

Mathematical and Statistical Methods of Analyzing the Successful Implementation of German-Ukrainian Projects

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Abstract: The extraordinary dynamism, complexity and ever-increasing interdependence of all transformation processes in the modern world in the face of crisis conditions necessitates strengthening partnerships and coordination of actions at the national, regional and international levels to ensure the quality and sustainability of higher education systems around the world. The research focuses on the successful practical implementation of German-Ukrainian projects of the Anhalt University of Applied Sciences, such as Digin.Net, Digin.Net 2, Study Visits, DigiJED, DigiJED 2, GLSs and Idea-East Hub. Based on the mathematical and statistical methods of analysis, a regression model was built to predict the attraction of funding for the development of education in Ukraine. A meta-analysis of existing practical projects and their financial plans was conducted, considering the definition of specific criteria for successful selection among competitors. Using factor analysis of quantitative and qualitative assessment of the indicators of implemented projects, the authors' model of criteria for successful selection of projects in DAAD was created.

1 INTRODUCTION

Education and science are at the centre of a large-scale transformation of German-Ukrainian partnership that will change not only the academic world, but also the environment of cooperation, its conditions, and life in general [1], [2], [3]. During the war and in the post-pandemic period, international academic cooperation proved to be not only very effective and sustainable, but also a lifeline to save and preserve the entire nation, its potential, and intellectuals. The article is devoted to a critical analysis of the existing German financial support for Ukraine in the field of education development based on statistical data and correlation and regression analysis.

The German-Ukrainian cooperation is examined on the example of the practical implementation of German-Ukrainian projects of the Anhalt University of Applied Sciences, such as Digin.Net, Digin.Net 2 [4], Study Visits, DigiJED, DigiJED 2 [5], Idea-East Hub [6], etc.

The purpose of the study is to conduct a meta-analysis of project financial plans in order to identify specific criteria for successful selection among

competitors and, based on the factor analysis of quantitative and qualitative assessment of the indicators of implemented projects, to create an authors' model of criteria for successful selection of projects in DAAD.

2 FINANCING GERMAN-UKRAINIAN EDUCATIONAL AND SCIENTIFIC PROJECTS

From 2013 to 2020, Germany committed 405,15 million euros to development finance to Ukraine for Education. Of this amount, 100% was provided as Official Development Assistance (ODA) grants, while 0 euro (0%) was provided in the form of ODA loans [7]. Development finance from Germany to Ukraine for Education was provided to different sub-sectors, as shown in the figure below. The largest commitments were 349,18 million euros to Higher education, 34,53 million euros to Education facilities and training and 12,26 million euros to Teacher training (Figure 1).

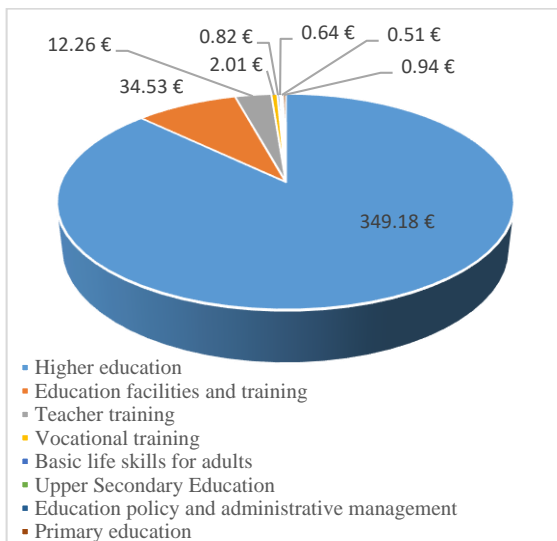


Figure 1: Total finance by sub-sector targeted 2013-2020, in million €.

Analyzing the ten sectors that received the most funds in 2013-2020, we can clearly see that most of the money is allocated to higher education, to support student learning.

Table 1: Top ten supported Sub-Sector in 2013-2020.

