Evaluation of Communication and Collaboration Processes for Creating an Integrative STEAM Space at the Saginov Technical University

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Abstract **– This article discusses the project on capacity building for training of engineering and technical specialists via STEAM technologies at the Saginov Karaganda Technical University (STU) in Kazakhstan. The project, entitled "Capacity building of engineers innovative training via STEAM education" was supported by the fund under the "Research in the field of education and science for 2021-2023" priority of the Science Committee of the Ministry of Education and Science of the Republic of Kazakhstan (Grant No. AP092600338). The current research presented in this article addresses the issues of assessing the level of professional communication and collaboration skills among teaching staff. The article describes the identified communication gaps and recommendations in three areas of training, presents the key statements of the theory of communication and collaboration formulated on the basis of the results obtained within the integrated educational STEAM space, structured as the core of the STEAM education framework. Additionally, a list of competencies according to advanced STEAM approaches have been developed.**

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1. Introduction

The intensive development of the knowledge economy dictates the need for developing countries to form a new paradigm for the development of human capital, where a person is able to manage innovative technological processes. Human self-awareness is central to this, whereas technology is just a progressive and convenient tool. In this regard, there is a need to change approaches to the training of specialists with engineering and technical education, providing a change of focus from the transfer of knowledge to one centered around a continuous search for understanding and critical comprehension.

In the conditions of modern Kazakhstani society, the need for specialists with a high level of critical and creative thinking, who are able to actively apply the creative methods in engineering design and scientific development, is increasing every year. At the same time, it should be noted, that in recent years Kazakhstan has seen a significant increase in the number of STEM laboratories. Despite this, the investigation of how exactly universities should train engineers for the creative industry remains open.

Based on the world experience as one of the most effective methods, it can be considered the capacity building for innovative training of technical specialists via the introduction of the Art component in STEM - STEAM education. In this way, the effectiveness of training can be increased by carrying out the integration of scientific, technical, and art areas in educational programs.

Research within the project “Capacity building for innovative training of engineers through STEAM education” is aimed at developing and implementing a framework for training engineers through STEAM technologies to implement sustainable training programs for intercultural communication, creative industry, and creative cooperation based on creativity and intellectual capital. Within the framework of the project study, an assessment of the needs of STEAM education capacity has been carried out. As a result, measures are being developed and implemented to build the capacity of training programs in technical specialties based on the development of specialized competencies that allow strengthening the qualifications and abilities of students and teachers at the international level.

As a result, an integrative STEAM space will be formed in the educational environment of a technical university, which is an open system of intercultural communication and collaboration [1].

2. Methodology

To launch the design of the abovementioned framework there has been conducted multifactor SWOT analysis as the first stage of the research devoted to STEAM needs analysis of technical university. The findings of SWOT analysis show the weaknesses of communication in the academic environment in a technical university and the need to improve collaboration processes as a key Art component of STEAM. In order to obtain additional information, a specialized survey was organized to the university teaching stuff.

The assessment of professional communication and dialogue of cooperation as a key factor in solving creative tasks in engineering was carried out on the basis of a developed survey to determine communication technologies and "communication gaps" according to two fundamental theories, analysis of the survey results to determine the problem field and data processing in the IBM SPSS program [2]. In this case, communication gaps are understood as the existing barriers that prevent the free distribution of information flows.

The survey is a structured set of questions designed to identify the existing methods, technologies and results of communication at a technical university; identifying breakpoints and developing recommendations for improving the efficiency of communication processes in a professionally oriented educational environment of higher education.

The proposed survey contains 5 selected blocks:

1. A block of socio-demographic questions, the characteristics of which are determined by the purpose, objectives of the study, variables included in the conceptual model, and research hypotheses. The block includes questions that allow the classification of respondents in accordance with the given characteristics [2],[3].

2. The block devoted to the issues of collaboration in the academic environment is presented on the basis of the Communicative Code, a system of principles for building a dialogue, which considers the speech behavior of each of the parties as deliberate and conscious speech actions. This code is based on the principle of cooperation by Herbert Paul Grice [4] (Grice, 1975) and the principle of courtesy by Jeffrey Leach [5] (Leech, 1983). The principle of cooperation of G. Grice is based on the understanding of dialogue as a joint activity of participants, each of whom contributes to the construction of communication, recognizing the common goal of the dialogue. The principle reflects the willingness of partners to communicate.

The questions in the survey are based on the deduced four Grice maxims [4], the achievement of which contributes to full compliance with the principle: the maxim of information quality, the maxim of information quantity, the maxim of relevance, the maxim of clarity. The essence of the principle is that during real verbal communication, participants may not comply with all maxims, but strive for this. Thus, it will be possible to maintain attention and contact with the interlocutor. At the same time, it is important to consider the balance of the known and the unknown for a particular audience.

3. The block involving the assessment of vertical communication "teacher-administration" is designed to ensure the formation of "group thinking" in the academic environment.

