An Adaptive Technique of Digital Maturity Integral Estimation for an Organisation

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Abstract: The paper reviews the digital transformation (DT) management technology for an organisation at the stage of evaluating its digital maturity. A characteristic feature of DT consists in profound changes in approaches to management, corporate culture, external communications, as well as an abrupt increase in efficiency. The relevant goal is to estimate the progress of DT and record the indicators of this progress in order to improve the efficiency of the further DT, as well as secure the transparency of an organisation in terms of its digital maturity. We present the developed system of estimating the digital maturity of an educational organisation. The objective of estimating digital maturity has been formalised thanks to analysing the existing approaches to validation of the digital maturity for an organisational object. The utilisation of the model developed is demonstrated on the example of higher education in the Russian Federation. The novelty of the given study is in introducing the mechanism of integral estimation calculation of digital maturity into the digital maturity evaluation methodology. The weights in this modified weighted average estimation are assigned to indicators of DM pronouncement level in such a way so that the integrated estimation could be transformed into a 100-point grading scale. The technique is adaptive and can be applied not only in educational organisations but also in organisations in other spheres of activity.

1 INTRODUCTION

The development of digital economy poses new challenges for education given the conditions of instability and uncertainty. The changes are so swift that the managerial decisions have to be made rapidly whereas innovations should be promptly introduced into the educational process. Transaction costs, linked to the implementation of the aforementioned transformations and innovations, also escalate. All this combined determines the need for DT as a process of permanent digitalisation of all the procedural components in the educational activities, which leads to minimising the costs referred to above thanks to creating and using digital services and platforms.

In general, maturity models as a software engineering method have already been applied in a plethora of spheres, from healthcare to education [1]. There is no single established definition of digital maturity in the scientific literature; nevertheless, it is possible to single out some basic features most authors agree upon. As such, I.V. Aslanova and A.I. Kulichkina [2], having analysed the vast accumulated experience, define digital maturity as a "gradual process of integration and implementation of [organisation] processes, human, and other resources into digital processes and vice versa". When applied to the realm of higher education, digital maturity most of all affects teaching and learning, curriculum, and management, among other things [3].

Manifold models of estimating digital maturity have been offered by the specialists worldwide. T. Thordsen, M. Murawski and M. Bick present a comprehensive review [4] of 17 related models, and come to a conclusion that most of those do not meet necessary standards. The researchers imply that it is

vital to define the semantics within digital maturity as a notion, also stating explicitly that the transparency of data collection is of great importance from an empirical point of view. M.V. Kupriyanova and co-authors admit that the available information on the existing models of digital maturity may not be very well-developed in terms of terminology, whereas sometimes it is habitual to concentrate on digital readiness or digital dividends instead. As an alternative, their work advances the concept of hierarchy analysis [5]. Croatian experts, V. Đurek, N. Begičević and R.N. Kadoić [6], employ the DSR (design science research) paradigm in their respective model specifically for universities. It incorporates seven layers, including leadership, planning and management, ICT resources and infrastructure, ICT culture and several others. M. Al-Ali and A. Marks, in turn [7], build their model on multiple instruments, including survey, interviews and direct observation. They pay special attention to the discrepancy between the DM requirements and practicalities of their implementation.With regard to case studies applying some of the models, R. Doneva, S. Gaftandzhieva, and G. Totkov [8] use their UniDigMaturity model for assessing the situation in Bulgarian higher educational institutions. They claim that even though their model makes allowance for national context, it can be easily adapted to any country and the desired level of educational system. K. Hummel and B. Schenk [9] provide their experience pertaining to a university of applied sciences, namely UAS in Baden-Württemberg. It was found that on a scale of 0 to 4, the UAS displayed an indicator of digital transformation at just 1.4 (the study had nine dimensions on the whole). H. Keshavarz and Ya. Norouzi [10] concentrate on digital maturity of university libraries, and they present their MMDIM (Maturity Model for Digital Information Management), including 5 levels, 10 dimensions, 20 components. In their study, the authors conclude that most of the organisations – in this case, libraries – are at Level 3 of DM.