	Amount, in mn €	Year	Donor	Recipient	Sub-Sector	Project Title
1.	47,5 mn	2020	Germany	Ukraine	Higher education	Student costs
2.	46,9 mn	2019	Germany	Ukraine	Higher education	Student costs
3.	45 mn	2018	Germany	Ukraine	Higher education	Student costs
4.	43 mn	2017	Germany	Ukraine	Higher education	Student costs
5.	41,4 mn	2016	Germany	Ukraine	Higher education	Student costs
6.	38,3 mn	2015	Germany	Ukraine	Higher education	Student costs
7.	34,6 mn	2014	Germany	Ukraine	Higher education	Student costs
8.	34,2 mn	2013	Germany	Ukraine	Higher education	Student costs
9.	6,02 mn	2017	Germany	Ukraine	Teacher training	Professional integration of internally displaced persons
10.	3,57 mn	2019	Germany	Ukraine	Education facilities and training	Operating expenses, Goethe-Institute (GI)

2.1 Main Financial Sources

The main sources of funding for most educational projects within the framework of cooperation between Germany and Ukraine are DAAD, Erasmus, and BMBF. DAAD is the world's largest funding

organization for the promotion of international student and research exchange, with an operating budget of around 634,7 million euros in 2021. Its most important funding providers include the Federal Foreign Office – AA (33,5%), the Federal Ministry of Education and Research – BMBF (32,5%), the Federal Ministry for Economic Cooperation and Development – BMZ (7,5%) and the European Commission and other international organizations European Union – EU (20,7%) [8].

In 2021-2027, the Erasmus+ budget of 21,208 billion euros provides an opportunity for Europeans to study, train and gain experience abroad.

Accordingly, DAAD, Erasmus and BMBF are the biggest investors in education. Funding of educational projects by foreign institutions is very important for Ukraine, especially considering the significant potential in the field of education.

2.2 Forecast Based on Regression Analysis

In 2020, Germany allocated 59,69 million euros to development funding to Ukraine for education, which was 100 % provided in the form of ODA grants. The disbursement rate was 105,2 %.

Consider the schedule of Germany's allocation of funds to Ukraine for the period 2013-2022. Moreover, the data for 2013-2020 were used from the Aid Atlas resource [7], and the calculation of the statistics of funding amounts was made on the basis of a forecast based on preliminary data and on the basis of statistical analysis using regression and trend line analysis (as of January 10, 2023, Figure 2).

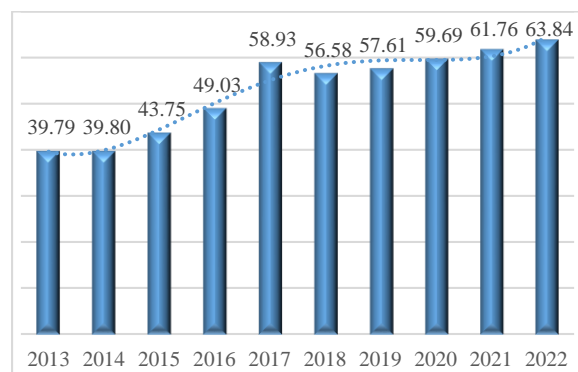


Figure 2: German funds to Ukraine for the development of education in 2013-2022, in million €.

Using data regression analysis and trend line analysis, it was found that the most effective trend line is a polynomial trend line. This curve is characterized by increasing and decreasing variables.

To get the approximation reliability value of R-squared (1):

$$R^2 = 0,9669, \quad (1)$$

we had to increase the equation to the 4th degree and use the corresponding one (Figure 2):

$$y = 0,0417x^4 - 0,9356x^3 + 6,7781x^2 - 14,069x + 50,183 \quad (2)$$

R^2 is close to 1 (0,9669), indicating minimal approximation error. Consequently, this (2) can be used to predict data in future years.

3 JOINT GERMAN-UKRAINIAN RESEARCH: IMPLEMENTED PROJECTS

The Anhalt University of Applied Sciences (HSA) is an active player in the dynamic process of internationalization. It has about 2 500 international students from more than 110 countries and 12 English-language study programs. International students, who now make up around 30 per cent of the total, have been the focus of the activities of the current internationalization strategy. The University is also very strong in research and has 87 300,00 euros of external funds per faculty member, compared to the federal average of 45 400,00 euros in engineering and computer science at HAWs University in the 10 strongest researches in the federal territory. In its research strategy (Senate Resolution of January 2021), the HSA set out to advance research, knowledge transfer and technology not only regionally but also internationally to address important future challenges, such as the energy transition, climate change and digitalization, through innovative applied research. According to the internationalization strategy of the University, it is actively involved in many projects focused on Eastern and South-Eastern Europe, including Ukraine, where the HSA is strategically positioned as an important partner. HSA is constantly expanding existing contacts in Ukraine and bringing them to a qualitatively higher level in order to create more international networking and interdisciplinary study programs, especially with double degrees, as well as to create an international innovative network of doctoral students and faculty based on this international network and innovative Universities. Innovative competitions and forums, innovative training and relevant professional development activities contribute to the sustainable involvement of all target groups of the University in the process of

internationalization and increase the competitiveness of the University.