Group thinking occurs when certain preconditions are met, such as when the group is highly cohesive, insulated from opposing opinions, and led by a directive leader who voices their desires. The negative results of this communication method can be: 1) vertical communication participants limit their discussion to only a few alternatives; 2) the decision initially approved by the majority of participants and is never revised to find less obvious pitfalls; 3) participants in vertical communication do not reconsider these alternatives, initially disapproved by the majority; 4) expert opinion is not requested; 5) participants in vertical communication are very selective in the collection and use of available information; 6) the upper level of communication flows is so confident in its ideas that it does not consider action plans in non-standard situations.

The block for assessing vertical communication includes a list of questions that allow you to assess the intensity of information flows, the level of feedback, the efficiency and reliability of information; to determine the nature and methods of information transmission.

The results obtained as a result of the survey in this block make it possible to assess the current situation and develop the necessary response measures.

4. The block for assessing "teacher-teacher" horizontal communication was developed on the basis of Enactment theory [6] (Klagge, 2018). "Decision theory" is aimed at understanding both the vital processes of society and the processes within the organization. Individuals and organizations are constantly in the process of self-improvement: process stability is achieved through the introduction of cycles of interaction and the development of rules for proper behavior. Acceptance theory can be seen as the process by which individuals achieve continuity and coordination. This process requires the adoption of certain rules and roles aimed at coordinating the actions of one individual with others.

Decision theory provides a rationale for distinguishing strategic and routine behavior. People use everyday communication habits, while their ability to find new ways to communicate is crucial to their success as members of an organization. In practice, much of what happens inside horizontal connections is routine, planned and random, not strategic. At the same time, decision-making occurs because people realize the importance of relationships. Thus, decision-making is connected with the tasks of the organization, where a person primarily positions himself as a member of a team whose activities are aimed at results in interaction with the external environment. In this regard, the success of the entire organization depends on the daily communication and routine patterns of individuals' behavior.

The block for evaluating horizontal communication includes a list of questions that allow you to assess the intensity of information flows, the level of feedback, the efficiency and reliability of information; to determine the main channels of information, the frequency of horizontal communications, the points of conflict, and to identify conditions for improving the effectiveness of horizontal communication.

5. The questions of the block "Communication with students (teacher-student)" are based on the theory of G. Hofstede "Cultural dimensions Theory" [7] and the study of communication in higher educational institutions, conducted by Taratukhina Yu.V. [1] based on this theory [7].

The survey provides an assessment of communication in the following dimensions:

1. The distance of power associated with various solutions to the main problem of human inequality. With a very high-power distance coefficient, the teacher tends to guide every step of the student, while with a decrease in the distance, more initiative passes to the student.

2. The parameters of "individualism – collectivism" in the educational process associated with the integration of individuals into primary groups. The following dependence is evaluated: influence of collectivism on effectiveness of the learning process, for example, the high indicators of collectivism lead to a low level of students' activity in the classroom, and thus, in the learning process the teacher has to solve the problem of students' inactivity in expressing own opinions in classroom discussion that affect students' learning progress. This parameter is also considered when analyzing communication gaps in the N. Karten study, while the main difference is the desire of people for emotional, social, organizational or institutional independence or support for collective values, including cooperation, loyalty and respect, acceptance of a collective point of view [8].

3. Adaptive and invariant segments of the educational process organization in a multicultural environment. Adaptation by a teacher is understood as the adaptation of educational information, methods and control and measuring materials to the specifics of the student (adaptation of educational tasks for different cultural groups), as well as the compilation of culturally specific basic glossary for the discipline – thesauruses, glossaries (ambiguity of terminology in different languages). Invariant content implies the compilation of universal atomic dictionaries by discipline or semantic maps.

The survey was conducted for three groups of teachers, who were conditionally divided according to the knowledge field of the disciplines taught: training in the field of art, training in the field of engineering and technology, as well as the IT sphere. Teaching staff of the Saginov Karaganda Technical University, as well as teachers of related specialties at major universities of the Republic of Kazakhstan acted as respondents for the present survey.

3. Results

The sample size of the mass survey was 568 respondents – teachers in organizations of higher and postgraduate education. 98 of them are engaged in teaching activities in the field of art training, 264 are in engineering and technology, 206 are teachers in the IT field. The survey included respondents attracted by the method of multi-stage quota sampling in Nur–Sultan, Almaty, Karaganda region, of which: 33.99% were men, 66.01% were women, doctors of sciences – 25.03%, candidates of sciences, PhD – 53.15%, without Master degree – 21.82%. Two megacities with a high number of universities were selected for the survey, as well as the Karaganda region, which is one of the major clusters

for the training of engineers in the machine-building and mining industries.

As a result of the study, the following was revealed: for the prevailing majority of respondents (72.3%), communication in the academic environment is limited to the exchange of information of various kinds, while the emphasis on achieving a certain level of understanding, subject to effort, is made by 21% of the respondents, the rest of the respondents understand communication as any interactions between living organisms. At the same time, collaboration in the academic environment is understood by the absolute majority of respondents as a joint activity of two or more parties in order to obtain certain results for each party, which are possible only by combining efforts. As the types of academic studies in which the technology of cooperation is most effectively implemented, the most popular answers are: practical exercises (89%), consultations (73%). More than 58% of respondents, when choosing effective communication strategies for creating and maintaining successful cooperation, chose joint research, 24% – joint authorship, 9% – mentoring; networking and joint teaching scored 3% and 4%, respectively, other strategy options were suggested by 2% of respondents. This distribution of opinions is approximately even for all selected areas of teaching.