The analysis of approaches to estimating digital maturity (DM) made it possible to single out two most interesting techniques allowing one to determine the DM of an organisation.

The first method is suggested by the Institute of Digital Development of Science and Education, FSAEI HE “MIPT”, and is described in [11]. The project of a digital passport for a HEB (higher educational body) under development includes 42 scalar indicators, distributed across five layers: Users and services; Information systems; Data control; Infrastructure; HR. All the indicators are formalised, characterising a basic – technical and engineering – level of digitalisation and basically rely on the requirements of governing and regulatory authorities. Along with that, the utilisation of the technique under discussion necessitates a well-organised system of data collection for calculations. This, in turn, requires a developed integrated information system of university management, which is not frequently found, for instance, in Russia, as it demands significant investments.

The second technique has been developed by the Consulting Analyst Company “Center for Advanced Governance” and has been tested in M.K. Ammosov North-Eastern Federal University [12]. This technique includes 20 indicators, distributed across seven layers: Infrastructure and instruments; Organisational culture; HR; Processes; Products; Models; and Data. Considering the methodological particularities of the calculations, the indicators have a pronounced cognitive directionality and express as a whole the digital potential (ability) and the desire to implement it (readiness) by the entities of the educational sphere at the present level of digital technology potential in the organisation. An advantage of the method is the simplicity of data collection for further calculation through surveying key specialists and processing the statistical data.

The conducted analysis of the existing models of estimating digital maturity in the educational organisations and companies in other spheres, as well as digital transformation of economy, allowed the authors to form their approach to estimating the level of digital maturity in an organisation.

2 METHODOLOGY AND TECHNIQUES

The suggested model is based upon the methods formed by the Consulting Analyst Company “Center for Advanced Governance” [12]. In their respective work, the authors hammered out original indicators of a certain level of digital maturity in an educational organisation for every layer of digital level indicators, reflecting the special features of educational, administrative and R&D processes in terms of a HEB [13].

“Level 0 – Beginner” of a digital maturity indicator reflects the beginner level of DM. The characteristics of this level of digital maturity in a HEB are:

- ineffective automation of basic business processes in a HEB;
- underdeveloped digital infrastructure;
- data handling is only limited to meeting the requirements as per regulatory legal acts;
- a low level of digital competencies among the students, academic staff, and administrative personnel.

A zero level of digital maturity in a HEB limits the potential of its development due to ineffective automation of basic business processes in a HEB and underdeveloped digital infrastructure that does not make it possible to implement the digital transformation projects. This results in a HEB's falling behind compared to other educational organisations with a higher level of DM, which, thanks to digital technologies, improve their efficiency. That means they also gain traction in terms of their attractiveness for parties in interest (companies, state, and students).

"Level 1 – Basic" determines the level of automating the processes, i.e. the implementation of IT solutions reproducing the existing processes. The characteristics of this level of digital maturity in a HEB are:

- non-systemic (discrete) optimisation of business processes in a HEB;
- a low level of digital infrastructure development;
- a low level of work culture in data handling;
- lack of systemic actions aimed at developing digital competencies in students, academic staff, and administrative personnel.

HEBs at "Level 1" of digital maturity are only entering the process of digital transformation and have not yet reached the primary effects of implementing their digital transformation strategies, which become more pronounced at the later stages of digital maturity, such as a better quality of rendering services, or decreasing labour costs etc.

"Level 2 – Advanced" corresponds to the stage of the process digitalisation in an organisation where the existing processes are ameliorated thanks to implementing IT solutions, their re-engineering and optimisation, whereas decisions are made based on data analysis. The characteristics of this level of digital maturity in a HEB are:

- preliminary optimisation of basic business processes thanks to orderly inoculation of services into the HEB's activities;
- modernisation of the existing infrastructure;
- introduction of data-driven management;
- digital capacity building in students, academic staff, and administrative personnel.