3.1 HSA-Ukraine Cooperation

Anhalt University of Applied Sciences maintains intensive contacts with Ukrainian Universities and regularly conducts student and academic exchanges. This is done in particular through the ERASMUS+ (KA 107), Eastern Partnership and professional international internship programs, as well as through various research funding in the fields of renewable energy, data science and the Internet of Things (IoT). HSA actively cooperates and already has double degree agreements with some Universities in the country. The most powerful technical Universities of the country are involved in cooperation:

- National Technical University of Ukraine “Igor Sikorsky Kyiv Polytechnic Institute” (KPI, Kyiv);
- Odesa Polytechnic National University (OPNU, Odesa);
- Oles Honchar Dnipro National University (DNU, Dnipro);
- State University of Intelligent Technologies and Communications (SUITT, Odesa);
- Tavria State Agrotechnological University (Melitopol);
- Ternopil Volodymyr Hnatiuk National Pedagogical University (TNPU, Ternopil);
- International Humanitarian University;
- Kharkiv National University of Radio Electronics (NURE, Kharkiv);
- Landwirtschaftliche Universität Kiew (Kyiv).

The English-language master's double degree programs: DDP Communication and Embedded Systems, DDP Data Science and a German-language bachelor's degree program in German – DDP Electrical and Information Engineering were created. More than 60 students have graduated from these programs and are working in German and Ukrainian companies, more than 40 professors and associate professors have completed internships at HSA, and more than 380 have completed international online internships in 2022.

In cooperation with Ukrainian Universities, in particular within the framework of the DAAD programs, HSA has already accumulated initial and positive experience. The Center of Excellence for Artificial Intelligence and Cloud Infrastructure Analysis - AI-aided Data Analysis and Data Transport Infrastructures (CoE AIDA-TI) was established in Kyiv under the leadership of HSA. The IDEA-East Hub, Digin.Net, Digin.Net 2, DigiJED,

DigiJED 2, Study Visits, GLS KDI 40, FIT4Ukraine, GLS Computer Systems and Networks/ Internet of Things (IoT), INTEGRA projects expand and consolidate promising cooperation in the academic sphere, they support a highly qualified didactic center for advanced training of all participants in the educational process, which has been focusing on the didactic features of digital learning for many years.

3.2 Funding of German-Ukrainian Projects of the HSA

A critical analysis of the progress in increasing the funding of German-Ukrainian cooperation shows how the interest in creating a clear and strong network between German and Ukrainian educational institutions is rapidly growing, which leads to the conviction that all possible resources and opportunities should be used to intensify this cooperation. This is evidenced by the data on the financing of projects from 2015 to 2025 (approved projects), with the grantee being the HSA (Table 2).

Let's consider Figure 3, which demonstrates the history of German-Ukrainian cooperation (as of March 02, 2023) and the prospects for the development and support of the education and science sector in terms of close cooperation and funding. Thus, the total amount of funding for projects from 2015 to 2022 (excluding projects managed by the international office HSA) is 755 784,5 euros. Funding for 2023-2025 is planned and agreed in the amount of 797 245,00 euros.

3.3 DAAD Funding: Case Study

All DAAD programs have a standard format for preparing a financial plan for all countries. The financial plan consists of the following three major sections:

- 1) Personnel expenses;
- 2) Material expenses;
- 3) Funded individuals.

Table 2: Funding of German-Ukrainian HSA projects leadership and participation of prof. E. Siemens.

