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Research Article

How to Support Teams to be Remote and Productive: Group Decision-Making for Distance Collaboration Software Tools

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ABSTRACT:

Global trends in digital transformation and the increasing importance of remote collaboration of the teams' members entail specific software platforms. In a crisis mode, the CIO has to propose digital collaboration tools to enable employees to work remotely as interim solutions in the short term. Determining the best-suited software products requires involvement of different experts in the area of IT, including CIO, IT specialists, and digital service team. Towards that goal, a group decision-making model that is suitable for fast evaluation is proposed. This model is capable to aggregate the group decision taking into account the experts' opinions with different weights. The applicability of this model has been demonstrated in the selection of software supporting the collaboration of remote teams using video conferencing, learning management systems, and project management. These three main products are common and suitable for business companies, universities, and research organizations. The obtained results show the practical applicability of the proposed group decision-making model by reasonable, objective and motivated decisions.

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Introduction

Nowadays, organizations are highly dependable on information technology (IT) not only to run their businesses but to stay competitive too.[1] To realize the planned operational or strategic benefits the organization has to rely on Chief Digital Officer (CDO) or Chief Information Officer (CIO). It is observed that the duties of CIOs merge a wide range of responsibilities that indicate their importance in the organization.[2] The activities of the CIO are related to re-engineering the existing business processes and their management, identifying new capability to use the contemporary tools, planning and integration of physical infrastructure and its accessibility, identifying and exploiting the company's resources, etc.

The Chief Executive Officer (CEO) and Top Management teams (TMT) play a critical role in strategy design and therefore greatly affect organization performance due to their position and nature of decision-making.[3] The results show that the interaction between CEOs and TMTs can improve organization performance. The role of top management is vital for planning, but CIO should provide motivated alternative decisions to cope with different challenges.[4] Some enthusiastic CIO promotes new development methods, new software applications, or the use of new IT devices. The more reasonable way is to form a board of top managers along with the CIO to discuss the challenges and requirements of the strategic IT innovations and to ensure consistent and reliable IT-enabled operations.[5]

Digital transformation requires constant engagements in order to estimate the applicability of new technologies in the context of specifics hardware requirements. In this regard, CIO should answer first if these new technologies are applicable to the business need of the organization. If the answer is positive, the required infrastructure is to be evaluated in respect of two possible ways: for upgraded or to be changed with a new. This is not an easy task and CIO should be able to determine the required short-term and long-term changes.[6] If remote collaboration capabilities are not available the CIO has to propose such interim solutions in the short term. In addition to the CIO and IT specialists, a new digital service team is to be involved to solve complex and challenging problems of digital transformation.[7] This team should be able to formulae and implement the needed cybersecurity policy at different levels.[8] For evaluation and selection of such complex and multi-dimensional problems, a group of different experts is to be involved.[9, 10] In some unexpected and crisis situations like coronavirus pandemic, CIO together with IT and digital service teams should adjust to a new reality and quickly propose decisions to continue team working at a distance. Businesses also have to consider governance and compliance requirements for remote work as remote collaboration is the new normal in the workplace. The same is valid for the academic sector where some kind of organizational efficiency and cyber resilience are to be done too.[11,12] Besides this, the Gartner recommends evaluating the technology trends by using a framework to identify their impact on people, businesses, and the IT estate.[13] All of this motivates the authors to analyse the existing software tools that make possible the

collaboration between team members at distance. In this respect, a straightforward mathematical model for group decision-making in the determination of suitable software tools to support the collaboration at distance is proposed. These software tools concern 3 important aspects, namely: videoconferencing, learning management systems, and project management.

The rest of the article is organized as follows: Section 2 presents some main parameters of the most popular software products for videoconferencing, learning management systems, and project management. Section 3 describes the proposed group decision-making model in the selection of software tools for remote collaboration. Section 4 reports the results of the numerical application of the group decision-making model. Section 5 provides results analysis and discussion, while the conclusions and future investigations are drawn in Section 6.