A HEB at "Level 2" of digital maturity can be recommended to use best practices aimed at digital maturity, develop the existing infrastructure for subsequent expansion of their basic business processes, take action with a view to further build digital capacity among students, academic staff, and administrative personnel, continue their transition to data-driven management.

Finally, "Level 3 – Perfect" models the state of actual digital transformation, where the activities of an organisation are permeated by novel processes, products and models with conceptually new properties. The characteristics of this level of digital maturity in a HEB are:

- a high level of basic business processes optimisation thanks to introducing services in most of the business processes in the HEB activities;
- well-developed digital infrastructure;
- a high level of work culture in data handling;
- a high level of digital competencies in students, academic staff, and administrative personnel.

HEBs that reached a top level of digital maturity are capable of providing effective management, improving the quality of educational and scientific activities thanks to creating a unified digital environment provided with services, implementing new forms of organising basic processes, based on data management. HEBs that reached the given level, are recommended to develop novel models of managing their basic business processes taking into account the capabilities acquired in the process of digital transformation, bring the existing services to the level of an ecosystem, implement consultancy and methodological support for other players in the area [13].

Besides, we upgraded the model of DM estimation developed by "Center for Advanced Governance" with two more original indicator layers: "Global digital environment" and "Personality factor".

The "Global digital environment" indicator layer reflects the degree of digital unity between HEB activities and its external relations, as well as the degree of HEB's belonging to the global digital educational and research environment. The introduction of such a layer is predetermined, among other factors, by the fact that it is "creation, development and exploitation of IT infrastructure and information systems in the sphere of science and

higher education in Russian Federation" that is one of the priority directions of digital transformation of science and higher education suggested by Russian Ministry of Science and Higher Education [14].

The "Personality factor" indicator layer in turn reflects the degree of intolerance to digital immaturity of certain processes and activities, degree of impact of digitalisation processes in a HEB on employees' personal development, degree of democratism in HEB's digitalisation processes, as well as the degree of adequate understanding of ethical and social aspects of digitalisation in education and science by HEB employees.

As such, the suggested technique of estimating the level of DM in an educational organisation is structured as the following model (Table 1).

This leaves open the question of how to calculate the integrated level of digital maturity in an organisation. As such, in the model developed by the "Center for Advanced Governance" (upon which our technique is based), defining an overall level of digital maturity is not envisioned at all, whereas visual representation of the estimates obtained is only implemented in the form of a radar chart [12].

We suggest determining an integrated indicator of organisations' digital maturity (*DM*) using the following (1):

$$DM = \sum_{i=1}^{n} \sum_{j=1}^{m} k_{ij}^{l} x_{ij}, \; l = \overline{0,3}, \tag{1}$$

where x_{ij} is a variable of the *j*th reply of a respondent to the *i*th question in the questionnaire: $x_{ij}=1$, if a respondent attributed their *j*th answer to the *i*th question, $x_{ij}=0$ if vice versa; k^{l}_{ij} is the weight of the *j*th answer to the *i*th question; *l* is the index of digital maturity level in an organisation.

Table 1: Structural model of estimating the digital maturity of an organisation.

Layer of DM indicators	DM indicators
Organisational culture: Support of constant advancement and innovation processes facilitating effective change control	Developed digital tools for task management
	Effectors' pro-activeness when managing tasks
	Inter-operational control and assessment of results
Competencies: Personnel possessing competencies necessary for successful work in the digital economy environment	Development level of digital competencies among the staff
	Proficiency in using digital and analytical tools
	Maturity of the approach to developing digital competencies
Processes: Process-based management practices: methods of optimising processes, lean management, design thinking; monitoring processes and constant updates	Process management maturity
	Opportunities to optimise processes
	Degree of process automation
Products: Analysis of existing digital projects, their requirements and related activities	Participation in the creation of digital projects
	Managing digital products requirements
	Applying digital technologies in product creation
Models: Using various types of analytical models, updating them constantly, ensuring their validity and applying the results in the processes	Degree of proficiency in analytical approaches
	Degree of learning trajectories digitalisation
Data: Access to data for real-time decision-making taking into account their integrity, quality and safety for work	Degree of data classification
	Data processing performance level
	Data quality
Infrastructure and instruments: Access to modern digital infrastructure and maintaining workability on all types of devices	Workplace engineering
	Existence of developed digital services for the personnel
	Safety and security arrangements
Global digital environment: Access to modern global digital educational and research environment	Degree of digital unity
	Clarity of understanding one's belonging to the global digital environment
Personality factor: Employees' ability to embrace positive and constructive digital transformation	Degree of intolerance to digital immaturity of processes
	Degree of democratism in digitalisation processes
	Degree of impact of digitalisation processes on personal development
	Degree of adequate understanding of ethical and social aspects of digitalisation in education and science