Years	2015	2017	2019	2020	2021	2022	2023	2024	2025	Total
Study Visits	9 600,0	9 600,0	9 600,0			9 600,0				38 400,0
GLS Ukraine							15 000,0	45 000,0		60 000,0
AIDA TI						28 384,5	10 665,0			39 049,5
Pers Init			10 200,0			26 700,0	64 080,0			100 980,0
DigInNet 2			28 014,9	90 600,0	91 985,1	117 000,0	80 000,0			407 600,0
Idea East Hub						62 500,0	62 500,0	62 500,0	62 500,0	250 000,0
Sachsen Anhalt						30 000,0	245 000,0			275 000,0
DigiJED 2						232 000,0	150 000,0			382 000,0
Total, in €	9 600,0	9 600,0	47 814,9	90 600,0	91 985,1	506 184,5	627 245,0	107 500,0	62 500,0	1 553 029,5

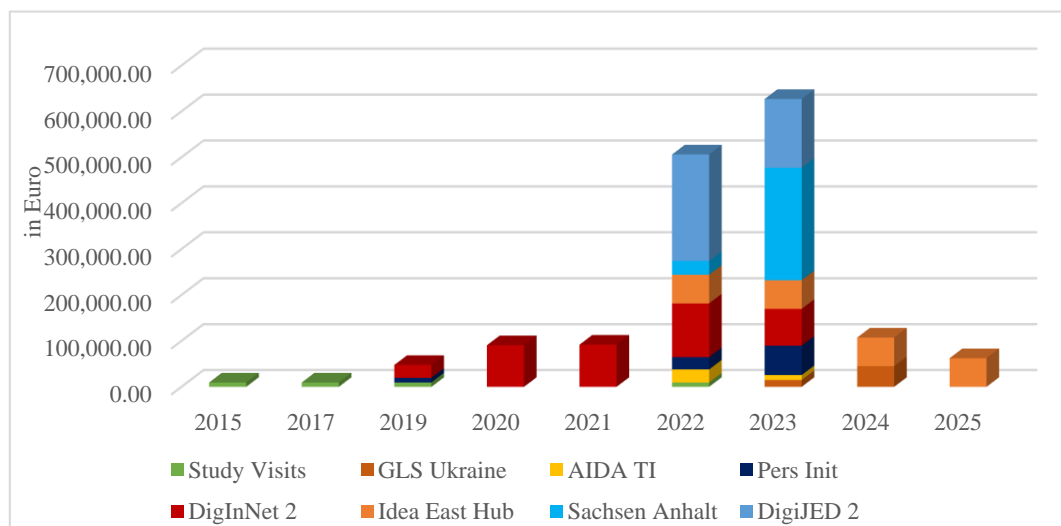


Figure 3: Funding of projects 2015-2025, in €.

Each of these sections is divided into subsections depending on the project program. For example, the first section is related to the financing of the personnel for project implementation and supervision and may contain the following items:

- Academic staff;
- Research assistants;
- Student assistants;
- Other personnel.

The second section describes, for example, the material expense required to implement the project:

- Fees,
- Mobility of project staff;
- Stay of project staff;
- Material resources internal/external to be procured within the project.

The section on supported persons contains information on their financing and justification in a particular project according to subsections:

- Funded individuals/ Supported persons;
- Mobility of funded individuals;
- Accommodation of funded individuals.

In addition, each subsector has a list of eligible funding activities and rules for their use [9]. The factors should be in the focus:

- Targeted - the goal;
- Timely - planning of all activities;
- Geographical - countries, regions;
- Legal - to be guided by the laws of the countries participating in the project, visas, personal data protection, health insurance.

- Duration - dates;
- Relevance - transportation costs, accommodation costs, additional costs;
- Cost-efficiency - purchase of goods.

The financial plans of the projects that received funding were analyzed and it was determined that project funding is closely correlated with the criterion of Relation of the Program Goals with the Goals of the Project. The Spearman rank correlation coefficient has a value of $\sim +0,87$, which indicates a significant direct linear relationship between the described criterion and the financing of a particular project. This correlation can be considered significant at the significance level $\alpha=0,01$.

Figure 4 represents the aggregated results of the financial plans of HSA projects supported by DAAD in 2015-2025. A critical analysis shows that all DAAD projects are aimed at supporting and financing Human Resources such as salaries and mobility in education and research – 87,89 % in the categories of Personnel Expenses and Funded Individuals. Limited funding is allocated for the technical infrastructure of the project – 12,11 %.

These results confirm that DAAD programs are focused on supporting the educational and scientific activities of Students, Doctoral candidates, Postdoctoral students, Young scientists, Experienced scientists and Professors in accordance with the activities planned in the projects.