Below, we choose to focus on a few keys, in our opinion, results of the survey. In general, the following key features were identified:

1. The assessment of the power distance in the context of teaching revealed the predominance of a low distance in terms of such parameters of academic communication as: lesson model, learning trajectory, learning efficiency evaluation. Opinions about the level of feedback are divided approximately equally, however, in the field of communication, according to the respondents, a high-power distance prevails (Figure 1).

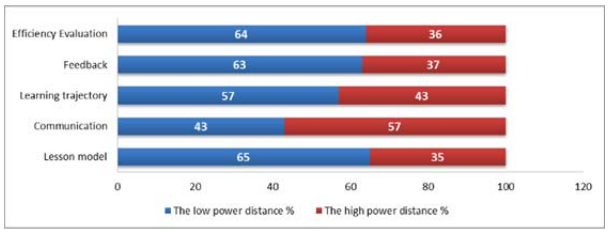

Figure1 Evaluation of the power distance according to the parameters of educational communication

As part of the assessment of the focus realization on the lesson models, it was recorded that, according to the majority of teachers, the student-centered model is used more often, while the initiative of students in the lesson is encouraged; 35% of respondents believe that the initiative should come from the teacher.

According to the "Learning trajectory" parameter, most teachers encourage students to choose their own path of learning, and most students themselves build a learning trajectory based on agreed models. In terms of the way that feedback is organized, the opinions of teachers were divided as follows: 63% of teachers allow students to contradict and criticize while the rest do not allow students to contradict and criticize. According to the parameter "Learning efficiency evaluation", a majority of teachers (64%) believe that the learning efficiency is a two-way process. Constant feedback and interactivity are important. Although some argue that the learning efficiency depends on the teacher and is regulated by him (36%). At the same time, there is a clear imbalance towards a high-power distance, when communication management is completely dependent on the teacher. The differences in percentages for every assessed item are not large enough, which leads us to the conclusion that it is possible to fulfill the communication gaps and introduce a number of solutions.

On the other hand, during the students' interviews, responses were received that were the opposite of the teachers' reactions:

"I don't think that low distance prevails when choosing a learning trajectory, rather, on the contrary, in most cases. So, it was for me and my classmates. The teacher rigidly dictates his conditions", 2nd year student, specialty "Mechanical engineering", Karaganda.

"I don't see the point in feedback, we are already busy enough with completing tasks to tell the teacher what he can improve. And they won't listen to us", 3rd year student, specialty "Transport, transport equipment and technologies", Nur-Sultan

"Of course, we would like to be heard, one of the teachers discusses with us all the issues that interest us. But many often treat formally." 2nd year student, specialty "Information Technology", Nur-Sultan.

"Critical remarks? Of course, we ask questions and get answers, but no one wants to criticize. First of all, because you will have to spend time on it, and the result will be zero", 1st year student, specialty "Mathematical and computer modeling", Almaty.

2. According to the parameter "Individualism – collectivism" in the learning and teaching process, according to the theory of G. Hofstede [7], the parameter "individualism-collectivism" characterizes the degree to which the participants in the interaction prefer to act independently, rather than as members of a particular group. The extreme values of this scale are the absolutization of individuals' interests and complete subordination to the interests of a group or society.

Thus, for a productive discussion, a balance must be maintained, assuming a willingness to discuss in the presence of different and opposite points of view, when students do not agree with the ideas of the majority but search for their solutions. Different pedagogical cultures will be dominated by different paradigms which work with information and academic content. In individual cultures, each personal goal is more important than group goals, awareness of one's "I" prevails, everyone's right to personal property, their point of view, private opinion is valued. Accordingly, flexible, adaptive methods of working with academic information are used.

In the process of teamwork and joint case solving, representatives of cultures with a high individualism index need a competitive spirit, the opportunity to express opinions, an independent opportunity to make decisions; representatives of collectivist cultures need a calm environment and high-quality technical means for group interaction [1]. According to Hofstede's research multicultural peoples of Kazakhstan have quite low levels of individualism – Kazakh culture, belonged to the main part of Kazakhstan population, in particular is given a ranking of 20 on a hundred-point scale. Kazakhstani peoples' cultures show a tendency to exhibit more collectivism than individualism as a Post-Soviet legacy [9], [10].

The analysis of the data obtained showed that according to the parameter "individualism – collectivism" teachers tend to choose the parameter "individualism", however, according to the parameter "collectivism", harmony and emotional comfort in the learning process were identified by the respondents as dominant. In addition, the importance of maintaining the professional authority (person) of the teacher in the process of academic communication was also noted (Figure 2).

