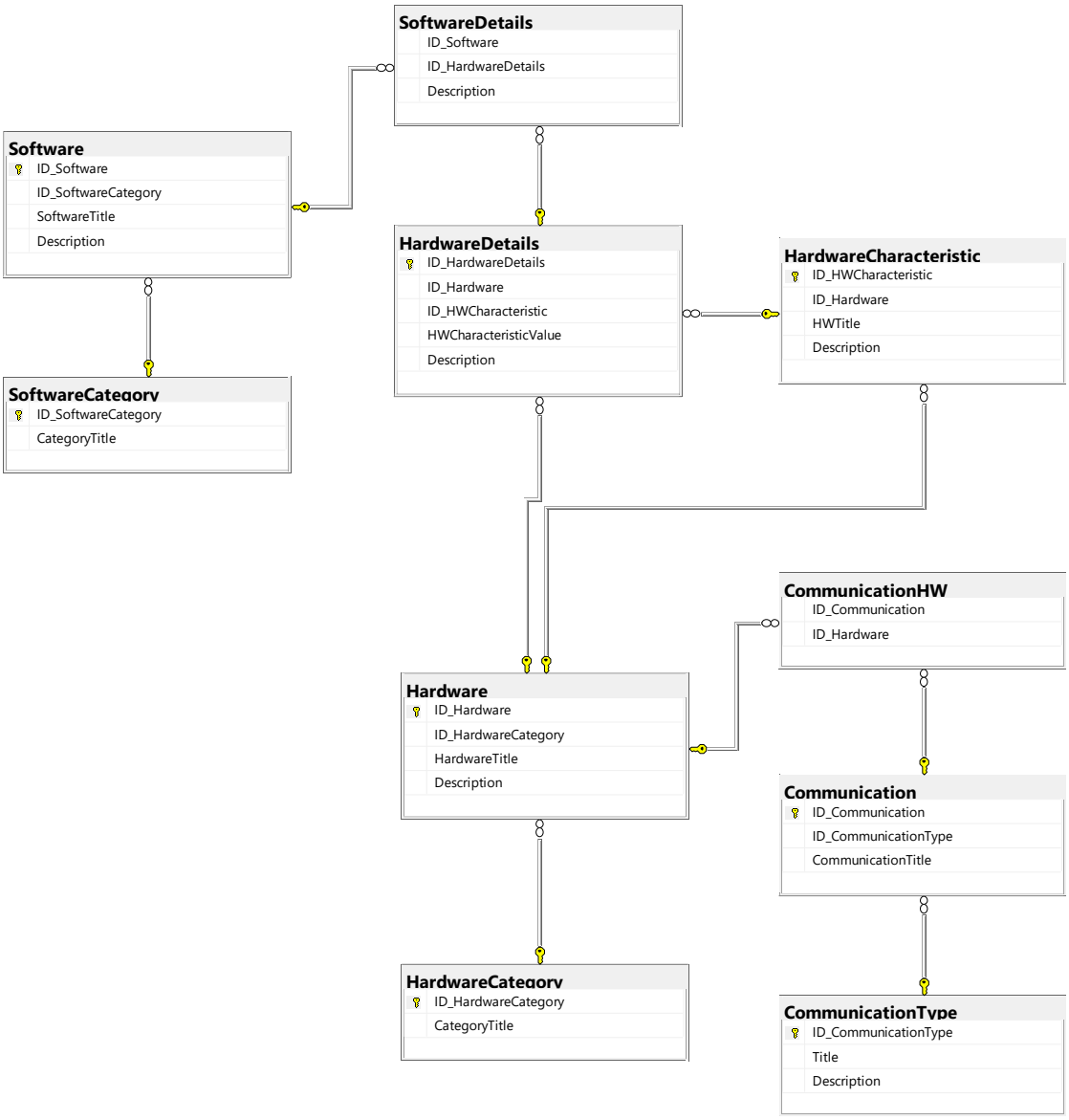

Figure 5: A part of database to describe company's digital infrastructure

Tables "Software", "Hardware" and "Communication" are main tables, which stored data about characteristics of digital infrastructure of the concrete company. Others tables was used for the detailed description some aspects of company's infrastructure and normalization scheme of the database.