The (k_l) weights are expertly set to correspond the answers and serve as normalising factors, bringing the integral results to certain values of a DM level (2):

$$k^l = \frac{\mathrm{DM}_l}{n}, l = \overline{0,3}. \quad (2)$$

As such, we deem it natural to use the following model parameters: DM_0=0 points is "Level 0 – Beginner"; DM_1=33.3 points is "Level 1 – Basic"; DM_2=66.7 points is "Level 2 – Advanced"; and DM_3=100 points is "Level 3 – Perfect".

3 RESULTS

The developed technique of estimating the DM was approbated at the Faculty of Computer Technology and Applied Mathematics, Kuban State University (KubSU). A total of 25 faculty members took part in the survey. Among those surveyed are primarily members of Department of Data Analysis and Artificial Intelligence, Associate Professors aged from 41 to 50, having worked at the university for less than 10 years. Figure 1 presents the level of digital maturity at the KubSU Faculty of Computer Technology and Applied Mathematics.

The results obtained allow us to make a conclusion that the DM estimations at most of the layers (8 out of 9), as well as the integrated DM at the faculty on the whole, fit the interval of a basic maturity level, i.e. slightly above average (55 points). The interpretation is as follows:

1) The digital support of advancement and innovation processes is hardly implemented at the faculty (42 points). The penetration rate of digital tools (34 points) and follow-up action regarding the goals set (32 points) is barely at the described beginner level.

2) The academic staff skills mostly correspond with the basic level of digital competencies, according to the Plan [14]. HR tools outreach to the staff (61 points) and data tools proficiency (58 points), are still not sufficient, though.

3) The adoption of process-based practices is quite well implemented (58 points). The degree of workers' understanding of the corresponding processes (including their content) is sufficient (68 points). However, the level of process optimisation and automation (45 points) leaves a lot to be desired.

4) The analysis of digital products and involved activities existing at the faculty demonstrates an average level of DM (48 points). Of concern is an insufficient penetration rate of digital products development tools (40 points).

5) The application of analytical tools and mathematical models in the activity processes, given the specificity of the faculty, is in general almost sufficient (58 points), which is mainly reflected upon the sufficient degree of their understanding by the academic staff. However, their application for organising educational activity is clearly underdeveloped (52 points for analysing data in one's principal field and 45 points for models of forming students' individual educational trajectories).

6) Data handling is also at an average level of development. Data completeness (56 points) and quality (61 points) for decision-making also suffer from a certain insufficiency. Similar to the "Processes" layer, the level of optimisation and automation in data processing (36 points) leaves a lot to be desired.

7) The access to modern digital infrastructure is also at an average level (49 points) and requires additional development in terms of creating extra automated jobs and digital services for the academic staff. The factor of cybersecurity appears essentially underdeveloped (36 points).

8) The maturity of global digital environment at the faculty is clearly insufficient (47 points), especially at the actual external communications level (36 points), which should be developed preferentially.

9) Up to the mark is the "Personality factor" layer (70 points), which is declarative of the sufficient HR quality at the faculty and encourages optimism regarding further digital development of the organisation. Of concern is the underdevelopment of the teamwork at the university level in terms of the expediency of its digital transformation (60 points).