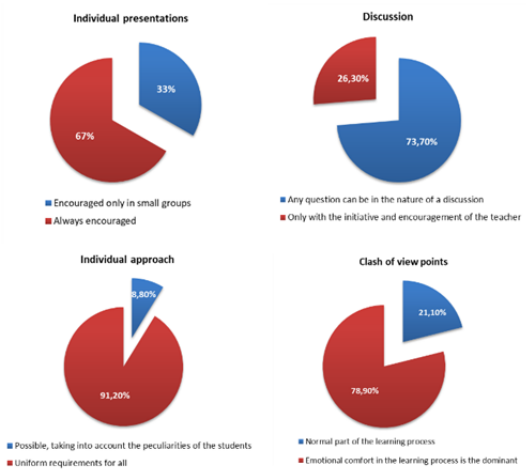

Figure 2 Evaluation of academic communication process in the classroom

In interviews, most of the surveyed students support the teachers' point of view:

"Of course, teachers encourage discussion, even give assignments, the more active you are, the higher the score.", 1st year student, specialty "Mining", Karaganda.

"Yes, we like to argue with each other in class. It doesn't matter if the subject of the dispute is related to discipline, the main thing is to spend time and prove your point. The teacher, of course, tries to make sure that we are not distracted from the topic of the lesson.", 3rd year student, "Mathematical and computer modeling", Almaty

"Discussion is a way of self-expression, finding the right solutions, I support the presence of different points of view. That's more interesting". 2nd year student, specialty "Architecture", Nur-Sultan.

3. According to the parameter "Preferred tools for organizing the academic process in a multicultural environment", there is a choice of such characteristic features of the learning process as: teamwork, individual work, teaching methods, academic content (56.1%); regulation of all types of academic activities – 43.9%. 78.9% of respondents prefer creative and reproductive tasks to the context thesaurus of discipline as a learning tool. At the same time, 71.9% of respondents choose coaching (pedagogical support), while 28.1% of teachers choose semantic maps of academic disciplines.

In the interview, the students ' opinions were divided:

"We do tasks in groups all the time. What for? I'm not entirely sure about the effectiveness of such exercises." 1st year student, specialty "Mechanical Engineering", Karaganda

"We are offered to carry out projects and other various tasks. Sometimes we draw something on posters, prepare presentations. We are already used to it. Although classes in the usual format are also held." 3rd year student, specialty "Information Technology", Nur-Sultan.

Thus, the following conclusions can be drawn:

1. 4 parameters of the characteristics of academic communication is a predominance of "low power distance", which indicates well-established and systematic processes. However, the parameter "communication" is characterized by a high-power distance, which can lead to low effectiveness of the interaction process as a whole, as well as have a negative impact on individual components of the learning process.

2. However, despite the high distance, there is a readiness for dialogue and open discussion at the level of the entire group. The results are also important for understanding the reasons for the communication gaps when the majority deny the need for reasoned discussions as an integral part of the learning process, which also indicates problems in the communication system and the desire for harmony at any cost.

3. The organization of the learning process in a multicultural environment is characterized by a fairly diverse choice of tools. However, a significant emphasis in the organization of work is placed on prescribed reporting, and not on the process itself and the result. A multicultural audience requires the teacher to clearly organize pedagogical activities in accordance with the models adopted in different cultures and select academic content, taking into account cultural codes and semiotic context. At the same time, both the evaluation system and the specifics of feedback play an important role.

All of the above problems require the development of new approaches to the organization of the communication process, as well as the development of communicative competencies of teachers and students.

Thereby, the proposed methodology made it possible to determine the problem field in the area of cooperation and communication technology, depending on the areas of training. According to the results of the survey, differences in the assessment of vertical and horizontal communication, the technologies of cooperation used in the framework of technical areas of training, as well as the level of "power distance" in the course of "teacher & student" communication were revealed.

At the first stage of the survey results analysis, the normality of the distribution was checked using the Pearson criterion, which allows us to assess the significance of the differences between the actual (revealed as a result of the study) number of outcomes or qualitative characteristics of the sample falling into each category, and the theoretical amount that can be expected in the studied groups with the validity of the null hypothesis.

A number of preparatory works include the distribution of all the results obtained in the areas of training. At the second stage, weight coefficients are assigned for evaluation criteria. As a result, a table with the encoding of respondents' responses was obtained. As a result of the calculation of the Pearson correlation coefficient, it can be concluded that since $\chi^2 criteria > \chi^2 obervations$, therefore, the data collected as a result of testing obey the normal distribution law. To analyze the tightness (strength) and the direction of the correlation between the two features, we use Spearman's rank correlation method.

According to the null hypothesis, there is a relationship between the presence of an academic degree and criteria-based communication assessments on the example of the communication initiation factor.

Let us carry out the necessary calculations to confirm the hypothesis.

The sampling distribution of the attribute A (academic degree) depending on B (communication) was obtained, while the presence of difficulties with the answer among the respondents to a large extent influenced the numerical difference with the total sample size. The results are shown in the table:

Table 1. The presence of an academic degree and criteria-based communication assessments on the example of the communication initiation factor.

B	[Communication: Communication initiated by students]	A					
		A1	A2	A3	A4	A5	n_{i*}
		No degree	Master Degree	Doctor PhD	Candidate of Sciences	Doctor in Sciences	TOTAL
B1	Very low	51	10	10	13	5	89
B2	Low	22	5	18	12	3	60
B3	Satisfactory	7	31	14	9	7	68
B4	Good	31	15	17	8	12	83
B5	Very good	20	17	15	5	4	61
n_{*j}	TOTAL	131	78	74	47	31	361

To check the independence of signs "A" and "B" we check the null hypothesis H_0: (pij = π*p*j for all i, j). Let us calculate the statistics χ^2 (obs.) observation by the formula: $\chi^2 = \sum\sum \frac{(n_{ij} - nij)^2}{nij}$, where nij are the observed frequencies.