In the Figure 6 displayed the part of database that shows digitalisation of workspaces.

As showed in the Figure 6, in this part of database was build relationships between software, hardware, communication interfaces and worker's spaces. Each workspace will be evaluate by experts in future.

In the Figure 7 showed the part of database that displays data to support the process of expert assessment.

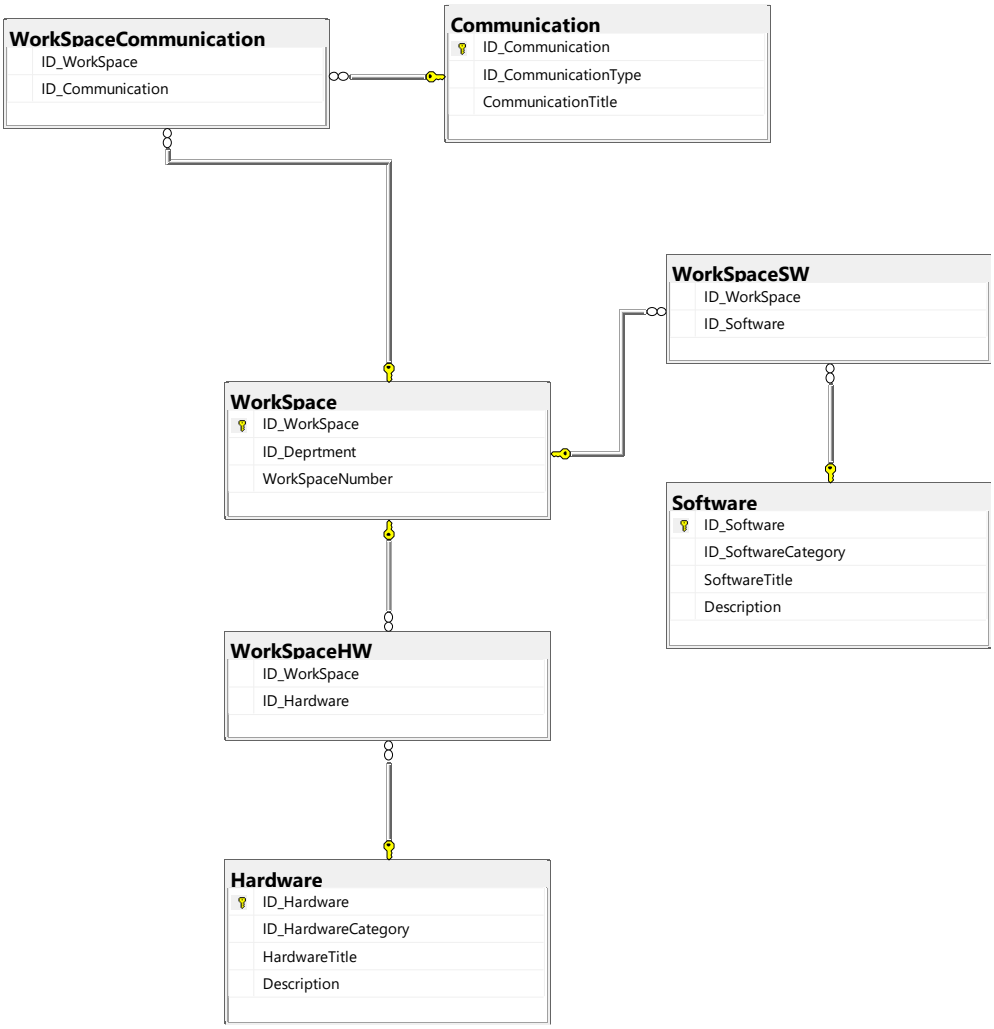

Figure 6: A part of the relational database that describes digitalisation of workspaces