Software Tools for Collaborative Remote Working

In order to address a new wave of globalization, technological and business solutions that allow collaboration between the team' members with remote access are needed. Furthermore, the new trends in digital technologies enable the home to become a space for entrepreneurship.[14] This includes different software decisions such as platforms for remote real-time collaboration between geographically dispersed teams.[15] The operations as product and process design can be performed by teams working together and share the same contextual platform. To support such remote collaboration, the current article examines three important aspects like videoconferencing, e-learning, and project management tools. All of these collaborative software tools can be successfully used to support the activities not only of different business companies but are helpful also for the universities and research organizations.

Software Tools for Videoconferencing

Videoconferencing tools are widely used in different e-learning domains to help students develop an understanding of the world beyond their own community.[16] These videoconferencing tools are a part of up to date business that contributes to better communication and establishing strong relationships. The authors show that the accessibility, flexibility, and utility are important aspects that are clear from participants' perceptions of videoconferencing.[17] Furthermore, videoconferencing facilitates cognition and supports B2B supplier-customer engagement and contributes to innovation in SMEs when the distance is a barrier.[18] To perform more effective and faster collaboration there exist some key features of software tools for video conferencing that are given in Table 1.

The most critical parameters of the software tools for video conferencing are the number of participants and the time duration of meetings. Some of these free tools allow effective collaboration between different numbers of users. For example, Zoom and Webex provide up to 100 users, while the Google Hangouts, CyberLink, and Lifesize accommodate no more of 25 users. Along with the num-

Table 1. Essential parameters of video conferencing tools.

	Number of participants	HD video	HD audio	Screen sharing	Group chat	Video meeting recordings	Time duration limit per meeting
Zoom	100	yes	yes	yes	yes	yes	40 min
Webex	100	--	--	yes	--	yes	40 min
Skype	50	yes	--	yes	yes	yes	unlimited
Google Hangouts	25	--	--	yes	yes	yes	unlimited
CyberLink U Meetin	25	--	--	--	--	--	30 min
Lifesize	25	--	--	yes	yes	--	24 hours

ber of participants, the next important parameter is videoconferencing time duration. These two essential parameters for the described above software tools are compared in Fig. 1.

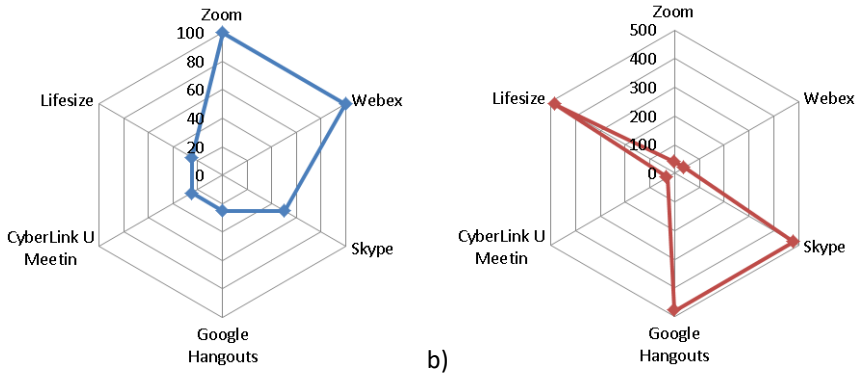

Figure 1: Performance of free video conferencing tools toward: a) number of participants; b) time duration limit per meeting.

In addition to the number of participants and videoconferencing time duration, there exist additional features like HD video and audio, screen sharing, group chat, and video recording. Some of them are supported while others are not available for usage in the freeware versions. All of these make the selection of a suitable videoconferencing tool complex problem that involves various quantitative and qualitative criteria.

Learning Management System Software

The learning management systems (LMS) are used not only in the education field but also in business training due to the numerous advantages.[19] To improve

the efficiency of online courses, different LMS are developed with different features. To increase the students' motivation in achieving a learning goal, the gamification elements could be integrated and used as a self-assessment in the e-learning environment.[20] The business could also benefit from such a system to propose some training courses for better understanding the systems work or to support cybersecurity education and training.[21,22] It is shown that using LMS has a significant relationship with learning effectiveness.[23] In order to increase the students' motivation, the latest versions of LMS are able to support mobile applications and a variety of integration options. The basic parameters of some free and popular LMS distributed into three main groups: supported specifications, deployment, and integration are shown in Table 2.