If the value of χ^2obs. fell into the critical region: $\chi^2 > \chi^2$crit (α; v=16), the null hypothesis is rejected with an error probability α and the features are considered dependent.

In this case, it makes sense to measure the resulting relationship between X and Y using the coupling (conjugacy) coefficients.

We obtain a contingency table of theoretical distribution frequencies:

Table 2. A contingency table of theoretical distribution frequencies

	A1	A2	A3	A4	A5	n_{i*}
B1	32.296	19.23	18.244	11.587	7.643	89
B2	21.773	12.964	12.299	7.812	5.152	60
B3	24.676	14.693	13.939	8.853	5.839	68
B4	30.119	17.934	17.014	10.806	7.127	83
B5	22.136	13.18	12.504	7.942	5.238	61
n_{*j}	131	78	74	47	31	361

Let us calculate the statistics χ^2:

$$\chi^2 = \sum\sum \frac{(n_{ij} - n\grave{i}j)^2}{n\grave{i}j} =$$

$$\frac{(51-32.3)^2}{32.3} + \frac{(10-19.23)^2}{19.23} + \frac{(10-18.24)^2}{18.24} + \frac{(13-11.59)^2}{11.59} + \frac{(5-7.64)^2}{7.64} + \frac{(22-21.77)^2}{21.77} +$$

$$+ \frac{(5-12.96)^2}{12.96} + \frac{(18-12.3)^2}{12.3} + \frac{(12-7.81)^2}{7.81} + \frac{(3-5.15)^2}{5.15} + \frac{(7-24.68)^2}{24.68} +$$

$$+ \frac{(31-14.69)^2}{14.69} + \frac{(14-13.94)^2}{13.94} + \frac{(9-8.85)^2}{8.85} + \frac{(7-5.84)^2}{5.84} + \frac{(31-30.12)^2}{30.12} +$$

$$+ \frac{(15-17.93)^2}{17.93} + \frac{(17-17.01)^2}{17.01} + \frac{(8-10.81)^2}{10.81} + \frac{(12-7.13)^2}{7.13} + \frac{(20-22.14)^2}{22.14} +$$

$$= \frac{(17-13.18)^2}{13.18} + \frac{(15-12.5)^2}{12.5} + \frac{(5-7.94)^2}{7.94} + \frac{(4-5.24)^2}{5.24} = 69.509$$

According to the table of χ^2-distribution we find:

$$\chi^2 crit\ (0.05;16) = 26.29623$$

where v = (r-1)(s-1) = (5-1)(5-1) = 16 is the number of degrees of freedom.

The critical region has the form $\chi^2 > \chi^2 crit$. Since the calculated chi-square value falls within the critical region, the hypothesis of independence is rejected with an error probability of 0.05.

Next, we use the information criterion for testing the hypothesis of feature independence

$$\chi_I^2 = 2\sum\sum n_{ij} ln \frac{n_{ij}}{n\grave{i}j}$$

For ease of calculation, the following formula can be applied:

$$\chi^2_I = 2(\sum\sum n_{ij} ln\ n_{ij} - \sum n_{i\cdot} ln\ n_{i\cdot} - \sum n_{\cdot j} ln\ n_{\cdot j} + n\ ln\ n)$$

given that the theoretical values of the frequencies nij* are found by the formula:

$n\grave{i}j = \frac{n_i n_{\cdot j}}{n}$ and properties of logarithms:

χ^2_I = 2(51*ln(51) + 10*ln(10) + 10*ln(10) + 13*ln(13) + 5*ln(5) + 22*ln(22) + 5*ln(5) + 18*ln(18) + 12*ln(12) + 3*ln(3) + 7*ln(7) + 31*ln(31) + 14*ln(14) + 9*ln(9) + 7*ln(7) + 31*ln(31) + 15*ln(15) + 17*ln(17) + 8*ln(8) + 12*ln(12) + 20*ln(20) + 17*ln(17) + 15*ln(15) + 5*ln(5) + 4*ln(4) + 131*ln(131) - 78*ln(78) - 74*ln(74) - 47*ln(47) - 31*ln(31) - 89*ln(89) - 60*ln(60) - 68*ln(68) - 83*ln(83) - 61*ln(61) + 361 ln 361) = 70.917

As a result of the calculations, we got

$$\chi^2_I = 70.92$$

Critical region when testing this hypothesis:

$$\chi^2_I > \chi^2 table = 26.29623$$

Since $\chi^2 obs$ = 70.92 falls into the critical region, the hypothesis H_0 is rejected with an error probability of 0.05.

Let us determine the strength of the connection by the contingency coefficients.

To estimate the strength of the connection, we calculate point estimates of the coefficients.