The main tables of this part of the database are:

- "Methodology" – a table for storing data about description of some methodology for assessing the level of company digitization;
- "Questionary" – a table, which display information about questioner metadata in some methodology;
- "Questions" – a table for storing questions related to some questioners;
- "Expert", "ExpertDetails", "ExpertSkills" – tables, which describe information about experts and their skills;
- "Answer", "AnswerScale" and "Assessments" – tables for storing data about the answers and experts' assessments of the company level digitalization;
- "Recommendation" – expert recommendations for improving of company digitalisation level.

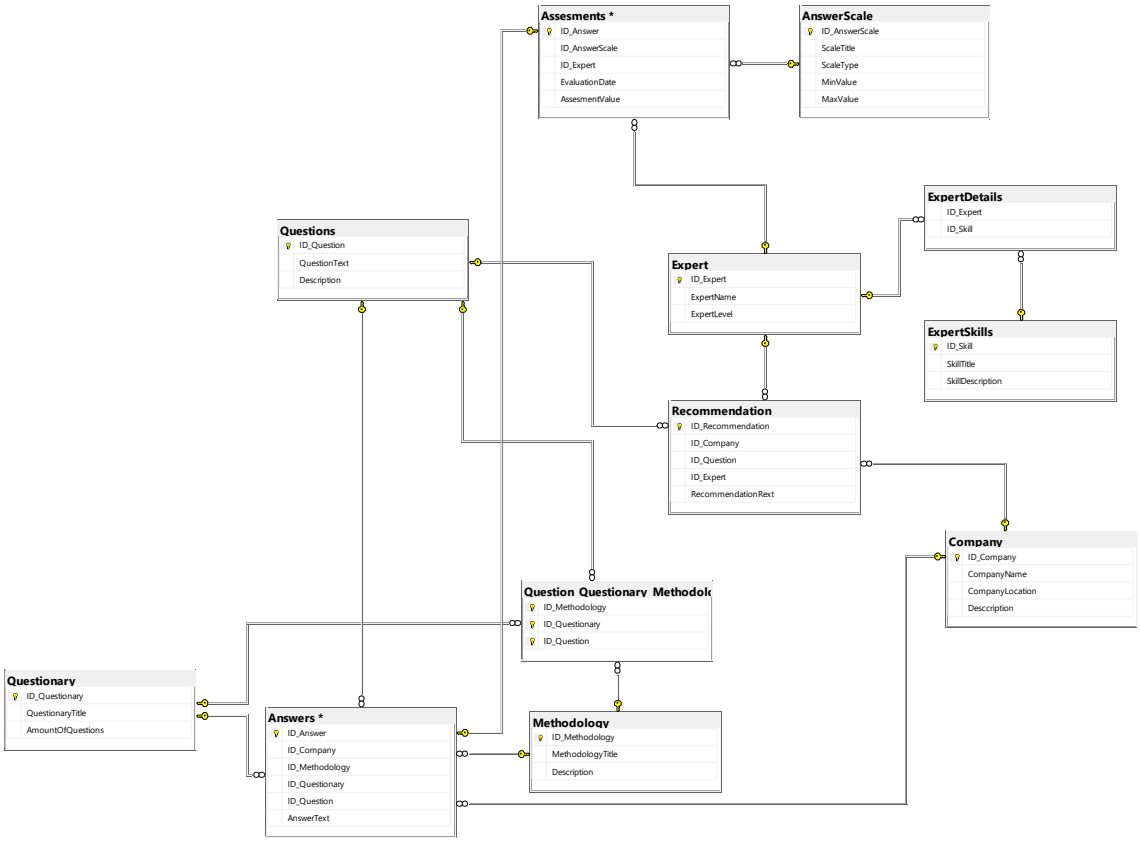

Figure 7: A part of database for supporting the process of expert assessment

Created database is using for the preparation data, which will be send to the recommendation service or recommender engine. Recommendation service works using technology of collaborative filtering. In the Figure 8 showed others approaches that can be used to implement recommendation system.