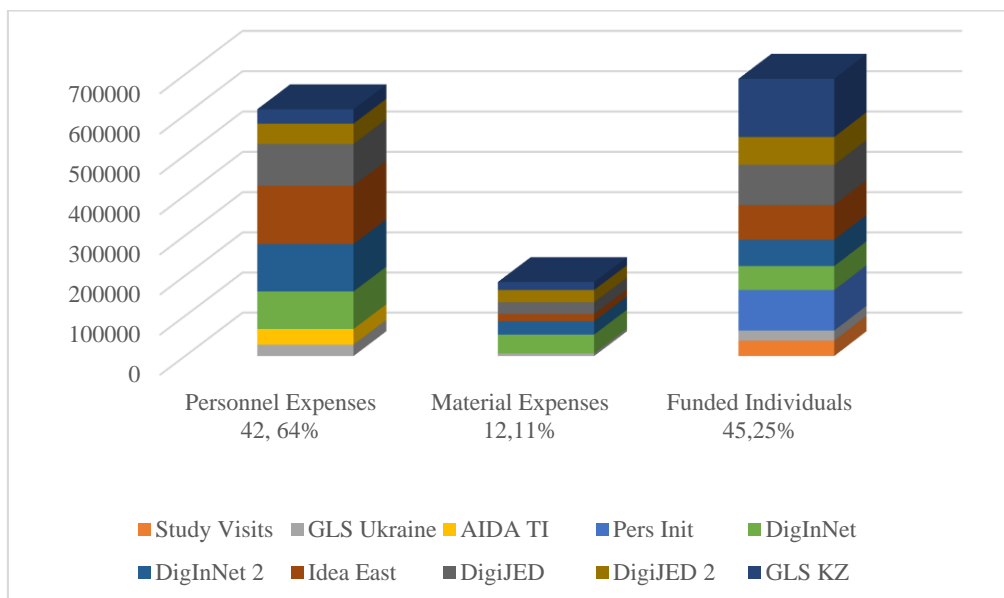


Figure 4: Main sections of HSA-DAAD projects funding 2015-2025, in %.

4 MODEL OF CRITERIA FOR SUCCESSFUL PROJECT SELECTION

The decision on funding is made by DAAD based on the evaluation of applications by the selection committee. Experience has shown that only some of the applications can be approved that meet the program’s goals mentioned. These are particularly well-organized activities, scientific, research and teaching work, visits and seminars which guarantee a close cooperation with Universities, scientists and students in Germany.

In order to research the positive dynamics of supporting new projects and obtaining funding in the future from DAAD, a detailed critical analysis of the selection criteria for each program, their weighting coefficient was carried out and a unique author's model of the criteria for successful selection of projects in the selected program was created.

Consider those programs in which HSA has participated and, thanks to a correct prospective assessment of the selection factors, received a positive decision on the application description and, as a consequence, subsequent funding.

4.1 Selection of Criteria

For program Study Visits and Study Seminars for Groups of Foreign Students to Germany 2021/2022 the main criteria for successful selection are summarized in Table 3. As part of this program, the application from the HSA was approved by a selection committee, and the “*Studienpraktikum Communication and Embedded System, KPI, OPSU*” project was funded and successfully implemented.

The main criteria for the successful selection of the program Support for the internationalization of Ukrainian higher education institutions – shaping the digital future together: German-Ukrainian higher education institution collaborations (2019–2021) are summarized in Table 3. The application was approved by a selection committee under this program and the „*DigIn.Net: German-Ukrainian Digital Innovation Network*“ project was funded and successfully implemented in 2019-2021. After the successful implementation of this project, DAAD proposed to prepare an application to participate in the program Support for the internationalization of Ukrainian higher education institutions. The application was approved by the selection committee for this program, and the project "*DigIn.Net 2: German-Ukrainian Digital Innovation Network - 2*" (2021-2023) is currently funded and actively implemented.

The criteria for successful selection for the program Internationalization of Universities of Applied Sciences (HAW/FH) "HAW.International" (Module B 2022 - 2025), are given in Table 3. The application was approved by the selection committee of this program, and the project „*IDEA-East-Hub: International Innovation Hub for Data Science and renewable Energy - East*" is now funded and successfully implemented during the period 2022-2025.

Table 3: Main criteria for the successful selection of projects, DAAD.