Chuprov coefficient.

$$C = \sqrt{\frac{\chi^2}{n\sqrt{(r-1)(s-1)}}} = \sqrt{\frac{69.509}{361\sqrt{(5-1)(5-1)}}} = 0.219$$

Cramer coefficient

$$K = \sqrt{\frac{\chi^2}{n \cdot min[r-1, s-1]}} = \sqrt{\frac{69.509}{361 min[5-1, 5-1]}} = 0.219$$

Pearson contingency coefficient:

$$P = \sqrt{\frac{\chi^2}{\chi^2 + n}} = \sqrt{\frac{69.509}{69.509 + 361}} = 0.402$$

Thus, the strong relationship between "A" and "B" confirms our null hypothesis about the impact of having a degree on differences in the field of communication theory and collaboration between teachers in different areas. Definitely, the existing gaps depend on the area of the teacher's personality and his experience and are common for the studied population, with the exception of individual factors.

The final stage of the study was the Gap analysis through a focus group aimed at evaluating the results and making recommendations. The focus group was attended by nine experts, including: two representatives of industrial companies of the Karaganda region (Machine-building Consortium, ArcelorMittal Temirtau), representatives of the faculty of the universities of Karaganda, Nur-Sultan, Almaty, carrying out activities in the field of professional communication, as well as an international expert in the field of communication. This approach made it possible to obtain the resulting data based on the experts' own experience in terms of group dynamics.

One of the most important advantages of this method is the flexibility in the study of problematic issues and the maximum use of the research potential of the participants [11] (Morgan, 1990). As a result, the reasons for the emergence of communication gaps were formulated, and recommendations were developed for overcoming them.

According to the survey results, the majority of respondents underestimate the importance of feedback during the process of academic communication, in more cases limiting themselves to traditional methods of knowledge delivery, which imply the role of the student as a “listener” and “responder”.

At the same time, teachers 'joint work most often consists in conducting co-research and publishing the results. At the same time, other types of cooperation don't apply in mass. Thus, the choice of teaching methods and tools indicates that the expectations of the modern classroom are focused on students, but faculty members' practice is very teacher-oriented. In addition, we can see gaps in the 360-degree communication of teachers: with administration, other teachers, and students.

Most undergraduate students aren't quite ready to express opinions and communicate during lessons suggesting a high-power distance as well as reflecting their experience in a "traditional" educational system. However, graduate students are somewhat more ready to contribute and engage in dialogue with the teacher. An expert in intercultural communication, familiar with the context, said that the analysis of interviews with students implies that movement toward a more learner-centered STEAM framework has begun, but is in its infancy. The first step to solving this problem is asking for feedback, and the second is increasing attention to the communication and collaborative needs of participants in the academic process. Students and teachers need to see a rationale for the STEAM education paradigm. In that case, there will be a higher level of students' engagement in the learning process and, as a consequence, better results.

4. Discussion

At the moment, the results of the survey suggest that the creative methods are being used superficially. As a result, there is a lack of depth in students and teachers not being aware of why this approach has value and what benefits are for them as future engineers and technicians. The findings of the research say that there is a fairly high level of power distance in the university classroom and it would be difficult to alter. The Kazakhstan cultural features promote the situation, when a Kazakh student, for example, may take a lot of encouragement before feeling able to offer critical feedback to a teacher, with such a level of power distance. In such a learning environment, it may be more appropriate for teachers to foster creative and critical thinking through facilitating small group discussions, in which student-peers can develop their ideas. This approach will allow students to work through problems and have group discussions without confronting their cultural tendency to defer to the authority figure (in this case, the teacher) and also allowing them to work in a context which activates their cultural tendency to work collectively.

The structure of the responses clearly shows the "communication gaps" and allows us to develop recommendations for each direction separately. However, it should be noted that the proposed recommendations are partially common to the selected areas, which allows us to talk about both typical deficiencies of communication process and the prevailing stereotypes in the academic environment regarding communication in the learning and teaching process.

According to the results obtained, the main communication gaps were identified in the following areas:

1. The training in the field of art: feedback issues within the communication "teacher & teacher", "teacher & student", including at low power distance.

It is recommended to conduct trainings in the area of communication and collaboration, on the application of problem-solving and critical thinking methods in order to develop the technology of successful teacher-student collaboration.

2. Training in the field of engineering and technology:

The declarative nature of the vertical communication "teacher & administration", projected onto the communication "teacher & student"; the low level of feedback is partially compensated by clear methodological recommendations for "teacher-student" communication; it is difficult to assess the effectiveness of horizontal communication (lack of common goals) and "blurring of boundaries" between disciplines.

It is recommended to shift the emphasis towards a low power distance through stimulating feedback, conducting team work trainings for students and teachers, expanding the list of tasks for critical thinking. It is also recommended to reduce the workload of teachers, provide creative freedom to promote cooperation, and a number of trainings on conflict management in the educational environment. It requires the use of interactive teaching methods and academic coaching in order to provide more space for independent searches for solutions and the implementation of a creative approach to tasks.

3. IT training:

High readiness for communication is offset by levels due to the quality of communication at the "teacher & administration", "teacher & teacher" levels and the presence of instructions for "teacher & student" communication.

It is recommended to conduct trainings in the area of communication and cooperation with the use of problem-solving and critical thinking methods in order to develop the learning technology of successful teacher-student cooperation.