Table 2. Free Learning Management System.

LMS (Alternatives)	Supported Specifications			Deployment			Integration		
	SCORM 1.2	SCORM 2004	xAPI	Mobile Application	Self-Hosted Cloud-based	Self-Hosted System	SaaS/ Cloud	Word-press	Google Calendar
Moodle	yes	yes	yes	yes	yes	yes	--	--	--
Chamilo	yes	--	--	yes	yes	yes	yes	yes	yes
ILIAS	yes	yes	--	--	--	--	yes	--	--
Forma LMS	yes	yes	--	--	--	yes	yes	yes	yes

All of these LMS are compatible with the platforms of Linux, Mac, and Windows and also support the most popular browsers like Apple Safari, Google Chrome, Internet Explorer and Mozilla Firefox. The distribution of the LMS' parameters is illustrated in Fig. 2.

The use cases of academic learning are observed at Moodle, Chamilo and ILIAS; compliance training and employee training at Chamilo and Forma LMS; continuing education at Chamilo and ILIAS; customer training at ILIAS and Forma LMS; and public sector external at Chamilo.

The first group of supported specifications concerns the supported standards like SCORM and xAPI. SCORM provides the communication method and data models between eLearning content and LMS, while the new standard xAPI allows collecting data about a wide range of 'experiences' both online and offline learners. The second group of parameters addresses the way of deployment –

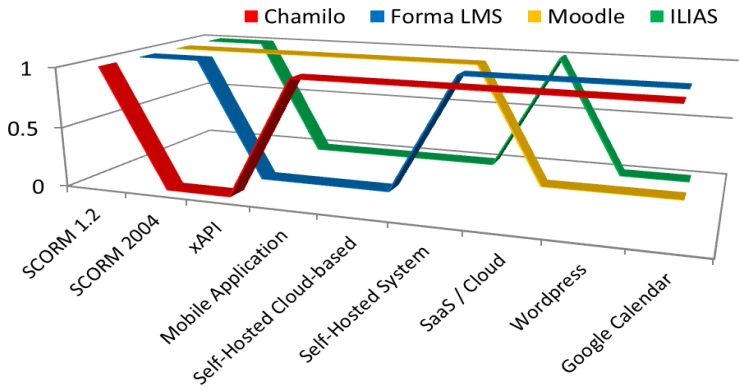

Figure 2: Performance of Learning Management Systems.

mobile application, self-hosted, cloud-based, self-hosted system, and SaaS/cloud. The last group of parameters, namely integration emphasizes the possibility to integrate additional applications helpful for the learning content visualization like WordPress and applications helpful for the learners like a calendar. The contemporary trend shows that mobile applications are mandatory for the purposes not on for education but also for different financial operations forecasting.[24] [25] As could be seen from Table 2 and Fig. 2, there are no perfect LMS capable to support all of the mentioned above parameters, so some reasonable decision based on objective evaluation is needed.

Software Platform to Support Project Management

Managing a project can be challenging, but using proper Project Management (PM) software tools could help to handle issues that come across. Project management is key to the project success that enables to the follow-up of the ongoing project activities. The PM software is a flexible solution that combines different sets of tools, features, and functionalities. They help organizations to achieve their goals by managing, tracking, communicating, and reporting on project activities, time, resources, and costs.[26] For both business and research organizations, there is a wide range of solutions that can be adapted to their activities, size, and resources. Furthermore, the needs of stakeholders from different levels are covered. For the project managers, the priority is scheduling, progress tracking, and portfolio management, which gives them a complete idea of deadlines and free resources. To be in collaboration is important for project team members, as well as tasks assignment, issue tracking, notifications, files and knowledge sharing, and project scope planning.[27] In the context of the digital transformation, PM software has the main advantage of having a web-based user interface, which provides centralized management and allows real-time collaboration and remote access for each individual team member in remote work. The main features and parameters of a restricted set of software for PM are shown in Table 3.

Table 3. Main features of software for project management.