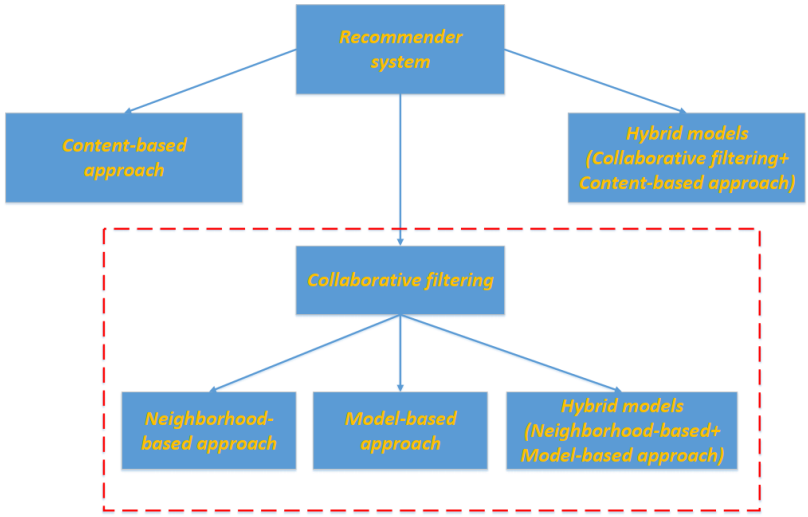

Figure 8: Approaches for building recommendation systems

The main idea of using collaborative filtering technology is preparation of cross-tabulation matrix, where columns interpret for the questions and rows display company name. In the cells of such matrix will be expert assessments, as quantitative values of answers for each questions in the interval from 1 to 5. In the Figure 9 showed the structure of the cross-tabulation matrix, and in the Table 4 – the scale, which using in the expert evaluation process.

		Questions						
		Q1	*Q2*	...	...	...	...	*Qn*
Company	*Company 1*	3	4					5
	Company 2	1	3					3
	...							
	...							
	...							
	...		Epxert assessments of answers for each Q1..Qn					
	...							
	...							
	...							
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	...							
	...							
	...							
	...							
	Company n	2	2					2

Figure 9: Cross-tabulation matrix

Table 4 The scale for expert evaluation

Unformal term	Assessments Value
Need complex digitalization	1 – 2
Average level of digitalisation which can be improved	3 – 4
Perfect level of digitalization	5

The main idea of using collaborative filtering in the process of making recommendations is to improve the level of company digitalization. In case when company has no digitalization, the system can make recommendations based on the most popular digital solutions implemented in the companies of the same working area. It is a cold start of digitalisation that can be describes with formula (1):

$$r_{xi} = \frac{1}{k \sum_{y \in N} r_{yi}} \quad (1)$$

where r_{xi} – a vector, which will store predicted values of expert assessments for each characteristics (Q1…Qn) of used evaluation methodology;

k – a total amount of companies in the same working area;

r_{yi} – a vector, which stored values of expert assessments for each characteristics (Q1…Qn);

N – a set of k companies most similar to company x, which also rated characteristics i;

In case, when company has expert assessments for some or all characteristics and wants to improve its level of digitalisation it is possible to use formula (2):

$$r_{xi} = \frac{\sum_{y \in N} sim(x, y) \cdot r_{yi}}{k \sum_{y \in N} sim(x, y)} \tag{2}$$

where $sim(x, y)$ – a similarity of digitalisation level for company x and y.