The obtained digital maturity level estimations of layers and their separate indicators make it possible to single out priority directions of digital transformation in an organisation, which is especially important bearing in mind permanent limitations on various kinds of resources (including financial, human, material resources etc.) As such, for example, in the department under consideration (KubSU Faculty of Computer Technology and Applied Mathematics) the "Organisational culture" layer has the lowest level of digital maturity. The head of the Faculty mainly allocates tasks and controls their execution through primitive instruments at the minimum level of digitalisation (in this case these are emails, messengers or phone calls).

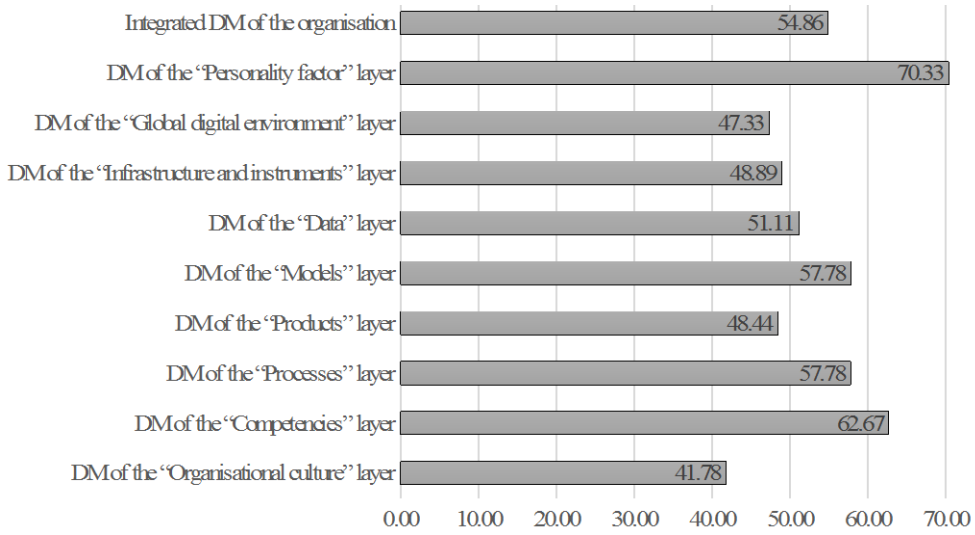

Figure 1: Digital maturity profile for the Faculty of Computer Technology and Applied Mathematics, KubSU, in accordance with the developed technique.

Consequently, the development of digital instruments and technologies of organisational interaction is seen as a priority direction of digital development at the KubSU Faculty of Computer Technology and Applied Mathematics when administering tasks of primary activities.

Therefore, estimating digital maturity in an organisation is, in fact, its internal check-up, which allows one to estimate its growth potential, single out priority development directions and elaborate an individual strategy for its digital transformation.

All in all, one can notice the existence of a definite basis for digital development at the faculty, a certain inefficiency of which should be compensated for thanks to constructive workload of highly-qualified human resources with sufficient supply of material resources.

4 CONCLUSION

The novelty of the given study is in introducing the mechanism of integral estimation calculation of digital maturity into the digital maturity evaluation methodology. This will allow one to draw a correct comparison between organisations or their separate departments, having different indicators in terms of scope of their activity. Apart from that, a change in an overall DM level of an organisational object in its dynamics can be regarded as an efficiency indicator in terms of digital transformation it is undergoing, which is a relevant applied research task of project management.

An application of the given description of calculating intergated result not just allows one to obtain a folding of estimations for individual indicators. In the description we suggest an integral indicator represents a modified weighted mean estimation of DM, where weights are assigned to replies but not questions, as it has been traditionally done in case of various techniques, including the mentioned method that we use as a basis for our work [12].

The suggested approach to estimating the digital maturity level of an organisation was endorsed at Faculty of Computer Technology and Applied Mathematics, Kuban State University. In general, its results demonstrate the presence of a certain basis for digital development of the faculty. The insufficiency of this basis should be compensated thanks to increasing constructive workload of high-quality HR coupled with adequate material support.

Even though we sought to estimate maturity of an educational organisation when developing our technique, the latter is adaptive and can be applied in organisations concerned with other areas of activities.

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