PM	Collaborators limit	Storage limit	Main free features						
			Custom Workflow	Timeline Tracking	Calendar	Chat	Portfolio Manage	Gantt Chart	Version Control
Jira	Up to 10	2 GB	yes	yes	yes	yes	--	--	--
Bitrix24	Up to 12	5 GB	yes	yes	yes	yes	yes	yes	--
Infolio	Unlimited	1 GB	yes	--	yes	yes	--	--	--
GitHub	Unlimited	0.5 GB	--	--	--	yes	yes	--	yes

The deployment of all these free project management platforms can be realized as SaaS, and access is via web-based and mobile application interface. In this regard, the limit of the number of collaborators and the limit of storage space depends on package offers from PM software providers. The distribution of parameters of four PM platforms is illustrated in Fig. 3.

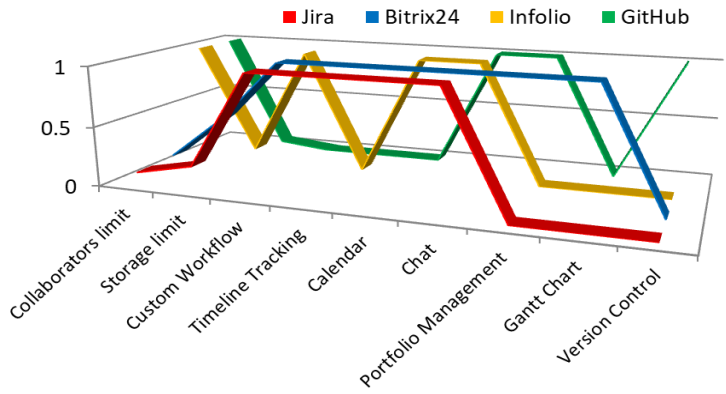

Figure 3: Parameters' performance of project management tools.

The visualization of workflow tracking, as the varieties of timelines and charts, play a key role in the successful and efficient implementation of project endeavours. They provide an overall picture of the project scope, work breakdowns, dependencies, and progress on the task and issues. The custom workflows help to adapt PM platforms to the established working methodology within the organization. It should be noted that only GitHub does not have this feature, because it is primarily a version control platform, but besides this, it is also effective in PM. Calendars are a basic tool for planning schedules, meetings, and notifications used by the project manager. Portfolio management enables the management of knowledge and people within the organization. In addition, for better collaboration among team members, there are project chats, which is common for the restricted set given in Table 3.

Group Decision-Making Models in Determination of Software Tools for Collaborative Remote Working

The business needs and the growing economy nowadays impose to make business decisions not only at different levels but considering also by different stakeholders.[28] To express the different points of view of the stakeholders toward the described above alternatives, a representative group of experts is formed. Each expert has to determine own coefficients that express the importance of predefined criteria toward given a set of alternatives. The most appropriate alternative should have maximum performance when aggregating all points of view of the group of experts. So, the mathematical formulation of group decision-making in the evaluation and selection of software tools for collaborative remote working could be expressed by the following model-1:

$$maxA_i = \sum_{j=1}^{N} w_j^e p_{ij} \, , for \; i = \{1,2, \dots , M\} \tag{1}$$

$$\sum_{j=1}^{N} w_j^e = 1 \tag{2}$$

where the number of alternatives is expressed by index $i = 1, \dots , M$; the number of evaluation criteria has index $j = 1, \dots , N$; the performance of the parameters regards to i-*th* alternative toward j-*th* criterion is expressed by p_{ij}; w_j^e are the coefficients that express the importance of j-*th* criterion from point of view of e-*th* expert.

The formulated model (1) – (2) is similar to the classic SAW, but evaluation scores are replaced by the 0 or 1 numbers to express the existence or not of parameters used as evaluation criteria. To consider the importance of the opinions of experts' additional coefficients is introduced by the following model-2:

$$maxA_i = \sum_{e=1}^{E} \lambda^e \sum_{j=1}^{N} w_j^e p_{ij} \, , for \; i = \{1,2, \dots , M\} \tag{3}$$

$$\sum_{j=1}^{N} w_j^e = 1 \tag{4}$$

$$\sum_{e=1}^{E} \lambda^e = 1 \tag{5}$$

where λ^e are weighted coefficients about the importance of opinion for the e-*th* expert and take values within the range of [0, 1].