Similarity measure of level digitalisation uses different evaluation metrics. The two most popular metrics are: cosine metric and Pearson's correlation metric. Cosine's metric calculated by formula (3):

$$cos\alpha = \frac{\overrightarrow{r_{xi}} \cdot \overrightarrow{r_{xJ}}}{|\overrightarrow{r_{xi}}| \cdot |\overrightarrow{r_{xJ}}|} \tag{3}$$

$\overrightarrow{r_{xi}}$ – a vector of digitalisation level for company which wants to improve it;

$\overrightarrow{r_{xJ}}$ – a vector, which interpret level of digitalisation for other company.

$$sim(c, c') = \frac{\sum_{q \in Q(c,c\prime)} (r_{cq} - \overline{r_c}) \cdot (r_{c\prime q} - \overline{r_{c\prime}})}{\sqrt{\sum_{q \in Q(c,c\prime)} (r_{cq} - \overline{r_c})^2 \cdot \sum_{q \in Q(c,c\prime)} (r_{c\prime q} - \overline{r_{c\prime}})^2}} \tag{4}$$

where $sim(c, c')$ – similarity of company c and c'.

$q \in Q$ – characteristics of level digitalization;

r_{cq} – vector of digitalisation level for company c;

$r_{c\prime q}$ – vector of digitalisation level for company c'.

Formula (4) is the same that metric like centered cosine and gives more accurate results than classical cosine metric. It takes into account not only positive value and zero, but negative values in the cross-tabulation matrix.

This expert system structure ensures the collection and analysis of data on the digital transformation of SMEs, the application of expert knowledge and AI to assess and provide recommendations, as well as continuous training and adaptation of the system. The modular architecture allows for flexible expansion and improvement of the system in the future.

4. Results/Discussions

The proposed conceptual model of the online platform for expert assessment and analysis of the digital transformation of SMEs in Ukraine provides a comprehensive framework for supporting SMEs in their digital transformation journey. The key results and points for discussion based on this study are as follows:

1. Adaptation to the Ukrainian context: The developed model takes into account the specific challenges and needs of Ukrainian SMEs, such as varying levels of digital readiness, legislative differences, and the impact of the ongoing war. This localized approach is crucial for the effective implementation and adoption of the platform by Ukrainian businesses.
2. Integration of expert knowledge and AI: The platform leverages both expert knowledge and artificial intelligence techniques to provide accurate assessments and personalized recommendations. The combination of expert rules and machine learning algorithms enables the system to continuously learn and adapt to the evolving digital landscape and the unique requirements of individual SMEs.
3. Modular architecture: The modular structure of the platform allows for flexibility and scalability, facilitating future expansions and improvements. This is particularly important given the rapid advancements in digital technologies and the changing needs of SMEs. The ability to easily integrate new modules and features ensures the platform's long-term relevance and value.
4. User-centric design: The platform emphasizes a user-friendly interface and intuitive interaction, making it accessible to SMEs with varying levels of digital literacy. The provision of educational materials and resources further supports SMEs in their digital transformation efforts and helps bridge the knowledge gap.

Conclusion

The proposed conceptual model of the online platform for expert evaluation and analysis of the digital transformation of SMEs in Ukraine has significant potential for accelerating the digital transformation of Ukrainian SMEs. The platform offers a comprehensive approach that takes into account Ukrainian-specific context, integrates expert knowledge and AI technologies, has a modular architecture, and focuses on usability.

Adapting to Ukrainian realities, including different levels of digital readiness of SMEs, legislative differences, and the impact of the current war, is key to the effective implementation and use of the platform by Ukrainian businesses. The combination of expert rules and machine learning algorithms allows the system to continuously improve and adapt to the changing digital landscape and the unique needs of individual SMEs.

The platform's modular structure allows for flexibility and scalability, facilitating future expansion and improvement. This is especially important given the rapid development of digital technologies and the changing needs of SMEs. The ability to easily integrate new modules and features guarantees the long-term relevance and value of the platform.

The implementation of the proposed online platform can become a powerful catalyst for the digital transformation of SMEs in Ukraine, providing them with the necessary tools, recommendations and support for successful adaptation to the digital economy. This, in turn, will contribute to increasing the competitiveness, efficiency and resilience of Ukrainian SMEs both locally and internationally.

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