As a result of the analysis of the identified STEAM approaches for integration and the results of the survey, the Key statements on communication and collaboration within the educational STEAM space were identified:

Communication within STEAM education should be performed based on the following key statements:

1 Low power distance, focused on stimulating and promoting the initiatives of the communicating parties, one of which is dependent ("teacher & student", "teacher & administration").

2. Effective feedback of vertical and horizontal communications, equal exchange of information among all communicating parties

3. An adaptive segment of the academic process organization providing the principles of the "responsive university" framework, responding to the needs of the state, the individual and society, as well as to the personal qualities of students.

4. "Individual thinking" in the academic environment is the openness of a cohesive group to alternative points of view, providing a comprehensive consideration of emerging problems.

5. Adaptive structure of digital communication based on social presence and developed media culture.

6. Language theories and linguistics. The break of template thinking based on the Language Expectation Theory due to a positive violation of the expectations of communication participants.

Collaboration within the framework of STEAM education should be carried out on the basis of the following key statements:

1. A system of principles for building a dialogue aimed at cooperation within the framework of deliberate and conscious speech communication.

2. The principle of cooperation (readiness of partners for communication) is based on the understanding of dialogue as a joint activity of participants, each of whom contributes to the construction of communication, recognizing the common goal of the dialogue.

3. Striving to achieve the maximum level of quality, quantity, relevance, clarity of the transmitted information.

4. Continuity and coordination of the actions of individuals, ensuring the adoption of certain rules and roles aimed at coordinating the actions of one individual with others on the basis of the principle of politeness.

5. Strong relationships based on strong professional ties of common values, aimed at building stable communication systems. (network society, communication mapping).

6. Achieving professional goals focused on the expectations and needs of the audience, based on a deep understanding of the subject, relevance and feasibility of the goals set. (persuasive presentation).

These key statements on communication and collaboration make it possible to form the conceptual core of the STEAM-education framework with the subsequent build-up of the implementation principles and STEAM approaches as part of the integration of STEAM methodology into the main processes of the university, including: the academic process, the extracurricular process, the research work and methodological processes, advanced training of teaching staff, upgrading infrastructure process, academic management and partnerships.

At the same time, special attention should be paid to understanding the final result from the use of STEAM techniques, based on the analysis of the world experience in implementing STEAM and the identified statements of communication and collaboration within the educational STEAM space.

The research group conducted a comparative analysis and correlation of the obtained results at this stage of the project with the National Qualifications Framework of the Republic of Kazakhstan and labor functions set for the group "Professionals in the field of science and technology" in accordance with the National Occupations Classification of the Republic of Kazakhstan, including a description of the main types of professional activity by economy branches. The National Qualifications Framework is a unified description of qualifications, based on the learning outcomes, allows determining the descriptors of all educational levels.

This analysis is due to the need to determine professional competencies based on STEAM approaches in accordance with the required descriptors set for the "bachelor" qualification level. In accordance with the specialists' activities groups description, which provides for the improvement or development of theories and teaching methods, including the research work, a number of required descriptors have been identified that are relevant to most classes within the group "specialists-professionals" and corresponding to the level of "bachelor" in National Qualifications Framework.

Thus, the competencies of engineering and technical specialists formed based on determined STEAM approaches are the following:

1. *Discussion of the goal*: make explicit the rationale for the various approaches identified; explain the reasoning for this approach, so that students themselves realize their own part in the creation and understanding of knowledge.

2. *Application of project-based teaching methods in engineering design*: teach engineering design through interactive, open, interdisciplinary content; develop a set of actions to create a finished creative product based on prototyping; use various language means and techniques in communications, taking into account their compliance according to the specifics in groups of permanent and shift composition.

3. *Application of project-based teaching methods in scientific developments*: perform systematic analysis to study multi-layer interactions based on information from global sources of different levels; use theoretical developments and experiments to test hypotheses and develop and analyze the model; develop a research strategy in the face of novelty and uncertainty.

4. Training Transactive memory: manage information overloads between team members; develop technologies to support innovation and team ambidexterity; find a balance between speed and creativity, scale and productivity; analyze and predict group and individual behavior based on long-term performance indicators.

5. Creative thinking strategy: recognize a wide range of subjective analyzes of objective data and evaluate the potential to meet the needs of creative production; recognize individual methods of searching for ideas; develop divergent and convergent abilities in non-regulated conditions.

6. Simulation method and case study: develop action programs to address specific, complex, unstructured problems under conditions of uncertainty; search for alternative breakthrough solutions, including in professional and competitive projects.

7. Studio training: apply graphical mock-up skills as a way to generate ideas and communicate within a team; carry out creative dialogue communication, including the virtual environment; apply the principles of internalization in the process of solving production problems.

8. Focus-based learning for the creative industry: develop integral solutions to problems based on empirical evidence of their effectiveness; organize teamwork to solve the tasks with the exception of unnecessary erroneous decisions.

9. Teaching facilitation technology: apply the skills of organizing group work, taking into account the personal characteristics of the team members and their effective use to solve the tasks; adjust the process of completing tasks in an uncertain environment; manage conflicts and stress in the process of group work.

10. Self-management training: organize work within the framework of networking based on self-organization and self-government technologies; develop decision making and execution skills; systematize the conceptual foundations for understanding the communicative intentions of the partner, the authors of the texts.