The overall performance of alternatives is the sum of the multiplication of parameter performance, coefficients for the criteria importance and coefficients about the importance of experts' opinion. The best-suited alternative is the alternative with maximum performance value.

Numerical Application

To test the applicability of the group decision-making model (1) – (2) for selection software tools for collaborative remote working, the input data from described above tables (Table 1, Table 2 and Table 3) are used. A group of three

experts is used to express the coefficients for relative importance between criteria toward the given alternatives, namely CIO (E-1), IT expert (E-2), and an expert from the digital service team (E-3). These experts are determined as the most representative persons responsible for digital transformation.

Decision-Making for Software Tools for Video Conferencing

The weighted coefficients for the relative importance between evaluation criteria from a group of three experts along with the normalized data about the videoconferencing tools are summarizing in Table 4. The normalizing is done within the range between 0 and 1, where the absence of a feature is expressed by 0 and 1 when it is present. The maximum participants' number (100) is equivalent to 1, and the other calculated values are shown in Table 4. The value of videoconferencing time duration expressed by "unlimited" is considered equal to 8 hours (480 min) that represent the maximum, i.e. equal to 1 and the other calculated values are shown in Table 4.

Table 4. Normalized parameters of the alternative video conferencing tools.

DMs & Alternatives	Number of participants	HD video	HD audio	Screen sharing	Group chat	Video meeting recordings	Time duration limit per meeting
	w_1	w_2	w_3	w_4	w_5	w_6	w_7
E-1	0.20	0.08	0.07	0.13	0.05	0.15	0.32
E-2	0.10	0.13	0.18	0.15	0.07	0.15	0.22
E-3	0.13	0.10	0.20	0.19	0.10	0.08	0.20
A-1	1	1	1	1	1	1	0.0833
A-2	1	0	0	1	0	1	0.0833
A-3	0.5	1	0	1	1	1	1
A-4	0.25	0	0	1	1	1	1
A-5	0.25	0	0	0	0	0	0.0625
A-6	0.25	0	0	1	1	0	1

The ranking of the alternatives based on the normalized data from Table 4 and weights for the criteria importance given from each expert are illustrated in Fig. 4.

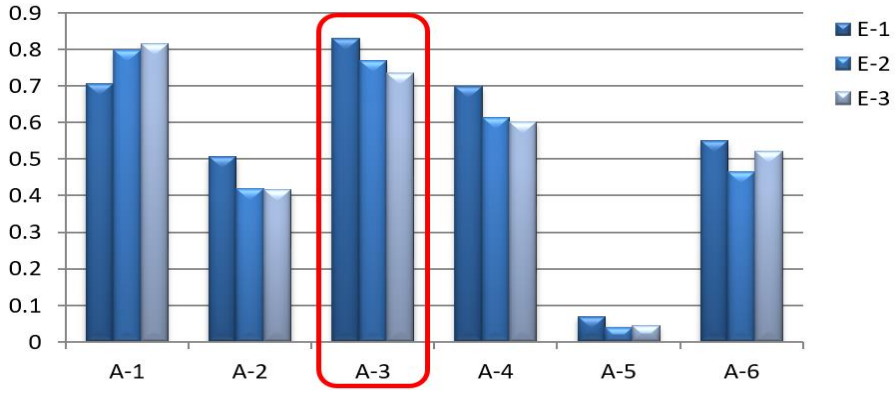

Figure 4: Ranking of the alternatives from different experts.

The numerical results show that the best choice for expert E-1 is the alternative A-3 (Skype) with performance equal to 0.83, while for the experts E-2 and E-3 – the best choice is the alternative A-1 (Zoom) with a performance of 0.798333 and 0.816667 respectively (Fig. 4). In conclusion, following the proposed model (1) – (2) and taking into account the opinions of all experts, the aggregated group decision is to be the choice of alternative A-3 (Skype) as it has the maximal performance equal to 2.335.