	Study Visits	DigIn.Net	DigIn.Net 2	Idea East Hub	DigiJED, 2	GLS
Relation of the Project to the Program Goals, the Measures and Objectives	X			X	X	X
Plausibility of Project Description and Financing Plan		X	X	X	X	X
Quality of the Project Program	X			X		X
Contentual Preparation	X		X	X		X
Technical Requirements (Digital Existing Infrastructure)		X	X	X		X
Experience with Digital Teaching and Administration		X	X	X	X	X
Involvement of Young Scientists		X	X		X	X
Correlation of Subject - Cultural	X					
Encounter and Exchange of Experience	X			X		X
Sustainability of the Project		X	X	X	X	
Concept for Further Development			X	X	X	X
Plausibility of Ukraine Expertise		X	X		X	
Language Skills	X					X
University Partnerships	X			X	X	X

In the program Ukraine digital: Ensuring academic success in times of crisis (2022, 2023) the main criteria for successful selection are given. The application was approved by the selection committee for this program, and the projects "*DigiJED and DigiJED 2: Digital Education with Joined Efforts*" are funded and actively implemented in 2022-2023. The program "German-language study programs (GLS) in East-Central, Southeast and Eastern Europe as well as the Caucasus and Central Asia - 2023 - 2024" describes the main criteria for a successful

selection. Two applications from Anhalt University of Applied Sciences (one for Ukraine, the other for Kazakhstan) were approved by the selection committee and are funded and implemented from 2023.

4.2 Methodology

Analyzing the above criteria of the listed programs and considering the selection criteria of other relevant DAAD programs, the factors influencing the successful decision of the competition committee were analyzed, and on their basis the weight of each criterion was determined using a multi-criteria evaluation approach. Factor analysis was conducted to reduce the sample size of the criteria, as well as to group them based on correlations. The principal components method was used as a selection method, and Varimax with Kaiser normalization was used as a rotation method. To optimize the calculations, the statistical software package SPSS was used [10], the results of which are presented in the following Tables 4, 5.

4.2.1 Implementation

The main criteria with corresponding weighting coefficients are:

- Relation of the Project to the Program Goals, the Measures and Objectives (X1, weight - 8%);
- Plausibility of Project Description and Financing Plan (X2, weight - 10%);
- Quality of the Project Program (X3, w. - 6%),
- Contentual Preparation (X4, w. - 8%);
- Technical Requirements (Digital Existing Infrastructure) (X5, w. - 8%);
- Experience in Digital Teaching and Administration (X6, w. - 10%);
- Involvement of Young Scientists (X7, w. - 8%);
- Correlation of Subject - Cultural (X8, w. - 2%),
- Encounter and Exchange of Experience (X9, w. - 6%);
- Sustainability of the Project (X10, w. - 8%),
- Concept for Further Development (X11, w. - 8%);
- Language Skills (X12, w. - 4%);
- Plausibility of Ukraine Expertise (X13, w. - 6%);
- University Partnerships (X14, w. - 8%).

The factor analysis resulted in the data presented in Table 4 with the values of the total explained variance and Table 5 - the matrix of returned components or factor matrix were obtained. Table 4 shows that the value of three Eigen factors is greater than one. Therefore, only three factors are selected for analysis. The first factor explains 34,308 % of the total variance, the second – 12,97 % and the third – 9,433. Only 14 criteria are included in the analysis, as the rest of them in total give a very small variance, and therefore have little influence on decision-making (this was also considered when finding weighting coefficients).

Table 4: Total explained variance.

	Initial Eigenvalues			Sums of Squares of Loads		
	Total	% of variance	Cumulative % of variance	Total	% of variance	Cumulative % of variance
1	5,146	34,308	34,308	3,466	23,105	23,105
2	1,945	12,970	47,278	2,536	16,907	40,013
3	1,415	9,433	56,711	2,505	16,698	56,711
4	0,990	6,601	63,312			
5	0,936	6,238	69,550			
6	0,760	5,068	74,617			
7	0,693	4,622	79,240			
8	0,612	4,083	83,323			
9	0,529	3,529	86,852			
10	0,473	3,151	90,004			
11	0,433	2,889	92,893			
12	0,339	2,262	95,155			
13	0,301	2,007	97,161			
14	0,245	1,635	98,797			
15	0,181	1,203	100,000			
Method of selection: Principal component analysis						

Further, in each row of the resulting factor, the factor loadings that have the highest absolute value are noted (Table 5). These factor loadings should be understood as correlation coefficients between criteria and factors. Thus, the criterion X1 is most strongly correlated with factor 1, the correlation value is 0,866; the criterion X2 is also most strongly correlated with factor 1 with a value of 0,641; the criterion X5 is most closely related to factor 2 (0,783), etc. In most cases, the inclusion of a variable in one factor, based on the correlation coefficients, is unambiguous.