11. Mentoring: develop the establishment of trusting relationships that help achieve goals; be able to transfer experience and knowledge effectively; identify the strengths of the team members for the distribution of responsibilities and the optimal solution of the tasks.

12. Teaching flexibility of professional thinking: assess the influence of hidden beliefs, unconscious biases and stereotypes on personal and professional decisions; use techniques for developing thinking flexibility and neuroplasticity; combine opposing content areas to encourage innovation in the classroom; correct previously made decisions in connection with changes in conditions in the course of work.

13. Interdisciplinary collaboration through the blurring of boundaries: evaluate and predict changes in the industry, taking into account the influence of interdisciplinary areas; use socialization and self-realization as a tool for intercultural communication in the modern multicultural world; collaborate with specialists from related industries; solve problems at the junction of different areas.

14. Team building trainings: conduct brainstorming sessions to solve communication problems; analyze and predict group and individual behavior in a team;
manage information flows in the team; to manage conflicts and stresses in the process of solving production tasks.

15. Intercultural collaboration and communication: ensure the development of effective communication and relationship building skills; analyze regional features and their influence on design, the possibility of application in their cultural field; build speech interaction in accordance with the norms adopted in a particular culture, taking into account speech specifics; apply tools and methods of intercultural interaction within the formalization and regulation of the processes of professional activity.

16. Design-research method with highly thinking ability (generating productive ideas): apply various methods of searching for ideas in professional activities; apply the acquired knowledge to create business projects and start-ups*;* analyze the results of theoretical and experimental studies; make recommendations based on the results of the analysis.

17. Teaching Interactive Methods: actively interact with all participants in the process of solving learning problems; apply group communication skills in the learning process; own interactive technical means and technologies for the exchange and processing of information.

18. Soft Skills Training: use the flexibility of thinking to make objective decisions in any professional activity; effectively interact with specialists in various fields; develop effective thinking and self-management skills.

19. Development of minor programs and micro-qualifications: determine personal needs for additional skills to solve professional problems; identify new trends in existing professional activities; master additional skills in terms of professional need.

20. Teaching Note taking and active listening technology: perform the analysis of educational and professional information and its visual presentation for the most effective use; increase personal productivity, as well as the ability to influence, persuade and negotiate based on active listening techniques.

21. The ability to synthesize, critical understanding of an array of information and structure: make decisions based on a convergent approach; develop critical thinking skills; develop flexibility and neuroplasticity of thinking.

22. Co-teaching techniques: structure the received information at the intersection of various disciplines and carry out its analytical interpretation; solve problems on the basis of interdisciplinary interaction; analyze information from various points in the process of communication and collaboration.

23. Reflection for operational adjustment of educational activities: receive and efficiently assimilate incoming information; carry out two-way horizontal communication on educational activities*;* possess the psychological mechanism of professional self-improvement and self-actualization.

24. Technologies of professional self-presentation: possess self-presentation technologies with demonstration of practical professional skills; manage the audience taking into account its level and characteristics; develop structured demonstration materials using information technology.

25. Hot-spot analysis technology: look for bottlenecks in the production process; identify patterns of problems and ways to solve them.

26. Hand-on creative courses: get the necessary practical skills in a short time; gain knowledge through practical experience; apply creative skills to solve tasks.

5. Conclusion

The topic of the scientific-technical sphere and art integration is one of the most relevant for the professional and technical society today, and creative industries based on creativity and intellectual capital have added new accents to the discussion.

The capacity building for innovative training of technical specialists via the introduction of the Art component in STEM is based on the identification and assessment of problem areas and communication gaps at a technical university. The results of the research allow us to identify the problematic field in the sphere of communication and cooperation technologies within the framework of the "art-engineering-IT" components. The survey revealed the predominance of "low distance" in terms of the four "power distance" parameters, which indicates the well-established and systematic processes. At the same time, the parameter "communication" is characterized by a high-power distance, which can lead to low effectiveness of the interaction process as a whole, as well as a negative impact on individual components of the academic process. A positive result, despite the high distance, can be considered a readiness for dialogue and open condemnation at the level of the entire group.

At the same time, the organization of the academic process in a multicultural environment is characterized by a fairly diverse choice of tools, however, a significant emphasis in the organization of work is placed on prescribed reporting, and not on the process itself and the result. A multicultural audience requires the teacher to clearly organize pedagogical activities in accordance with the models adopted in different cultures and select educational content, taking into account cultural codes and semiotic context. At the same time, both the evaluation system and the specifics of feedback play an important role. The identified key statements of communication and collaboration within the integrated educational STEAM space, as well as the formed list of STEAM competencies of technical graduates will contribute to the effective solution of a number of existing problem situations in the training of specialists for the creative industry.

Thus, the results of this study will contribute to increasing financial well-being through creative economy and creative industries due to the unity of exact science and humanitarian approaches, which will support innovators in the modern engineering world. Also, the implementation of this project will create conditions for the formation of the basis of scientific knowledge and practical skills among the target audience through the technology of innovative training, as well as for the development of the potential for innovation and creativity of training programs for technical specialists.

The results achieved can be used in the practice of technical universities in Kazakhstan as guidelines for capacity building of training engineers, developing STEAM education as a key factor in the creative industry.

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