Decision-Making for Learning Management System Selection

The corresponding weighted coefficients for the relative importance between evaluations criteria determined from group members' along with the normalized data about the LMS are shown in Table 5.

Table 5. Normalized parameters of the alternative for Learning Management Systems.

DMs & Alter-na-tives	Supported Specifications					Deployment			
	SCORM 1.2	SCORM 2004	xAPI	Mobile Appli-cation	Self-Hosted Cloud-based	Self-Hosted System	SaaS / Cloud	Word-press	Google Calendar
	w_1	w_2	w_3	w_4	w_5	w_6	w_7	w_8	w_9
E-1	0.08	0.15	0.16	0.12	0.09	0.13	0.07	0.10	0.10
E-2	0.07	0.13	0.17	0.11	0.08	0.20	0.10	0.08	0.06
E-3	0.07	0.10	0.05	0.10	0.13	0.15	0.10	0.10	0.20
A-1	1	1	1	1	1	1	0	0	0
A-2	1	0	0	1	1	1	1	1	1
A-3	1	1	0	0	0	0	1	0	0
A-4	1	1	0	0	0	1	1	1	1

Here the normalizing is simple and expresses availability or not of some evaluation criteria by using 0 for absence and 1 for the presence of the corresponding feature.

The ranking of the alternatives LMS based on the normalized data from Table 5 and weights for the criteria importance given from each expert are illustrated in Fig. 5.

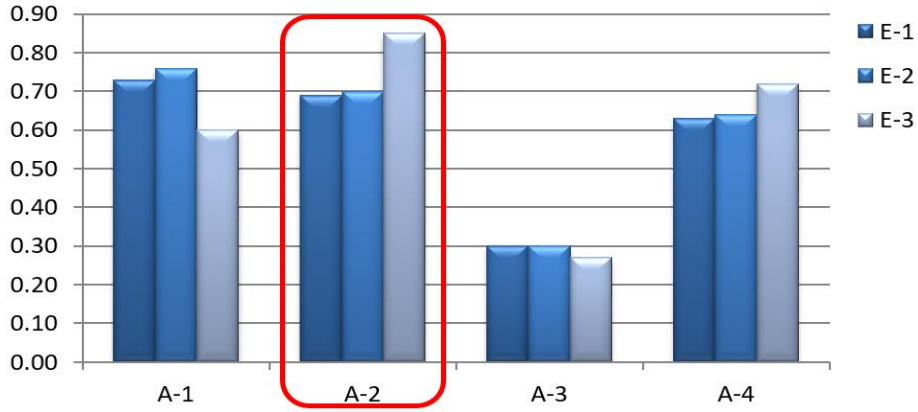

Figure 5: Ranking of LMS alternatives from different experts.

The results show that alternative A-2 (Chamilo) is the choice for the E-3 as it has the better performance equal to 0.85, while for the experts E-1 and E-2 the best choice is the alternative A-1 (Moodle) with values of 0.73 and 0.76 respectively. In conclusion, the aggregated group decision when selecting the LMS is to be the choice of the alternative A-2 (Chamilo) as it has the maximum performance equal to 2.24.

Decision-Making for Project Management Software

The weighted coefficients for the criteria importance determined by each of the group member and the normalized parameters about the software tools for project management are presented in Table 6.

The normalization of the parameters about the project management software is realized within a range between 0 and 1. These values express the presence or not of parameters except the parameters for the collaborators' limit and storage limit. The unlimited of collaborators limit is considered equal to 1 (like best parameter performance), while the parameter for the maximum storage limit takes the value of 1 (for the alternative with 5 GB for Bitrix24). The rest normalized values describing the project management software parameters are given in Table 6.

Table 6. Weighted coefficients about the criteria importance and normalized parameters of the alternative for PM tools.