Table 5: Matrix of returned components.

	Components		
	1	2	3
X1	0,866	0,628	-0,191
X2	0,641	0,157	0,215
X3	0,727	-0,153	0,311
X4	0,533	-0,106	0,394
X5	-0,362	0,783	4,52E-02
X6	-1.2E-02	0,763	-3,8E-02
X7	3.58E-02	0,525	0,543
X8	-0,117	0,719	-0,267
X9	2.56E-02	0,551	-8,8E-02
X10	0,652	-9.5E-02	0,285
X11	0,485	-0,110	0,665
X12	0,199	0,802	0,108
X13	0,125	-0,292	0,392
X14	-0,251	0,592	0,392

Method of selection: Principal component analysis
 Rotation method: Varimax with Kaiser normalization
 a. The rotation is performed in 8 iterations

4.2.2 Results Interpretation

Therefore, based on the above, the criteria can be attributed in the following order to three factors:

Factor 1. Qualitative component of the application, 40%:

- Plausibility of Project Description and Financing Plan (X2, weight - 10%);
- Relation of the Project to the Program Goals, the Measures and Objectives (X1, weight - 8%);
- Contentual Preparation (X4, weight: 8%);
- Sustainability of the Project (X10, weight: 8%);
- Quality of the Project Program (X3, weight: 6%).

Factor 2. Quantitative component of the application, 38%:

- Experience in Digital Teaching and Administration (X6, weight: 10%);
- Hardware and Software (Digital Existing Infrastructure) (X5, weight: 8%);
- University Partnerships (X14, weight: 8%),
- Encounter and Exchange of Experience (X9, weight: 6%);
- Language Skills (X12, weight: 4%);
- Correlation of Subject - Cultural (X8, weight: 2%).

Factor 3. Prospects and forecasting further development, 22%:

- Involvement of Young Scientists (X7, weight: 8%);
- Concept for Further Development (X11, weight: 8%);
- Plausibility of Ukraine Expertise (X13, weight: 6%).

Thus, it is possible to outline and demonstrate the author's model of the main criteria for successful project selection (Figure 5).

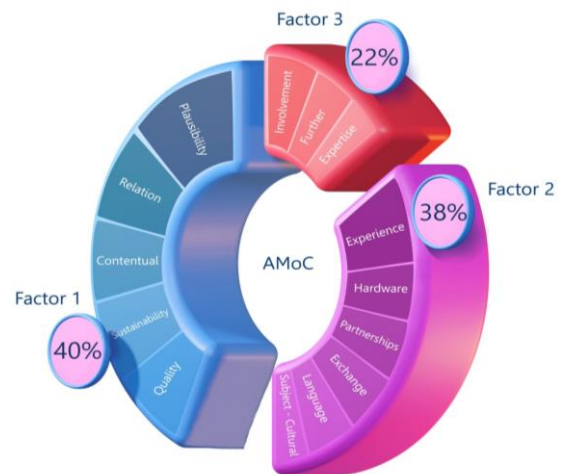


Figure 5: Model of the criteria for successful project selection.

When preparing a new application for funding in any DAAD program, it is worth paying attention to the conservative provision on „Plausibility of Project Description and Financing Plan” (X2) and one of the innovatively significant provisions that has emerged as a result of reform changes in modern learning formats - "Experience in Digital Teaching and Administration" (X6), which have the greatest weight.

3 CONCLUSIONS

The analysis of the growing financial flows to the higher education sector in Ukraine shows a rapid trend towards the importance and necessity of organizing effective measures to strengthen and expand German-Ukrainian cooperation in the field of digital internationalization.

The successful implementation of the HSA projects contributes to the prospective development of international cooperation, which is constantly evolving and expanding through new partners,

connections, scientific schools, and the creation of new joint double degree programs.

Financial grants from DAAD programs are primarily aimed at supporting human resources in projects (over 87%). Using factor analysis, the author's model of the criteria for successful selection of DAAD projects was developed, tested and presented, which allowed to identify 3 main factors: *Factor 1. Qualitative component of the application, Factor 2. Quantitative component of the application, Factor 3. Prospects and forecasting further development* and the 2 main criteria: *"Plausibility of Project Description and Financing Plan"* and *"Experience in Digital Teaching and Administration"* that should be paid the most attention to when preparing documentation for submission to DAAD programs.

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