DMs & Alter-natives	Collaborators limit	Storage limit	Custom Workflow	Timeline Tracking	Calendar	Chat	Portfolio Manage	Gantt Chart	Version Control
	w_1	w_2	w_3	w_4	w_5	w_6	w_7	w_8	w_9
E-1	0.09	0.10	0.05	0.18	0.19	0.05	0.10	0.11	0.13
E-2	0.18	0.09	0.07	0.07	0.07	0.10	0.02	0.13	0.27
E-3	0.12	0.10	0.17	0.14	0.17	0.06	0.02	0.11	0.11
A-1	0.1	0.4	1	1	1	1	0	0	0
A-2	0.12	1	1	1	1	1	1	1	0
A-3	1	0.2	1	0	1	1	0	0	0
A-4	1	0.1	0	0	0	1	1	0	1

The ranking of the alternatives for PM based on the normalized data from Table 6 considering the coefficients for the criteria importance in accordance with the point of view from each expert are illustrated in Fig. 6.

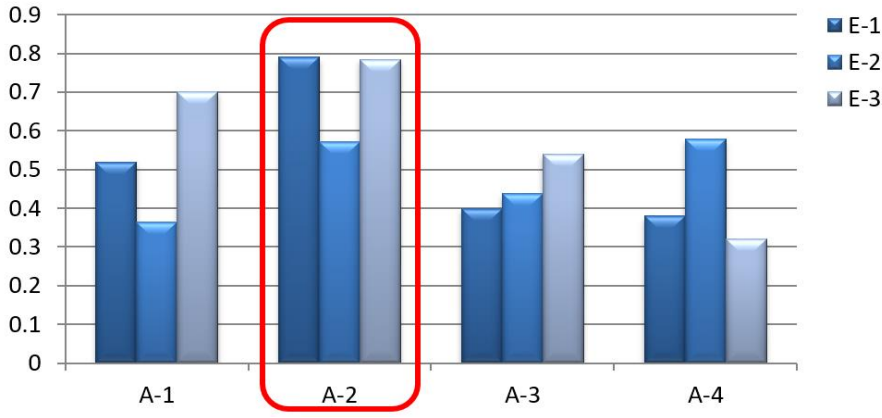

Figure 6: Ranking of the alternatives for Project Management from the different experts' point of view.

Considering only the opinion of E-1, the best selection for PM should be A-2 (Bitrix24) as it has a better performance equal to 0.7908. The same decision is valid also for expert E-3 where alternative A-2 has the maximal value of 0.7844. In contrast to E-1 and E-3, the given weighted coefficients for the criteria importance form the expert E-2 determine as the best alternative A-4 (GitHub) with a value of 0.579. In conclusion, the group decision based on the aggregated

opinions of the experts shows that the choice should be alternative A-2 (Bitrix24) due to obtained maximum performance equal to 2.1468.

Group Decision-Making in Software Tools Selection

To get more transparent group-decision, the corresponding weighted coefficients for the importance of opinion for each expert are used. Three different cases are investigated to demonstrate the applicability of the proposed mathematical model (3) – (5).

The Case-1 simulates the situation where opinions of all experts are with equivalent importance. The Case-2 shows that the most important opinion is given on expert E-3, followed by the expert E-2 and then expert E-1. The last Case-3 illustrates that the most valuable opinion is provided by the expert E-1 followed by expert E-2 and less important is the opinion of expert E-3 as shown in Table 7.

Table 7. Weighted coefficients for the importance of opinion for each expert.

Experts	Case-1	Case-2	Case-3
E-1	0.33	0.20	0.50
E-2	0.33	0.35	0.40
E-3	0.34	0.45	0.10

These weighted coefficients for the importance of each expert when aggregating the group decision along with the normalized data from Table 4, Table 5, and Table 6, are used to solve corresponding tasks following the proposed model (3) – (5). The obtained group solutions for videoconferencing, e-learning and project management tools under three different cases for the experts' opinions importance are visualized in Fig. 7.

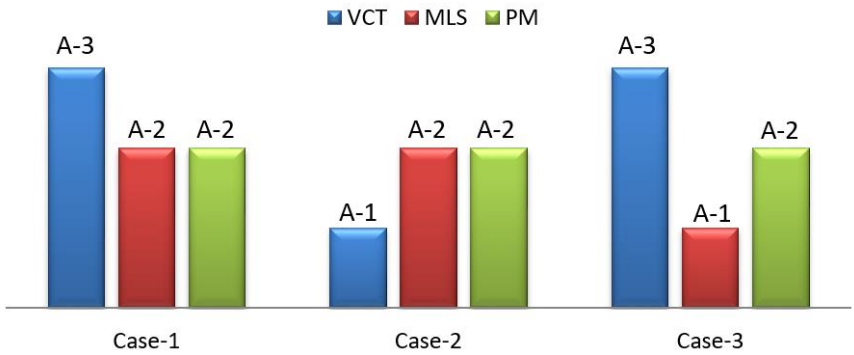

Figure 7: Aggregated group decisions in alternatives determination for VCT, LMS, and PM for three different cases for the experts' opinion importance.

In the case of VCT selection when all experts' opinions are considered with equal importance, the group decision is the alternative A-3 (Skype). The same decision is for the Case-3 where the expert E-1 and E-2 have predominant influence compared to the opinion of E-3 in aggregating the group decision (Table 7). When more advantages in opinions are given on E-3 and E-2 than E-1 (Case-2), the group decision is to be alternative A-1 (Zoom) (Fig. 7). All of these group decisions are based on the same normalized VCT parameters, and coefficients for their importance from each expert including additional weighted coefficients for experts' opinion importance. Although E-2 and E-3 determine alternative A-1 as the best choice and only E-1 determines alternative A-3 as the most suitable one, the obtained group determines alternative A-3 in two of three cases. The aggregated group decision for LMS shows that the best choice is the alternative A-2 (Chamilo) when all experts' opinions are considered with equal importance. This group decision is duplicated also in Case-2, while under Case-3 the group decision is the alternative A-1 (Moodle).

The group decisions toward preferable PM software in all three cases show that alternative A-2 (Bitrix24) is to be the better decision, although the expert E-2 identifies alternative A-4 as the best. Taking into account the aggregated group decisions shown in Fig. 7, it can be summarized that the best decision for Case-1 has to be Skype, Chamilo and Bitrix24; for Case-2 this combination is Zoom, Chamilo and Bitrix24, while for Case-3 the combination is Skype, Moodle and Bitrix24.

The obtained results show that the proposed group decision-making modelling approach is applicable when the selection is based only on existing software parameters. This is due to the used relations (1) and (3) that include an element for parameters' performance (p_{ij}) instead of classical evaluation. For evaluation and selection of commercial software tools (not open source or freeware), additional parameters such as support, ease of use, recommendations by other users, price, etc. are to be considered too.

When forming the group decision, it is important to take into account the experts' opinions with different importance as they differ in reality. The level of importance should be coherent with the responsibilities of each expert and their practical experience. There are some open questions related to the determination of the ratio between responsibilities and practical experience best fitted to a particular group decision.

It should be noted that each software tool in any business organization (research institute or university) has to be done with the active participation of the CIO, IT specialists and experts from the digital service team. This is due to the requirements to ensure compatibility between software and hardware equipment, and last but not least the company policy for cloud or self-hosted systems.

Once the selection of the proper collaboration software tools is done, it is needed to determine how they will be installed and administered. The easy and promising way is to use some kind of wireless technologies that provide remote access. This means to consider some already installed smart technologies to

avoid duplication and to decrease the transmitted signals' impacts on the human body. These activities are planned as future investigations. Detailed studies conducted through appropriate surveys could identify possible psychological and physical impacts of excessive use of smart technologies and contemporary trends of digital transformation.

Conclusions

The digital transformation can benefit from different software products for remote collaboration by providing the middleware where the teams' members can work together. If remote collaboration capabilities are not available the CIO together with the IT specialists and digital service team, has to propose some interim solutions in the short term to overcome unexpected crisis situations. To deal with such problems, a group decision-making model suitable for fast evaluation is proposed. This model allows aggregating experts' opinions with different importance when forming the group decision. The numerical results show the applicability of the proposed model in the selection of software supporting the collaboration of remote teams using video conferencing, learning management systems, and project management.

There are some open questions related to the determination of the weights of importance about the experts in an aggregated group decision. The weights are to be coherent with the responsibilities of each expert and their practical experience. These problems along with the evaluation of commercial software tools for remote collaborations are planned as future investigations.

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